OREDA

Offshore Reliability Data Handbook

4th Edition

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[1] The companies listed below are those being members of OREDA in 2002.

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Requests for interpretation may arise regarding the meaning of parts of the handbook as they relate to specific applications. Those requests should be directed to SINTEF Industrial Management at the addresses given. As publications issued by the OREDA project represent a consensus of all participating companies, it is important to ensure that any interpretation has also received the joint agreement of those companies. For this reason, it may in some cases be necessary to consult the OREDA Steering Committee. In these cases it will not be possible to provide an instant response to interpretation requests, except in those cases where the matter has previously received formal consideration.

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PREFACE

The reliability, availability, maintenance and safety (RAMS) of offshore exploration and production (E & P) facilities are of considerable concern to employees, companies and authorities. RAMS analyses are carried out to provide a basis for decisions in offshore engineering, fabrication and operations. In order to allow these analyses to be conducted, a source of reliability data is required.

The OREDA participating companies have responded to this need by publishing four reliability data handbooks. The previous editions of the OREDA handbook were published in 1984, 1992 and 1997 respectively.

The current 2002 edition has not been changed significantly compared to the former –97 edition. However, it should be noted that *drivers are no longer included within the boundary of the driven unit* but defined as separate entities. As the 2002 edition contains a lot more subsea data than previously, these data are presented in a fashion more adapted to subsea application. The handbook is divided into two parts. Part I describe the OREDA project, different data collection phases and the estimation procedures used to generate the handbook. In Part II the reliability data tables are presentedfor both topside and subsea equipment. In order to interpret and apply the data given in Part II in the most correct manner, it is recommended to read Part I before using data shown in Part II.

While each new edition of the handbook is considered to be a step forward, it is realised that the quality and the quantity of the data presented in the handbook may be inadequate for certain applications. The OREDA Steering Committee's intention is therefore to keep the handbook up to date according to the state of technology by publishing new editions.

The current handbook covers phase IV and V of OREDA data collection. This represent broadly the time period of 1993 – 00. It may, however, be seen that some data collected may be beyond this time period.

Data collected are in general not covering the whole lifetime of equipment, but typically a time windows of 2 – 4 years of operation. Infant mortality failures are as a rule not collected for topside equipment, hence, the data collected are from the normal steady-state operating time period as illustrated in Figure 5. For subsea equipment failures are in general collected on a whole lifetime basis, i.e. including the infant mortality period.

The source data for this book are stored in a computer database except for phase I. The database and the associated software are available only to the oil companies participating in the OREDA project. The data presented in this handbook are extracted and compiled from this database and presented as generic data tables. *The database does, however, contain additional information -and information on a more detailed level- than what is covered in this handbook.* For those who want to exploit this possibility, one of the participating oil companies needs to be contacted. A list with contact names for each participating company can be found in the OREDA Homepage: http://OREDA.com

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PART I

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INTRODUCTION

THE OREDA PROJECT

The Offshore Reliability Data (OREDA) project was established in 1981 in co-operation with the Norwegian Petroleum Directorate. The initial objective of OREDA was to collect reliability data for safety equipment. The current organisation, as a co-operating group of several oil companies, was established in 1983, and at the same time the scope of OREDA was extended to cover reliability data from a wide range of equipment used in oil and gas exploration and production. Offshore topside and subsea equipment are primarily covered, but some onshore E & P equipment is also included.

The main objective of the OREDA project is to contribute to an improved safety and cost-effectiveness in design and operation of oil and gas exploration and production facilities; through collection and analysis of maintenance and operational data, establishment of a high quality reliability database, and exchange of reliability, availability, maintenance and safety (RAMS) technology among the participating companies.

PROJECT PHASES

Phase I (1983 - 1985)

The purpose of phase I was to collect and compile data from offshore drilling and production operations. The data were published in the OREDA-84 handbook. An objective of the handbook was to demonstrate the ability of the eight participating oil companies to co-operate on this issue and create a forum for a common co-operative process in this field. Data was collected on a wide area of equipment (large population) but not with as much detailed information as in later phases.

Phase II (1987 - 1990)

The scope was adjusted to only collect data on production critical equipment, to improve the quality of the data, and to store the data in a PC database format. A tailor-made PC program (called the OREDA software) was developed to aid the collection and analysis of the data. The data were published in the OREDA-92 handbook. This Handbook also contains the data collected in phase I.

Phase III (1990 - 1992)

The number of equipment categories was increased, and more data on maintenance programs were collected. The data quality was improved by means of the comprehensive "Guidelines for Data Collection" and through quality control. The OREDA software was modified into a more general-purpose data collection tool, and its user interface was improved. The data collected in this phase are contained in the OREDA-97 handbook.

Phase IV (1993 - 1996)

A new general software was developed for data collection and analysis, plus specific software and procedures for automatic data import and conversion. Data were collected mainly for the

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same equipment as in phase III, and the data collection was - to a greater extent - carried out by the companies themselves. Data on planned maintenance are included.

Phase V (1997 – 2000)

Some new equipment classes were included and more focus was given on collecting subsea data. As a parallel activity, the ISO standard 14 224: "*Petroleum and natural gas industries - Collection and exchange of reliability and maintenance data for equipment*" was developed and issued in July 1999. A revised version including downstream equipment is currently being developed by ISO TC67 Workgroup 4 with the secretariate at NTS in Oslo. (See: http://www.nts.no/)

Phase VI were completed in 2001 and **phase VII** is planned to last 2002 - 2003.

Up-to-date information on the OREDA project is available on the Internet address:

http://www.oreda.com

PARTICIPANTS

During phase IV and V several changes have been experienced in company participation in OREDA as to new companies joining and leaving OREDA as well as companies being merged/sold. The following summarise the companies that have contributed with data in these phases:

Companies	Phase IV	Phase V	Comments
AGIP	√	√	
BP.	√	√	
Chevron	√	√	Merged with Texaco
ELF	√	√	Merged with TOTAL
Esso/Exxon	√	√	(Merged with Mobil)
Norsk Hydro	√	√	
Phillips Petroleum Company Norway	√		
Statoil	√	√	
Saga Petroleum	√		Sold to Norsk Hydro
Shell	√	√	
Texaco		√	Merged with Chevron
TOTAL	√		Merged with Elf

ORGANISATION

OREDA is managed by a Steering Committee with one member and one deputy member from each of the participating oil companies. The Steering Committee elects one of its members as chairman and appoints a Project Manager. The Project Manager co-ordinates the activities approved by the Steering Committee, including data quality assurance. Det Norske Veritas served as Project Manager during phases I and II; SINTEF during phases III - V, and act as current project manager in Phase VII.

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EQUIPMENT CATEGORIES COVERED IN THE DIFFERENT PHASES

Table 1 shows the equipment categories that have been included in the four OREDA handbooks (including this one). Most of the equipment derives from offshore installations, but a few equipment units from onshore E&P have also been included. In phase V more emphasis has been placed on collection of subsea data.

Table 1 Equipment classes covered by the four OREDA Handbooks

System	Equipment class	Phase I (-84 edition) (1983 – 85)	Phase II (-92 edition)[2] (1987 – 90)	Phase III (-97 edition) (1990 – 92)	Phase IV (2002 edition) (1993 – 96)	Phase V (2002 edition) (1997 – 00)	SUM
		No. of units	No. of units	No. of units	No. of units	No. of units	No. of units
Rotating machinery	- Gas Turbines		109	54	56	28	247
	- Compressors	17	50	45	75	56	243
	- Combustion engines				39	64	103
	- Pumps	478	271	103	294	152	1298
	- Turboexpanders				7	8	15
	- Electric generators	76		49	87	8	220
	- Electric motors				56	122	178
Static equipment	- Vessels	359	329	54	148	51	941
	- Heaters and boilers				8	1	9
	- Heat exchangers	519	170	75	51	17	832
Other topside	- Valves	658	645	899	821	349	3372
	- F&G detection equipment	3683		5828	79	779	10369
	- Process sensors/control	3740		487	140	69	4436
Misc. equipment phase I only	- Misc. el. systems	1321					1321
	- Misc. safety systems	1703					1703
	- Misc. utility systems	1035					1035
	- Drilling systems	880					880
Subsea equipment	- Control systems			14		17	31
	- Wellhead & X-mas tree			21		83	104
	- Pipelines					144	144
	-Template					4	4
	- Manifold					29	29
	- Risers					42	42
	- Running tools					6	6
	- Misc. equipment (phase II)		15				15
Total		**14469**	**1589**	**7629**	**1841**	**2037**	**27565**

[2] The –92 edition do also contain the data issued in the –84 version.

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SCOPE OF THE OREDA HANDBOOK

The OREDA handbook presents high quality reliability data for offshore equipment collected during phase IV and V of the OREDA project. The intention of the handbook is to provide both quantitative and qualitative information as a basis for RAMS analyses.

For each *topside* equipment unit, the following information is presented:

- A drawing illustrating the boundary of the equipment unit, i.e., a specification of subunits and so-called maintainable items that are part of the equipment unit.
- A listing of all failure modes, classified as *critical*, *degraded* or *incipient*, respectively.
- The observed number of failures for each failure mode.
- The aggregated observed time in service for the equipment unit, classified as calendar time, operational time, and number of demands.
- An estimate of the failure rate for each failure mode with associated uncertainty limits.
- A repair time estimate, i.e., the number of man-hours required to repair the failure and restore the function.
- A repair time estimate, i.e., the elapsed time in number of hours required repairing the failure and restoring the function. This time is the *active* repair time, i.e. the time when actual repair work was being done.
- Supportive information, e.g., number of items and installations.
- A cross-tabulation of maintainable item versus failure mode, and of failure descriptor/-cause versus failure mode.

For each *subsea* equipment unit, the following information is presented:

- A drawing illustrating the boundary of the equipment unit, i.e., a specification of subunits and components that are part of the equipment unit.
- A listing of all components.
- The observed number of failures for each component.
- The aggregated observed time in service for the equipment unit, classified as calendar time.
- An estimate of the failure rate for each component with associated uncertainty limits.
- A repair time estimate, i.e., the elapsed time in number of hours required repairing the failure and restoring the function. This time is the *active* repair time, i.e. the time when actual repair work was done.
- Supportive information, e.g., number of items and installations.
- A cross-tabulation of component versus failure mode, of subunit versus failure mode, of equipment unit versus failure mode and of failure descriptor/-cause versus failure mode.

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LIMITATIONS

Information released from each participating company has been kept confidential by rendering it anonymous. Only generic data are published. The single event information, which is the basis for the estimates, is (in most cases) gathered from two or more installations, and consequently the figures in the handbook reflect a weighted average of the experience.

The OREDA project is so far restricted to failure data collected on hardware components and systems; information about human errors is not included. Nevertheless, component failures may have been caused by human errors and, therefore, implicitly, human errors are included in the failure rate estimates.

Details and limitations of the methods used are described in the section "ESTIMATION PROCEDURES" on page 23.

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THE OREDA TOPSIDE DATA STRUCTURE

GENERAL

In order to collect data and analyse them in a consistent manner, a taxonomy description has been developed in the OREDA project. The following gives a summary of that taxonomy to better understand the platform on which these data have been collected and stored. Note that some of the parameters given in this description are not included in the generic data presented in this handbook, but contained in the source database.

MAIN DATA CATEGORIES

For each equipment category the database is split into three separate database files: an *Inventory* part, a *Maintenance* part, and a *Failure* part.

The **Inventory** part contains a description of each *equipment unit* for which data have been collected, e.g., pump. This description contains technical data (e.g., capacity, size) as well as some operating and environmental data (e.g., operating mode, vibrations). The inventory description for each equipment unit is stored in an *Inventory record* in the database.

The **Failure** part contains the failure events being experienced for an equipment unit (inventory) during the period of surveillance; one record for each failure event. The failure events are always related to one equipment unit (inventory).

The **Maintenance** part contains information about the corrective and the scheduled preventive maintenance program for each equipment unit (e.g., maintenance action, interval, man-hours). Data on corrective maintenance is related to its preceding failure, while data on preventive maintenance is related to the equipment unit.

SYSTEM HIERARCHY

The various items are classified into equipment categories termed *Equipment classes* e.g. pumps, compressors, valves etc. Each individual item within a class is termed an *Equipment Unit* (e.g. one pump). Each equipment class is further classified according to its design characteristics and type of service (system). Table 2 gives an example for the two equipment classes *Pumps* and *Fire & Gas detectors*.

Equipment within an equipment class is subdivided in two lower indenture levels, called *subunits* and *maintainable items (MI)*. This subdivision is purely hierarchic and has the following interpretation:

Level 1 – Equipment Unit: The highest level used in OREDA and typically includes an equipment unit with one main function, e.g. pump, compressor.

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Level 2 – Subunit: An equipment unit is subdivided in several subunits, each with one function required for the *equipment unit* to perform its main function. Typical subunits are e.g., cooling, lubrication. The subunits may be redundant, e.g., two independent start units.

Level 3 - Maintainable Item (MI): These are subsets of each subunit and will typically consist of the lowest level units that are due for preventive maintenance.

The hierarchy is illustrated in Figure 1.

Table 2 System Classification (Example)

EQUIPMENT CLASS		DESIGN CLASS		SYSTEM	
Description	Code	Description	Code	Description	Code
Pumps	PU	Centrifugal	CE	Water fire fighting	FF
		Reciprocating	RE	Sea water injection	WI
		Rotary	RO	Oil handling	OH
				Gas utilities	GU
				Gas processing	GP
				.....	....
Fire & Gas detectors	FG	Smoke/combustion	BS	Fire detection	FD
		Heat	BH		
		Flame	BF		
		Hydrocarbon gas	AB	Gas detection	GD
		H2S gas	AS		

(Example: PU-RO-OH indicate a rotary pump used in oil handling)

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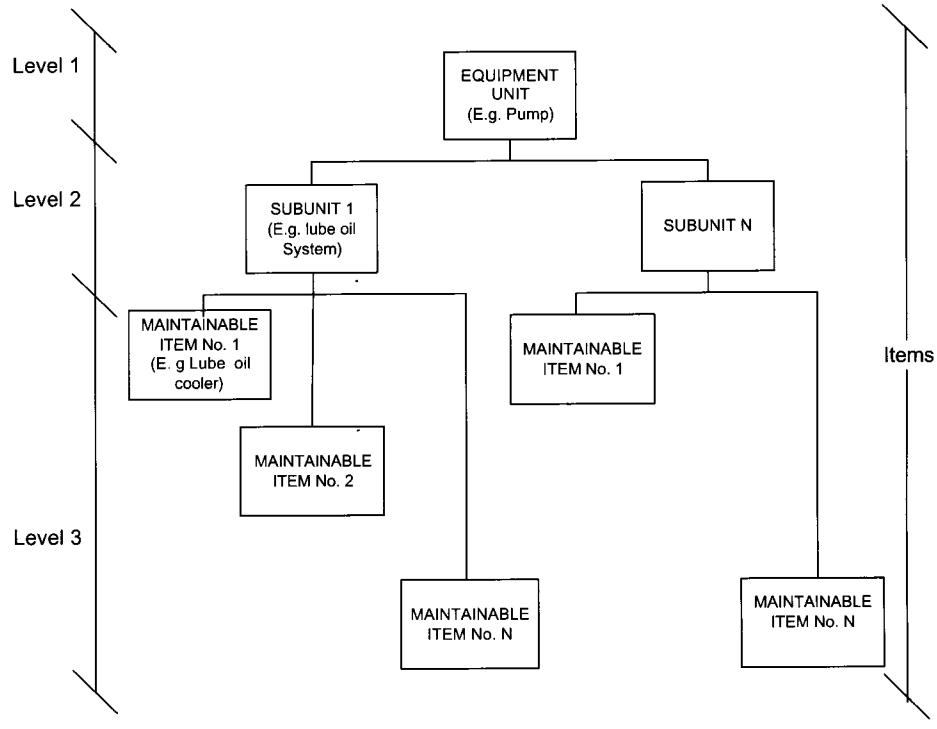

Figure 1 System Hierarchy

Several subunits may be relevant for several equipment categories (e.g., lubrication system, starting system). In these cases the subunits are given the same name and the same set of MIs. This is done in order to standardise the subunits/MIs as much as possible, although some of the MIs in these subunits may not apply for all equipment categories.

EQUIPMENT BOUNDARIES

To compare failure events from different equipment categories, installations, or sources, it is important to have a common definition of which components or parts that are to be included in an inventory. The *boundary* defines parts associated with the generic item that are considered to be essential for its function or that are sold by the manufacturer as part of the item. For example, the power transmission (e.g. gear) is included within the boundary for a pump, while the driver (e.g. el.motor) is not. The boundary is normally sufficiently determined by a boundary diagram as illustrated in Figure 2. Further, a tabular description as shown in Table 3 lists those subunits and MIs that are included within the boundary.

The boundaries are established to confine the same items as the corresponding tag numbers or sub-tag numbers used by the participating oil companies. The equipment units correspond to the companies' main tag level, while the subunits correspond to the sub-tag level.

When establishing the equipment boundaries, the following principles have been applied:

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- The connected units are excluded from the equipment unit boundary unless specifically included by the boundary specification. *Failures that occur in a connection (e.g. leak) are included* unless it is known specifically that it has occurred on the connected item outside the boundary.

- When a driver and the driven unit use common subunits (e.g., lubrication), failures of this subunit is as a common rule related to the *driven* unit.

- Failures on drivers (e.g. gas turbine) and driven units (e.g. compressors) are presented for each of those equipment classes *separately*. When e.g. a failure rate for a combination of driver and driven units is needed (e.g. compressors driven by gas turbines) the combined values from those two equipment classes should be used.

- Instrumentation is included only where this equipment has specific control and/or monitoring function for the equipment unit and/or is locally mounted (sensors). Instrumentation of a more general use, such as supervisory system (SCADA) is, as a rule, not included.

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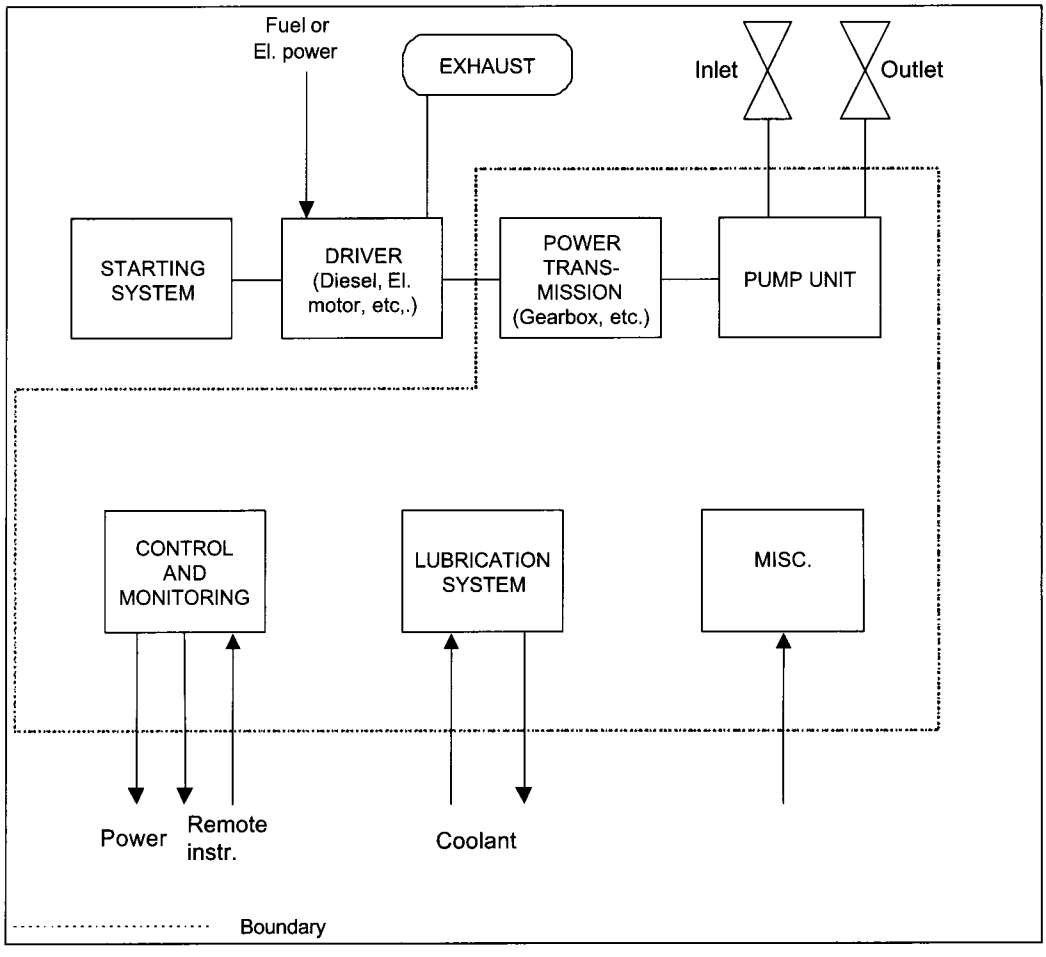

Figure 2 Boundary Definition, Pumps

INVENTORY DATA

For each equipment unit there is an inventory description divided into two parts:

1. One part common to all equipment categories (e.g., manufacturer, model, function, operating time).

2. One part containing equipment category specific data (e.g., capacity, size, power consumption).

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Table 3 Subdivision in Maintainable Items, Pumps

EQUIPMENT CLASS	PUMPS				
SUBUNITS	**Power transmission**	**Pump unit**	**Control and Monitoring**	**Lubrication system**	**Miscell-aneous**
MAINTAINABLE ITEMS	• Gearbox • Bearing • Seals • Lubrication • Coupling to driver • Coupling to driven unit	• Support • Casing • Impeller • Shaft • Radial bearing • Thrust bearing • Seals • Valves • Piping • Cylinder liner[1] • Piston[1] • Diaphragm[2]	• Control unit • Actuating device • Monitoring unit • Internal pwr supply • Valves	• Reservoir • Pump w/ motor • Filters • Cooler • Valves • Piping • Oil	• Purge air • Cooling/ heating system • Filter, cyclone • Pulsation damper • Others

FAILURE DATA

In OREDA a failure event is defined as a *physical* failure of equipment. This implies that all events where a work order is issued, and some maintenance action carried out, would be considered as failure in OREDA (see the definitions on page 40).

For each failure a description (record) of the failure is given in the database together with the corrective action(s) carried out to restore the item to normal operating condition. The information is partly based on numeric data, partly on codes selected from a predefined menu, and partly on free text.

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THE OREDA SUBSEA DATA STRUCTURE

MAIN DATA CATEGORIES

The OREDA subsea database consists of three main parts: An *Inventory* part, a *Failure* part, and a *Maintenance* part.

The **Inventory part** contains a description of each Equipment Unit (e.g. an X-mas tree). It contains technical and operational data on all three indenture levels applied: (1) Equipment Unit, (2) Subunit and (3) Component level.

The **Failure part** contains the failure events experienced for one Equipment Unit during the period of surveillance; one failure record for each failure event. If no failures are experienced for a specific equipment unit, the corresponding failure database will be empty. Subsea failures are linked to the lowest level in the equipment hierarchy, the component level.

The **Maintenance part** contains information about the corrective maintenance/ intervention being carried out (e.g. maintenance action, downtime, resources) and is related to a failure event record.

SYSTEM HIERARCHY

The *system hierarchy* in OREDA, subsea part, is broken down into four levels starting on top viz.:

- **Field/Installation:** This is an identifier for the subsea field and its installation(s). For each field several installations may be included.
- **Equipment unit:** An equipment unit on the highest equipment level used in OREDA which typically includes a unit with one main function, e.g. X-mas tree, control system, etc.
- **Subunit:** An equipment unit is subdivided in several subunits, each with function(s) required for the *equipment unit* to perform its main function. Typical subunits are e.g. umbilical, HPU etc. The subunits may be redundant, e.g. two independent HPUs.
- **Component:** These are subsets of each subunit and will typically consist of the lowest level items that are being repaired or replaced as a whole (e.g. valve, sensor etc)

The hierarchy is illustrated in Figure 3.

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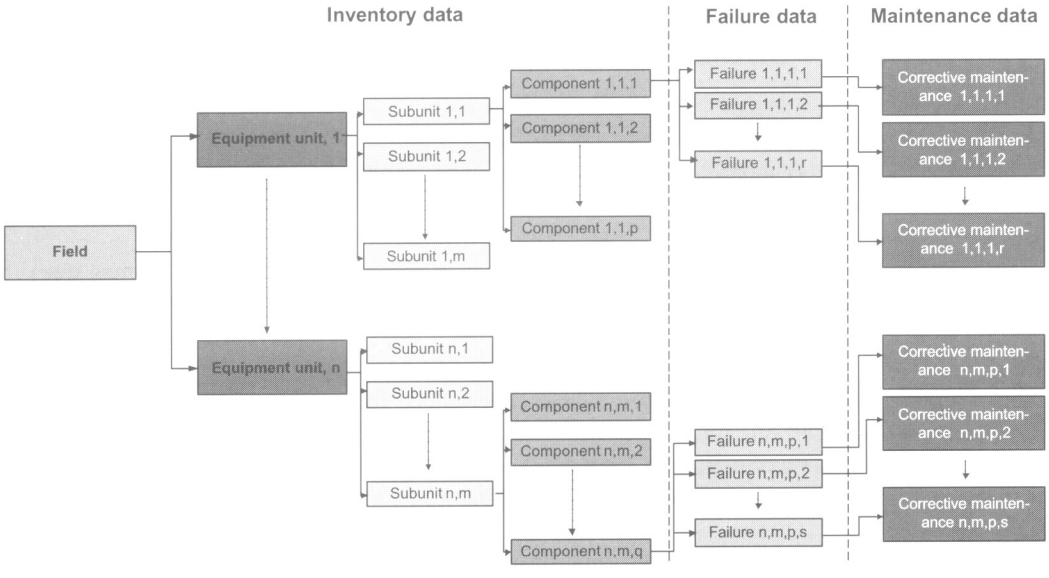

Figure 3 - System hierarchy

The failures and corrective maintenance actions are as shown in Figure 3 linked to the component where they occurred.

EQUIPMENT BOUNDARIES

The boundaries of what constitutes a subsea system and the various levels in the inventory need to be clearly defined to ensure that in-service times and failures are allocated correctly. A typical equipment level boundary used in OREDA is illustrated in
Figure 4. Boundary details for the each equipment class are given in each equipment class chapter respectively.

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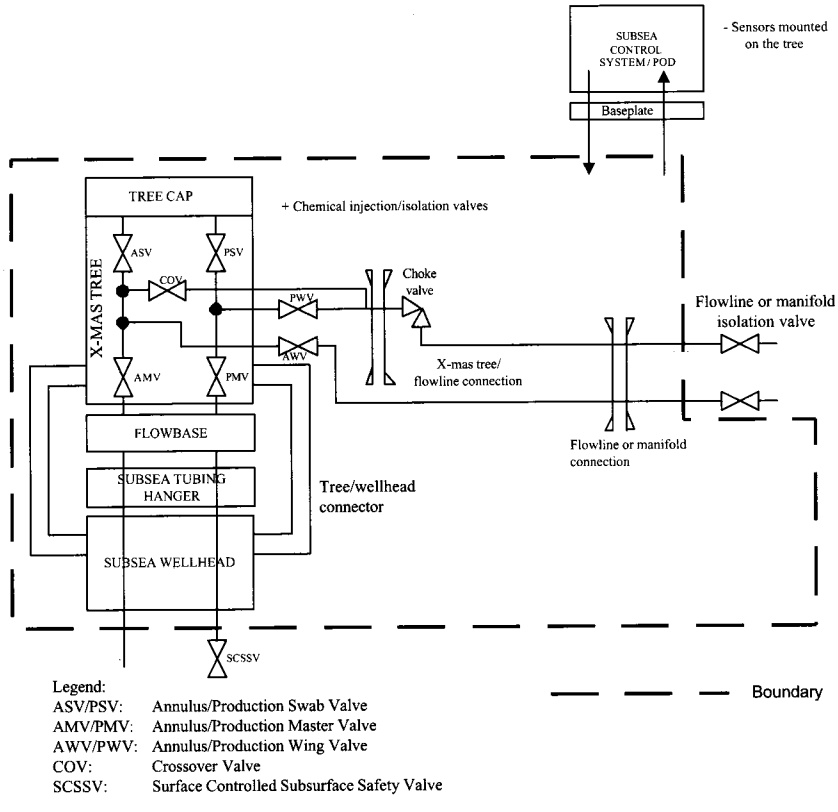

Figure 4 - Boundary definition, X-mas tree

INVENTORY DATA

The inventory data are used to describe an equipment unit and its associated subunits and components, to be able to compare equal with equal and retrieve relevant data from the database. Furthermore, the inventory data may represent explanatory variables affecting the observed reliability.

These data are mainly of static character; i.e. they do not change in course of time. They are also recorded once for each item. Some are, however, of a more dynamic nature and may change during the surveillance period (e.g. no. of demands).

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FAILURE EVENT AND MAINTENANCE DATA

For each failure a description of the failure is given together with the maintenance/intervention (corrective action) carried out to restore the item to normal operating conditions. This information is divided in two event records:

- *Failure*; i.e. description of the failure event
- *Maintenance/intervention*; i.e. description of the maintenance action

These records contain a set of attributes describing the failure and maintenance action respectively. The attributes are based on numeric data, codes selected from a predefined menu, and free text description.

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ESTIMATION PROCEDURES

The main purpose of the OREDA-2002 handbook is to present average failure rate estimates together with repair time estimates. This section presents a brief description of the statistical methods that are used.

FAILURE RATE

The *failure rate* function tells us how likely it is that an item that has survived up to time t, will fail during the next unit of time. If the item is deteriorating, this likelihood will increase with the age t. A man who has reached the age of 95 years will obviously have a higher probability of dying during the next year than a 20 years old man. The failure rate function will therefore usually be a function of the time - or, the age of the item.

To give a mathematical definition of the failure rate function, we start with the time to failure, T, of the item, i.e., the time from the item is put into operation until the first failure occurs. It is generally impossible to predict the exact value of the time to failure, and T will therefore be a random variable with some distribution. The failure rate function, $\lambda(t)$, may now be defined mathematically as:

$$\lambda(t)\cdot\Delta t \approx \Pr(t < T \le t + \Delta t \mid T > t)$$

The right hand side of this equation denotes "the probability that the item will fail in the time interval $(t, t + \Delta t)$, when the item is still functioning at time t" or with other words: "the probability that an item that has reached the age t will fail in the next interval $(t, t + \Delta t)$." The approximation is sufficiently accurate when Δt is the length of a very "short" time interval.

The failure rate function is sometimes also called 'hazard rate' or 'force of mortality'.

The life of a technical item may generally be split into three different phases: the *burn-in* (or infant mortality) phase, the *useful life* phase, and the *wear-out* phase. The failure rate function will usually have different shapes in the three phases. As illustrated in Figure 5, the failure rate function may be decreasing in the burn-in phase, close to constant in the useful life phase, and increasing in the wear-out phase. The curve in Figure 5 is called a "bath-tub" curve because of its characteristic shape, and is often claimed to be a realistic model for mechanical equipment.

If we assume that the failure rate function is constant during the useful life phase, this means that the item is not deteriorating during this phase. The deterioration will start when, or if, the item enters the wear-out phase.

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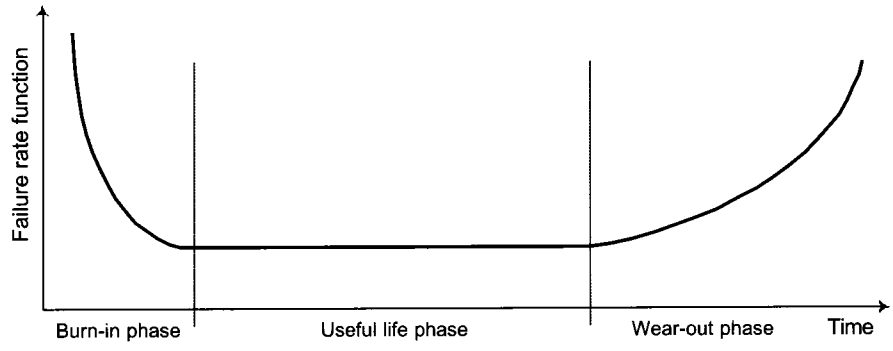

Figure 5 Bath-Tub Shape of the Failure Rate

So-called burn-in problems may be caused by inherent quality problems in the item, or by installation problems. Inherent quality problems may sometimes be removed by careful quality testing prior to installation. Installation problems have been disregarded in the OREDA data collection, notably for most *topside equipment*. The burn-in phase is therefore not included in the OREDA database, and we may assume that the data collection is started with the useful life phase. For subsea equipment data is collected on a whole lifetime basis, i.e. data collection starts when the equipment is installed and ready for its intended service. This means that the equipment may no necessarily have been

Many of the items covered in OREDA are subject to some maintenance or replacement policy. The items will thereby often be replaced or refurbished before they reach the wear-out phase.

The main part of the failure events in the OREDA database will therefore come from the useful life phase, where the failure rate is close to constant.

All the failure rate estimates presented in this handbook are therefore based on the assumption that the failure rate function is *constant* and independent of time, in which case $\lambda(t) = \lambda$.

Note

- No statistical tests have been performed to verify the assumption of a constant failure rate.
- Since data are assumed to come from "bottom" of the bath-tub curve, the failure rate estimates presented therefore represent some kind of minimum over the entire life cycle of the equipment.

An important implication of the constant failure rate assumption is that an item is considered to be "as good as new" as long as it is functioning. All failures are purely chance failures and independent of the age of the item.

The mean time to failure, MTTF, may be calculated as

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$$\text{MTTF} = \frac{1}{\lambda}$$

These and related concepts are thoroughly discussed in e.g., Høyland and Rausand (1994).

ESTIMATORS AND UNCERTAINTY LIMITS FOR A HOMOGENEOUS SAMPLE

When we have failure data from identical items that have been operating under the same operational and environmental conditions, we have a so-called *homogeneous sample*. The only data we need to estimate the failure rate λ in this case, are the observed number of failures, n, and the aggregated time in service, τ.

The estimator of λ is given by:

$$\hat{\lambda} = \frac{\text{Number of failures}}{\text{Aggregated time in service}} = \frac{n}{\tau}$$

See e.g. Høyland and Rausand (1994) for further details.

The aggregated time in service, τ, may be measured either as calendar time or operating time, and both these are presented in the data tables in Part II.

Note that this approach is valid only in the following situations:

- Failure times for a specified number of items, with the *same* failure rate λ, are available.
- Data (several failures) is available for *one* item for a period of time, and the failure rate λ is constant during this period.
- A combination of the two above situations, i.e., there are several items where each item might have several failures. This is the typical situation for the OREDA data.

In the data tables in Part II of the handbook, estimates are given for each failure mode.

Uncertainty intervals for the failure rate

The uncertainty of the estimate $\hat{\lambda}$ may be presented as a 90% confidence interval. This is an interval (λ_L, λ_U), such that the "true value" of λ fulfils:

$$\Pr(\lambda_L \le \lambda < \lambda_U) = 90\%$$

With n failures during an aggregated time in service τ, this 90% confidence interval is given by:

$$\left(\frac{1}{2\tau} Z_{0.95,2n}, \frac{1}{2\tau} Z_{0.05,2(n+1)} \right)$$

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where $z_{0.95,\nu}$ and $z_{0.05,\nu}$ denote the *upper* 95% and 5% percentiles, respectively, of the χ^2-distribution with ν degrees of freedom, see Table 4, page 31.

Example
Assume that $n = 6$ failures have been observed during an aggregated time in service $\tau = 10000$ hours.

The failure rate estimate is then given by:

$$\hat{\lambda} = n/\tau = 6 \cdot 10^{-4} \text{ failures per hour}$$

and a 90% confidence interval is given by:

$$\left(\frac{1}{2\tau} z_{0.95,2n}, \frac{1}{2\tau} z_{0.05,2(n+1)}\right) = \left(\frac{1}{20000} z_{0.95,12}, \frac{1}{20000} z_{0.05,14}\right) = (2.6 \cdot 10^{-4},\ 11.8 \cdot 10^{-4})$$

The estimate and the confidence interval are illustrated in Figure 6.

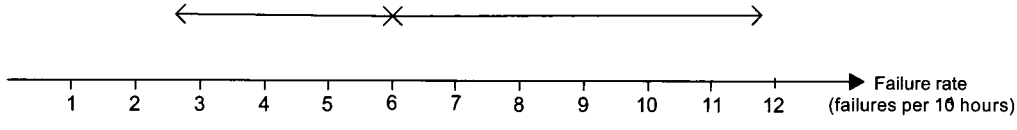

Figure 6 Estimate and 90% Confidence Interval for the Example.

Note
The given interval is a confidence interval for the failure rate for the items we have data for. There is no guarantee that items installed in the future will have a failure rate within this interval.

MULTI-SAMPLE PROBLEMS

In many cases we do not have a homogeneous sample of data. The aggregated data for an item may come from different installations with different operational and environmental conditions, or we may wish to present an "average" failure rate estimate for slightly different items. In these situations we may decide to merge several more or less homogeneous samples, into what we call a multi-sample.

The various samples may have different failure rates, and different amounts of data - and thereby different confidence intervals. This is illustrated in Figure 7.

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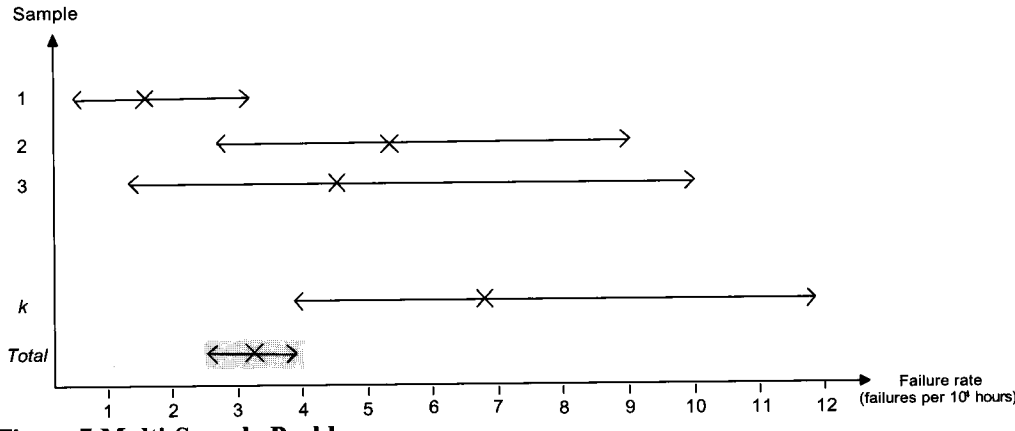

Figure 7 Multi-Sample Problem

To merge all the samples, and estimate the "average" failure rate as the total number of failures divided by the aggregated time in service will not always give an adequate result. The 'confidence' interval will especially be unrealistically short, as illustrated in Figure 7. We therefore need a more advanced estimation procedure to take care of the multi-sample problem.

Below, the so-called OREDA-estimator of the "average" failure rate in a multi-sample situation is presented together with a 90% uncertainty interval. Spjøtvoll (1985) gives a rationale for the estimation procedure.

The OREDA-estimator is based on the following assumptions:

- We have k different samples. A sample may e.g., correspond to a platform, and we may have data from similar items used on k different platforms.
- In sample no. i we have observed n_i failures during a total time in service τ_i, for $i = 1,2,\ldots, k$.
- Sample no. i has a constant failure rate λ_i, for $i = 1,2,\ldots, k$.
- Due to different operational and environmental conditions, the failure rate λ_i may vary between the samples.

The variation of the failure rate between samples may be modelled by assuming that the failure rate is a random variable with some distribution given by a probability density function $\pi(\lambda)$.

The mean, or "average" failure rate is then: $\theta = \int_0^\infty \lambda \cdot \pi(\lambda)\, d\lambda$.

and the variance is: $\sigma^2 = \int_0^\infty (\lambda - \theta_\Lambda)^2 \cdot \pi(\lambda)\, d\lambda$.

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To calculate the multi-sample OREDA-estimator, the following procedure is used:

1. Calculate an initial estimate $\hat{\theta}_1$ of the mean ("average") failure rate θ, by pooling the data:

$$\hat{\theta}_1 = \frac{\text{Total no. of failures}}{\text{Total time in service}} = \frac{\sum_{i=1}^{k} n_i}{\sum_{i=1}^{k} \tau_i}$$

2. Calculate:

$$S_1 = \sum_{i=1}^{k} \tau_i$$

$$S_2 = \sum_{i=1}^{k} \tau_i^2$$

$$V = \sum_{i=1}^{k} \frac{(n_i - \hat{\theta}_1 \tau_i)^2}{\tau_i} = \sum_{i=1}^{k} \frac{n_i^2}{\tau_i} - \hat{\theta}_1^2 S_1$$

3. Calculate an estimate for σ^2, a measure of the variation between samples, by:

$$\hat{\sigma}^2 = \frac{V - (k-1)\hat{\theta}_1}{S_1^2 - S_2} \times S_1 \quad \text{when greater than 0, else 0.}$$

4. Calculate the final estimate θ^* of the mean ("average") failure rate θ by:

$$\theta^* = \frac{1}{\sum_{i=1}^{k} \frac{1}{\frac{\hat{\theta}_1}{\tau_i} + \hat{\sigma}^2}} \times \sum_{i=1}^{k} \left(\frac{1}{\frac{\hat{\theta}_1}{\tau_i} + \hat{\sigma}^2} \times \frac{n_i}{\tau_i} \right)$$

5. Let $SD = \hat{\sigma}$

   In the data tables in Part II of the handbook θ^* corresponds to the mean (column 4), and *SD* corresponds to the standard deviation (column 6).

   The *lower* and *upper* "uncertainty" values are given by:

$$\int_{Lower}^{Upper} \pi(\lambda)\, d\lambda = 90\%$$

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Since the distribution $\pi(\lambda)$ is not known in advance, the following pragmatic approach is used:

6. $\pi(\lambda)$ is assumed to be the probability density function of a *Gamma* distribution with parameters α and β.

7. The parameters α and β are estimated by:

$$\hat{\beta} = \frac{\theta^*}{\hat{\sigma}^2}$$

$$\hat{\alpha} = \hat{\beta} \cdot \theta^*$$

8. The following formulas are now applied:

$$Lower = \frac{1}{2\hat{\beta}} z_{0.95,2\hat{\alpha}}$$

$$Upper = \frac{1}{2\hat{\beta}} z_{0.05,2\hat{\alpha}}$$

where $z_{0.95,\nu}$ and $z_{0.05,\nu}$ denote the *upper* 95% and 5% percentiles, respectively, of the χ^2-distribution with ν degrees of freedom, see Table 4, page 31. In situations where ν is not an integer, an interpolation in the χ^2-distribution is performed.

Note 1
More detailed analysis of the OREDA data (see Vatn 1993) has indicated that there may be a large variation between installations. The multi-sample OREDA estimator should therefore as a rule be used instead of the n/τ estimator which is based on a homogeneous sample. The variation between the samples (installations) is measured by the standard deviation SD.

Note 2
In the OREDA-84 and OREDA-92 handbooks, a slightly different approach was taken. The mean value was estimated with the same procedure as in this handbook, but the *lower* and *upper* values were given a slightly different interpretation.

Note 3
In the case of $k = 1$, the procedure cannot be used. In this case the n/τ estimate is given for the mean, and the *lower* and *upper* values should be interpreted as a traditional 90% confidence interval.

Note 4
If no failures are observed for an item, the following approach is used to obtain lower, mean and upper values for "All failure modes":

1. Let $\hat{\lambda}_P$ denote the failure rate estimate ("mean") one level up in the taxonomy hierarchy.

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2. Let τ denote the total time in service (operational or calendar) for the item of interest

3. Let

$$\alpha = 1/2$$

$$\beta = \frac{1}{2\hat{\lambda}_P} + \tau$$

4. An estimate for the failure rate is now

$$\hat{\lambda} = \frac{\alpha}{\beta}$$

5. The standard deviation is given by

$$SD = \sqrt{\frac{\alpha}{\beta^2}}$$

6. A 90% uncertainty interval is given by

$$\left(\frac{1}{2\beta} z_{0.95,2\alpha}, \frac{1}{2\beta} z_{0.05,2\alpha)} \right) = \left(\frac{0.002}{\beta}, \frac{1.9}{\beta} \right)$$

ESTIMATION OF DEMAND PROBABILITIES

If information about "number of demands" is given (see Section "Data table, Reliability Data", page 32) it is possible to estimate the demand probability. The demand probability is always related to one specific failure mode, for example a critical fail to start. The demand failure probability is estimated by:

$$\hat{p} = \frac{n}{d}$$

where n is the number of failures with the appropriate failure mode, and d is the number of demands. Note that in the data table presentations the demand probabilities may apparently look different. The reason for this is that in some cases there are registered "demand failures", but the number of demands is not recorded for one or more inventories. For these inventories, the demand failures are not added to the total number of demand failures for that data table.

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PERCENTAGE POINTS OF THE CHI-SQUARE DISTRIBUTION

Table 4 Percentage Points of the Chi-square (χ^2) Distribution

$Pr(Z > z_{\alpha,\nu}) = \alpha$

ν/α	0.995	0.990	0.975	0.950	0.05	0.025	0.010	0.005
1	0.00	0.00	0.00	0.00	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.10	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	7.81	9.35	11.34	12.84
4	0.21	0.30	0.48	0.71	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	11.07	12.38	15.09	16.75
6	0.68	0.87	1.24	1.64	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	15.51	17.53	20.09	21.96
9	1.73	2.09	2.70	3.33	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	23.68	26.12	29.14	31.32
15	4.60	5.23	6.27	7.26	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	31.41	34.17	37.57	40.00
25	10.52	11.52	13.12	14.61	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	43.77	46.98	50.89	53.67
40	20.71	22.16	24.43	26.51	55.76	59.34	63.69	66.77
50	27.99	29.71	32.36	34.76	67.50	71.42	76.15	79.49
60	35.53	37.48	40.48	43.19	79.08	83.30	88.38	91.95
70	43.28	45.44	48.76	51.74	90.53	95.02	100.42	104.22
80	51.17	53.54	57.15	60.39	101.88	106.63	112.33	116.32
90	59.20	61.75	65.65	69.13	113.14	118.14	124.12	128.30
100	67.33	70.06	74.22	77.93	124.34	129.56	135.81	140.17

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TOPSIDE DATA TABLE FORMATS

DATA TABLE, RELIABILITY DATA

Each data table contains an identification of the item and the estimated reliability parameters. The figures provided should be interpreted on the basis of the assumptions specified in the boundary definition for each equipment category and the estimation method applied. The format of the data table is shown in Figure 8.

Taxonomy no		Item									
Population	Installations	Aggregated time in service (10^6 hours)						No of demands			
		Calendar time *			Operational time †						
Failure mode		No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Comments											

Figure 8 Format of the Reliability Data Tables

The various entries of the data table are explained in the following:

Taxonomy number and Item

The taxonomy number is a numerical identification of the item. The description of the item is given in a hierarchical structure. Only data from items of this generic category of components/equipment are input to the estimates presented in the quantitative part of the data table.

Population

Total number of items forming the basis for the estimates.

Installations

Total number of installations (platforms) covered by the data surveillance for the item in question.

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Aggregated time in service
Two types of time scales are presented as the basis for the failure rate estimates; calendar time and operational time. The aggregated time in service for the total population is given for both time scales. Note that while the calendar time is given with high certainty, the operational time has in many cases to be based on estimates (by the data collector).

Number of demands
The accumulated number of demands/cycles for the total population is given when available. In several cases these numbers are based on estimates and not accurate measurements.

Failure mode
This column contains a brief description of the manner in which the failure occurred, when such information is available.

Number of failures
The total number of failure events is presented for each failure mode. The accumulated number of failures is presented as "All modes".

Failure rate
The failure rate columns present estimates of the failure rate for each failure mode. Results are given both under the "multi-sample" assumption, and under the assumption of homogeneous data sets. In the multi-sample situation the failure rate is assumed to vary between installations (platforms), and each platform represents one sample. The following entries are included:

Mean	An estimate of the "average" failure rate with respect to the specified failure mode, obtained by using the OREDA estimator.
(Lower, Upper)	A 90% uncertainty interval for the failure rate.
SD	A standard deviation indicating the variation between the multiple samples.
n/τ	The total number of failures divided by the total time in service, i.e., the estimate of the failure rate we would use for a homogeneous sample.

All the entries are measured per 10^6 hours and refer either to calendar time (marked *) or operational time (marked †).

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Active repair time (hours)
This column contains the average calendar time (hours) required to repair and return the item to a state where it is ready to resume its functions. Active repair time is the time when actual repair work is being done. It does not include time to shut down the unit, issue work order, wait for spare parts, start-up after repair etc. The active repair time is therefore normally shorter than the *downtime* where some of the activities indicated above may be included.

Note:
During the data collection exercises it has been very difficult to obtain data regarding active repair times. In the OREDA database there is a good coverage of "restoration man-hours" data, whereas the data for "active repair time" is rather sparse. It should also be noted that active repair hours are highly influenced by how maintenance is organised on the platform. The figures for active repair times should therefore only be used as an indication of what the actual active repair times would be. It is highly recommended to use some kind of expert judgement in addition to the values given in the handbook.

Repair (manhours)
The repair columns present three values of the repair time (man-hours). The *mean* value is the average number of man-hours recorded to repair the failure and restore the function. The *min* and *max* values are the lowest and highest number of man-hours recorded for the repair of the item.

Comments
When available the on on-demand failure probability is given in the Comment field.

DATA TABLE, MAINTAINABLE ITEM VERSUS FAILURE MODE

The reliability data presented in the data table in Figure 8 (page 32) does not give information on which part of the equipment has failed. In the *Maintainable Item versus Failure Mode* listing the relative contribution from each maintainable item to the total failure rate may be obtained. The figures in the table represent *percentages of occurrence* for each combination of failure mode and maintainable item. The row sum represents the total percentage of failures that are related to the actual maintainable item. Note that several maintainable items might be assigned to each failure record. In such situations, the "score" for the actual maintainable item/failure mode combination is set to $1/n$, where n is the number of maintainable items listed for that failure record. The column sum represents the contribution for each failure mode in percentages.

This information is valuable input to an FMEA/FMECA analysis. The FMEA/FMECA analysis is further a major part of a reliability centred maintenance (RCM) analysis. As the RCM methodology focuses on failure causes, it is also important to have information regarding failure causes as discussed in the next section. Note that several maintainable items might be assigned to each failure record.

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DATA TABLE, FAILURE DESCRIPTOR VERSUS FAILURE MODE

In the *Failure Descriptor versus Failure Mode* listing the relative contribution from each failure descriptor (cause) to the to the total failure rate may be obtained. The figures in the table represent percentages of occurrence for each combination of failure descriptor and failure mode. The row sum represents the total percentage of failures that are related to the actual failure descriptor. The column sum represents the contribution for each failure mode in percentages.

As mentioned above, the information about failure causes is essential in an RCM analysis. For example scheduled replacement of units is only applicable if one or more failure causes may be related to ageing, wear, corrosion etc.

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SUBSEA DATA TABLE FORMATS

DATA TABLE, RELIABILITY DATA

Each data table contains an identification of the item and the estimated reliability parameters. The figures provided should be interpreted on the basis of the assumptions specified in the boundary definition for each equipment category and the estimation method applied. The format of the data table is shown in Figure 8.

Taxonomy no		Item											
Population	Installations						Aggregated time in service (10^6 hours)						
		Failure data					Calendar time						
Component	No of units		Severity class				Failure rate (per 10^6 hours)						Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ		Mean
Subunit no. 1 Component no. 1 Component no..2 **Subunit no. 2** Component no.... **Equipment level**													
Comments For components with no failures, n is set to 0.5 based on a non-informative prior. * Mean failure for the common component is used in the estimator.													

Figure 9 Format of the Reliability Data Tables

The various entries of the data table are explained in the following:

Taxonomy number and Item

The taxonomy number is a numerical identification of the item. The description of the item is given in a hierarchical structure. Only data from items of this generic category of components/equipment are input to the estimates presented in the quantitative part of the data table.

Population

Total number of items forming the basis for the estimates.

Installations

Total number of installations (platforms) covered by the data surveillance for the item in question.

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Aggregated time in service
The aggregated time in service for the total population is given for calendar time scale for the equipment unit level. A subunit and its related component(s) may have different calendar time recorded as the latter is recorded individually for each subunit and component in the database.

Component
This column contains the list of subunits and component for which the failure data is presented. The subunits are in bold letters. The equipment unit level data are presented in the last row. The number of items on each level is listed in the table.

Number of failures
The total number of failure events (#) is presented for each subunit and component. The criticality distribution is given for each item i.e. critical (C), degraded (D), incipient (I) and unknown (U).

Failure rate
The failure rate columns present estimates of the failure rate for each subunit and component. Results are given both under the "multi-sample" assumption, and under the assumption of homogeneous data sets. In the multi-sample situation the failure rate is assumed to vary between installations (platforms), and each platform represents one sample. The following entries are included:

Mean	An estimate of the "average" failure rate with respect to the specified failure mode, obtained by using the OREDA estimator.
(Lower, Upper)	A 90% uncertainty interval for the failure rate.
SD	A standard deviation indicating the variation between the multiple samples.
n/τ	The total number of failures divided by the total time in service, i.e., the estimate of the failure rate we would use for a homogeneous sample.

All the entries are measured per 10^6 hours and refer to calendar time.

Active repair time (hours)
This column contains the elapsed calendar time (hours) required to repair and return the item to a state where it is ready to resume its functions. This is the part of the total repair time used on-site. The *mean* value is the average number of hours recorded to repair the failure and restore the function. Active reapir time should not be mixed with *downtime* which my additionally include time periods such as shutdown, repair vessel mobilisation, start-up after repair etc.

Comments
The comment field presents comments to the calculation of failure rates.

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For components with no failures, n is set to 0.5 based on a non-informative prior.
* Mean failure for the common component is used in the estimator.

DATA TABLE, COMPONENT VERSUS FAILURE MODE

The reliability data presented in the data table in Figure 8 (page 32) give information on which part of the equipment has failed. The *Component versus Failure Mode* lists the number failure modes for each component. The figures in the table represent number of occurrence for each combination of failure mode and component. The row sum represents the total number of failures that are related to the actual component. The column sum represents the total number of each failure mode.

This information is valuable input to an FMEA/FMECA analysis (see e.g. IEC 812). The FMEA/FMECA analysis is further a major part of a reliability centred maintenance (RCM) analysis (see e.g. Rausand and Vatn 1997). As the RCM methodology focuses on failure causes, it is also important to have information regarding failure causes as discussed in the next section.

DATA TABLE, SUBUNIT VERSUS FAILURE MODE

The *Subunit versus Failure Mode* lists the number of failure modes for each subunit. The figures in the table represent number of occurrence for each combination of failure mode and subunit. The row sum represents the number of failures that are related to the actual subunit. The column sum represents the number of each failure mode.

DATA TABLE, EQUIPMENT UNIT VERSUS FAILURE MODE

The *Equipment unit versus Failure Mode* table lists the number of failure modes at the equipment unit level.

DATA TABLE, FAILURE DESCRIPTOR VERSUS FAILURE MODE

In the *Failure Descriptor versus Failure Mode* listing the relative contribution from each failure descriptor (cause) to the to the total failure rate may be obtained. The figures in the table represent percentages of occurrence for each combination of failure descriptor and failure mode. The descriptor is presented for each component. The row sum represents the total percentage of failures that are related to the actual failure descriptor for each component. The column sum represents the contribution for each failure mode in percentages.

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MISCELLANEOUS ESTIMATION PROCEDURES

NO FAILURES ARE OBSERVED FOR A SPECIFIC FAILURE MODE

In the data tables failure rate estimates are only presented for those failure modes for which failures have been recorded. The standard failure rate estimate in this situation is $\hat{\lambda} = 0$. An alternative procedure for estimating the failure rate in this situation is given under Note 4 on page 29. To use the procedure, the term *"All failure modes"* should be replaced with the failure mode of interest. Further information may be obtained from the Internet address:

http://www.sintef.no/oreda/analysis/

WEIGHTING OREDA-2002 DATA WITH OTHER DATA SOURCES

In many RAMS analyses, data may also be available from other sources than this handbook. For offshore RAMS analyses, the most obvious data source in addition to this book, is the previous handbooks. A method for weighting data from OREDA-97 and OREDA-2002 is given below. The method is based on an approach suggested in the OREDA Data Analysis Guidelines (Vatn 1993).

The calculations are repeated for all failure modes of interest. Let λ_{III} denote the mean failure rate for Phase IV and V data (column 4) in the OREDA-2002 handbook. Further, let SD_{III} denote the standard deviation in column 6. λ_{II} is the corresponding mean in the OREDA-97 handbook. A weighted failure rate estimate is given by:

$$\hat{\lambda} = \frac{\lambda_{II}^2 + \lambda_{III}^2 \left(\lambda_{II} / \lambda_{III} + |\lambda_{II} - \lambda_{III}| / SD_{III} \right)^2}{\lambda_{II} + \lambda_{III} \left(\lambda_{II} / \lambda_{III} + |\lambda_{II} - \lambda_{III}| / SD_{III} \right)^2}$$

where $|x|$ denotes the absolute value of x.

If in addition, standard deviation and uncertainty limits are required, please consult the Internet address:

http://www.sintef.no/oreda/analysis/

where also a rationale for the above procedure is given.

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DEFINITIONS[3]

The main terminology used in the OREDA-97 handbook is defined in this section. The specific definitions of the terminology and parameters used in the statistical estimation procedures are included in the section "Estimation Procedures".

Terms marked with **(C)** are categorised in pre-defined codes.

Active Repair Time
Active repair time is the total (calendar) time required to repair and return the item to a state where it is ready to resume its functions.

This excludes the time to detect the failure, time to isolate the equipment from the process before repair, delay and waiting for spare parts or tools, and any time after the repair has been completed if the item is not put into service immediately. Time for testing is included when such testing is an integrated part of the repair activity.

Boundary
The interface between an item and its surroundings.

Calendar Time
The interval of time between the start and end of data surveillance for a particular item.

Component (C) – Subsea
These are subsets of each subunit (subsea inventory) and will typically consist of the lowest level items that are repaired/replaced as a whole (e.g. valve, sensor etc.).

Equipment unit
The highest indenture level including subunits and smaller entities belonging to that equipment unit. Equipment unit corresponds in most cases to tag number for topside equipment.

Failure
The termination or the degradation of the ability of an item to perform its required function(s). It includes:

- Complete failure of the item
- Failure of part of the item that causes unavailability of the item for corrective action
- Failure discovered during inspection, testing, or preventive maintenance that requires repair
- Failure on safety devices or control/monitoring devices that necessitates shutdown, or reduction of the items capability below specified limits.

The following outages are not considered as failures:

- Unavailability due to preventive or planned maintenance

[3] Useful definitions related to this Handbook will also be found in the standards ISO 14224 and NORSOK Z016.

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- Shutdown of the item due to external conditions, or where no physical failure condition of the item is revealed. A shutdown is not to be considered a failure unless there is *some recorded maintenance activity.*

A required function is defined as any function necessary to maintain the item's capability of providing its output at specified capacity and quality. Note that a failure could be either complete loss of function or function degradation below an acceptable limit.

A failure will normally require a work order and involvement by maintenance personnel.

Failure Descriptor (C)
An attribute of the failure event that can be easily deduced technically. The failure descriptor is the *apparent, immediate cause* of the failure and is related to *subunit level.*

Failure Mode (C)
The effect by which a failure is observed on the failed unit. The failure modes describe the loss of required system function(s) that result from failures, or an undesired change in state or condition. The failure mode is related to the equipment unit level. The failure mode is a description of the various abnormal states/conditions of an equipment unit, and the posssible transition from correct to incorrect state.

The failure mode can be subdivided in two major classes:

1. Demanded change of state is not achieved

2. Undesired change in conditions (state)

The first class typically comprises events like fail-to-start/stop and fail-to-open/close, i.e. directly related to a failure of the *function* of the unit. The latter category can either be related to *function* and *condition* as follows:

a) Undesired change in *manner of operation* (e.g. spurious stop, high output)

b) Undesired *change of condition* (e.g. vibration, leakage). This category does not affect the function immediately, but may do so if not attended to within a reasonable time.

(See e.g., Rausand and Øien (1996) for a thorough discussion of failures and failure modes).

Item
A common term used to denote any level of hardware assembly; i.e. equipment unit, subunit, maintainable items and parts.

Maintainable Item (C)
An item that constitutes an assembly of parts that are normally the lowest indenture level during maintenance.

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Number of Demands
The total number of times an item is required to perform its specified function(s) during the calendar time.

Operational Time
The period of time during which a particular item performs its required function(s), between the start and end of data surveillance.

Population
The total number of items of one particular type in service during the period of the event data surveillance.

Sample
The group of items of one particular type in service - described by its taxonomy code - on one installation during the period of the event data surveillance.

Severity Class Types (C)
CRITICAL FAILURE: A failure which causes immediate and complete loss of a system's capability of providing its output.

DEGRADED FAILURE: A failure which is not critical, but which prevents the system from providing its output within specifications. Such a failure would usually, but not necessarily, be gradual or partial, and may develop into a critical failure in time.

INCIPIENT FAILURE: A failure which does not immediately cause loss of a system's capability of providing its output, but which, if not attended to, could result in a critical or degraded failure in the near future.

UNKNOWN: Failure severity was not recorded or could not be deduced.

The severity class is used to describe effect on operational status and the severity of loss of output from the system. Each failure has been associated with only one severity class, either critical, degraded or incipient, *independently of the failure mode and failure cause.* The severity classification is confined to the location and use of the *equipment unit* that has failed.

Subunit (C) - Topside
An assembly of items that provides a specific function that is required for the equipment unit to achieve its intended performance. Corresponds frequently with sub-tag number(s).

Subunit (C) - Subsea
A subsea equipment unit is subdivided in several subunits, each with function(s) required for the *equipment unit* to perform its main function. Typical subunits are e.g. umbilical, HPU etc. The subunits may be redundant, e.g. two independent HPUs.

Taxonomy (C)
A systematic classification of items into generic groups based on factors possibly common to several of the items, e.g. functional type, medium handled.

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PART II

Reliability Data Presentation

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RELIABILITY DATA PRESENTATION

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PREFACE

Part II of the Handbook present numeric failure and maintenance data for the various equipment classes as described in Part I. Part II is organised as follows:

The equipment classes are categorised in 5 major categories, as shown in the following table:

System	Equipment class
Machinery	- Compressors - Gas Turbines - Pumps - Combustion engines - Turboexpanders
Electric equipment	- Electric generators - Electric motors
Mechanical equipment	- Heat exchangers - Vessels - Heaters and boilers
Control and safety equipment	- Fire &Gas detectors - Process sensors - Valves
Subsea equipment	- Common components - Control systems - Manifold - Flowline - Subsea Isolation System - Risers - Running tool - Wellhead & X-mas tree

1. For each equipment class (e.g. compressors) there is an Inventory description at the start of the respective chapter that contains:

- Descriptive part
- Boundary diagram
- Subdivision in 'Subunits' and 'Maintainable Items'
- List of failure modes

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2. Then the data tables described in Part I with failure and maintenance data are given for the whole equipment class population (i.e. all compressors). Similarly the cross-tabulation of failure modes and failure descriptors/maintainable items is also given for the whole equipment class.

3. Next, the equipment class is split in more narrow taxonomy classes (e.g. centrifugal compressors) and the same tables as indicated above are presented for each of those taxonomy classes. Note that the split into various taxonomy classes may between equipment classes. The guiding rule has been to retain a population of similar design, size, performance and any other characteristics that has been deemed appropriate and at the same time keeping the size of the book within a manageable level.

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MACHINERY

Compressors

Inventory description

The compressor *driver* along with auxiliary systems such as lubrication, cooling and start systems for driver are not included within the compressor boundary as shown in Figure 10. Driver units are recorded as separate OREDA inventories (Electric Motor, Gas Turbine or Combustion Engine) and the failures on the driver, if recorded, are recorded separatelyfor each of thos driver categories.

A *compressor train* is considered as *one inventory* in OREDA. (Each compressor train may consist of up to four compressor stages either as separate units (casings) or integrated in one compressor unit).

For compressors with a common lub.oil- and seal oil system, failures are as a general rule assigned to the subunit that is assumed to be the one most affected. Otherwise the failures are assigned to the lub.oil system. Inlet and outlet valves are not within the boundary. The boundary definition is shown in Figure 10, and the subdivision in Subunits and Maintainable Items are shown in Table 5.

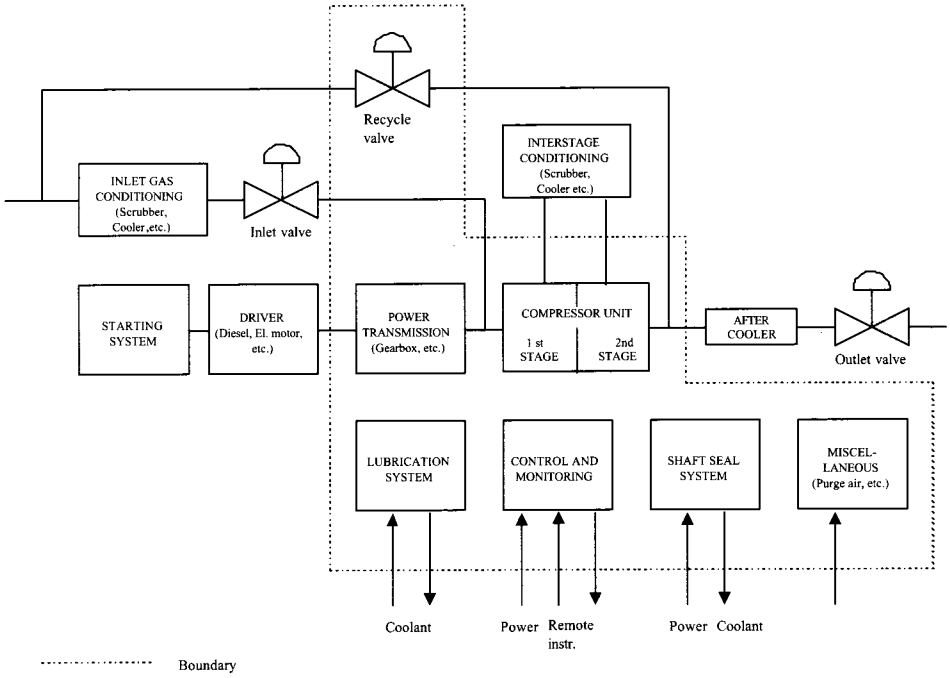

Figure 10 Compressors, Boundary Definition

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Table 5 Compressors, Subdivision in Maintainable Items

COMPRESSOR					
Power trans-mission	Compressor unit	Control and Monitoring	Lubrication system	Shaft seal system	Miscellaneous
• Gearbox • Bearing • Seals • Lubrication • Couplings • Instruments	• Antisurge system • Casing • Cylinder liner • Instruments • Shaft seals • Radial bearing • Thrust bearing • Interstage seals • Valves & • piping • Piston[4] • Packing • Rotor w/impellers	• Instruments • Cabling, junction box etc. • Control unit • Actuating device • Monitoring • Internal power supply • Valves	• Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Instruments • Seals	• Buffer gas system • Dry gas seal • Instruments • Overhead tank • Reservoir • Scrubber • Pump w/motor/gear • Filter • Valves • Seal gas • Seal oil	• Base frame • Cooler • Valves • Magnetic bearing control system • Piping • Purge air • Silencers

(For all subunits the MIs "Unknown" and "Subunit" are included.)

[4] Reciprocating compressor only

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List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELP	External leakage - Process medium
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

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Taxonomy no		Item									
1.1		Machinery Compressors									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
131	38	**Calendar time** * 3.8235			**Operational time** † 2.4253			82472			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**595***	**0.00**	**166.07**	**839.82**	**361.26**	**155.62**	**17.8**	**0.5**	**29.3**	**1818.0**
		595†	**0.08**	**268.58**	**1176.02**	**459.51**	**245.33**				
Abnormal instrument reading		3*	0.00	1.11	4.88	1.91	0.78	7.0	16.0	16.5	17.0
		3†	0.00	6.03	29.41	12.28	1.24				
Breakdown		5*	0.01	1.28	4.17	1.51	1.31	61.5	25.5	367.0	1481.0
		5†	0.00	6.20	34.23	17.26	2.06				
Erratic output		12*	0.00	6.00	29.41	12.36	3.14	32.2	3.0	56.8	580.0
		12†	0.00	9.41	43.25	17.34	4.95				
External leakage - Process medium		44*	0.00	10.26	50.98	46.43	11.51	8.3	0.5	12.0	197.0
		44†	0.00	12.45	51.89	58.15	18.14				
External leakage - Utility medium		31*	0.00	11.80	58.78	25.04	8.11	12.6	1.0	23.6	123.5
		31†	0.01	24.22	105.90	41.33	12.78				
Fail to start on demand		72*	0.21	22.45	74.13	27.10	18.83	26.3	1.0	37.3	704.0
		72†	0.59	40.25	127.61	45.88	29.69				
Fail to stop on demand		3*	0.00	1.44	7.87	3.69	0.78	3.5	3.5	10.8	18.0
		3†	0.00	2.80	15.40	7.43	1.24				
High output		1*	0.00	0.27	1.52	0.90	0.26	7.0	14.0	14.0	14.0
		1†	0.00	0.45	2.42	1.56	0.41				
Internal leakage		5*	0.00	1.38	7.61	3.74	1.31	113.4	2.0	171.4	304.0
		5†	0.00	2.68	14.47	9.25	2.06				
Low output		153*	0.00	39.10	202.86	148.47	40.02	15.0	0.5	22.3	964.0
		153†	0.00	44.11	230.34	187.13	63.08				
Noise		3*	0.00	0.99	5.68	3.07	0.78	51.0	4.0	37.7	76.0
		3†	0.00	1.86	9.91	6.54	1.24				
Other		4*	0.00	1.71	8.62	3.69	1.05	7.0	1.0	22.3	59.0
		4†	0.00	3.07	16.14	7.30	1.65				
Overheating		69*	0.00	17.03	88.21	65.54	18.05	7.9	0.5	15.2	447.0
		69†	0.00	20.16	104.43	81.99	28.45				
Parameter deviation		50*	0.00	12.26	63.60	50.49	13.08	15.5	0.5	20.5	250.0
		50†	0.00	14.91	77.84	63.18	20.62				
Spurious stop		124*	0.02	37.34	158.37	60.97	32.43	23.7	1.0	32.0	1818.0
		124†	0.27	60.30	224.30	82.81	51.13				
Structural deficiency		6*	0.00	2.29	12.24	5.64	1.57	13.4	2.0	19.6	43.0
		6†	0.00	3.02	14.75	6.17	2.47				
Vibration		10*	0.00	3.14	13.47	5.21	2.62	5.5	1.0	29.7	100.0
		10†	0.10	4.54	14.03	4.95	4.12				
Degraded		**544***	**0.20**	**177.75**	**733.92**	**278.74**	**142.28**	**10.4**	**0.3**	**15.9**	**410.0**
		544†	**0.95**	**267.11**	**1031.46**	**380.84**	**224.30**				
Abnormal instrument reading		15*	0.00	4.37	18.89	7.33	3.92	5.0	2.0	15.4	29.0
		15†	0.00	7.42	32.03	12.42	6.18				
Erratic output		18*	0.01	9.82	40.18	15.21	4.71	17.2	2.0	20.7	96.0
		18†	0.05	16.69	64.82	24.00	7.42				

Comments

(cont.)

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Taxonomy no	Item
1.1	Machinery Compressors

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
131	38	3.8235	2.4253	82472

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	49*	0.00	14.41	69.84	28.92	12.82	2.5	0.5	8.7	98.0
	49†	0.01	20.89	92.26	36.25	20.20				
External leakage - Utility medium	95*	0.00	33.69	164.70	68.96	24.85	13.5	0.3	20.6	218.0
	95†	0.00	46.25	222.39	91.67	39.17				
Fail to start on demand	1*	0.00	0.32	1.65	1.35	0.26	1.0	1.0	1.0	1.0
	1†	0.00	0.44	2.45	1.43	0.41				
Fail to stop on demand	5*	0.44	1.35	2.67	0.70	1.31	3.3	0.5	4.5	7.0
	5†	0.00	2.19	11.90	5.55	2.06				
High output	4*	0.00	0.99	4.12	1.57	1.05	4.7	3.0	4.4	7.0
	4†	0.01	1.49	4.93	1.80	1.65				
Internal leakage	13*	0.00	3.48	15.81	6.29	3.40	44.5	1.0	55.4	216.0
	13†	0.00	5.52	25.75	10.45	5.36				
Low output	109*	0.00	31.61	173.39	81.21	28.51	10.6	0.5	11.9	128.0
	109†	0.00	64.65	344.53	158.14	44.94				
Minor in-service problems	2*	0.00	0.48	1.81	0.67	0.52	2.0	2.0	2.0	2.0
	2†	0.03	0.76	2.27	0.77	0.82				
Noise	4*	0.00	0.92	3.58	1.33	1.05	17.4	5.0	26.0	64.0
	4†	0.01	1.49	5.20	1.92	1.65				
Other	68*	0.05	23.23	93.09	34.90	17.78	23.3	1.0	27.7	410.0
	68†	0.11	35.69	138.95	51.50	28.04				
Overheating	28*	0.00	8.34	43.22	19.06	7.32	8.3	1.0	12.0	48.0
	28†	0.00	11.36	54.56	22.48	11.54				
Parameter deviation	107*	0.00	41.05	233.42	124.90	27.99	3.9	0.3	6.7	101.0
	107†	0.00	48.02	265.16	159.89	44.12				
Structural deficiency	7*	0.00	2.71	14.91	7.02	1.83	4.4	0.5	7.4	17.0
	7†	0.00	3.56	18.44	8.09	2.89				
Unknown	6*	0.00	3.00	16.47	7.71	1.57	33.0	4.0	33.5	64.0
	6†	0.00	7.70	40.20	17.99	2.47				
Vibration	13*	0.26	4.06	11.84	3.92	3.40	9.9	1.0	22.3	96.0
	13†	0.09	6.49	20.70	7.46	5.36				
Incipient	**1064***	**0.20**	**292.46**	**1237.63**	**476.01**	**278.28**	**7.4**	**0.3**	**12.0**	**961.0**
	1064†	**9.20**	**725.38**	**2326.94**	**841.71**	**438.70**				
Abnormal instrument reading	374*	0.02	106.24	471.62	185.84	97.82	4.8	0.3	7.1	176.0
	374†	0.11	148.98	626.54	240.20	154.21				
Erratic output	7*	0.00	2.56	12.69	5.38	1.83	20.4	1.0	30.7	137.0
	7†	0.00	4.16	20.64	8.76	2.89				
External leakage - Process medium	23*	0.00	8.11	40.04	16.93	6.02	11.4	1.0	12.9	115.0
	23†	0.00	11.71	53.28	21.23	9.48				
External leakage - Utility medium	113*	0.19	30.35	106.30	39.24	29.55	12.3	0.3	21.9	370.0
	113†	0.89	128.20	440.61	162.36	46.59				
Fail to start on demand	1*	0.00	0.34	1.87	0.88	0.26	4.0	4.0	4.0	4.0
	1†	0.00	3.12	17.19	8.66	0.41				

Comments

(cont.)

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Taxonomy no		Item
1.1		Machinery Compressors

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
131	38	3.8235	2.4253	82472

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Internal leakage	48*	0.00	16.23	36.94	87.10	12.55	1.9	1.0	3.0	15.5
	48†	0.01	226.49	1050.49	424.42	19.79				
Low output	1*	0.00	0.25	1.35	0.62	0.26	-	2.0	2.0	2.0
	1†	0.00	0.40	2.23	1.07	0.41				
Minor in-service problems	326*	0.00	86.43	483.73	253.23	85.26	2.3	0.3	4.0	78.0
	326†	0.00	115.11	635.07	319.64	134.41				
Noise	8*	0.00	1.89	7.70	2.91	2.09	13.7	4.0	12.9	33.0
	8†	0.04	3.07	9.83	3.55	3.30				
Other	64*	0.01	19.15	82.97	32.21	16.74	57.1	1.0	63.2	961.0
	64†	0.05	35.52	144.98	54.83	26.39				
Overheating	10*	0.00	3.50	15.32	5.98	2.62	12.2	2.0	22.4	98.0
	10†	0.00	6.52	30.85	12.62	4.12				
Parameter deviation	38*	0.00	11.22	52.54	21.37	9.94	5.8	1.0	10.3	92.0
	38†	0.01	16.21	69.26	26.76	15.67				
Structural deficiency	13*	0.01	4.13	16.78	6.33	3.40	6.6	0.5	15.8	64.0
	13†	0.06	6.08	20.16	7.38	5.36				
Unknown	19*	0.00	6.66	28.47	30.96	4.97	14.5	2.0	13.3	32.0
	19†	0.00	20.44	108.37	72.52	7.83				
Vibration	19*	0.04	5.25	17.66	6.48	4.97	2.2	1.0	11.4	119.0
	19†	0.04	7.83	27.88	10.30	7.83				
Unknown	**63***	**0.03**	**26.37**	**109.84**	**41.87**	**16.48**	**15.6**	**0.8**	**23.5**	**249.0**
	63†	**0.04**	**43.36**	**180.25**	**68.62**	**25.98**				
Abnormal instrument reading	21*	0.00	7.98	44.10	22.32	5.49	3.0	1.0	8.1	16.0
	21†	0.00	14.80	81.34	39.27	8.66				
External leakage - Utility medium	5*	0.00	1.53	8.77	4.73	1.31	7.0	7.0	85.5	164.0
	5†	0.00	2.91	16.61	8.92	2.06				
Low output	1*	0.00	0.74	3.83	2.81	0.26	-	12.0	12.0	12.0
	1†	0.00	0.88	4.67	3.15	0.41				
Noise	1*	0.00	0.37	2.08	1.10	0.26	14.0	-	-	-
	1†	0.00	0.71	3.94	2.39	0.41				
Other	15*	0.00	7.53	33.06	12.94	3.92	16.0	2.0	21.0	105.0
	15†	0.01	12.79	54.67	21.12	6.18				
Overheating	1*	0.00	0.25	1.35	0.62	0.26	-	3.0	3.0	3.0
	1†	0.00	0.40	2.23	1.07	0.41				
Unknown	18*	0.00	6.75	31.73	12.93	4.71	19.9	0.8	34.5	249.0
	18†	0.00	9.18	39.92	15.52	7.42				
Vibration	1*	0.00	0.60	3.09	2.29	0.26	-	9.0	9.0	9.0
	1†	0.00	0.92	4.87	3.30	0.41				
All modes	**2266***	**0.39**	**656.86**	**2795.97**	**1078.30**	**592.66**	**11.3**	**0.3**	**17.9**	**1818.0**
	2266†	**16.32**	**1300.52**	**4175.73**	**1511.11**	**934.30**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 6.5 10^{-4}

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Maintainable item versus failure mode, to be continued
Item: Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Antisurge system	0.22	0.00	0.04	0.13	0.35	0.18	0.04	0.18	0.00	0.00
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	0.18	0.00	0.04	0.00	0.00	0.00	0.00
Buffer gas system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.22	0.00	0.00	0.04	0.00	0.09	0.00	0.00	0.00	0.00
Casing	0.00	0.02	0.04	0.18	0.00	0.00	0.00	0.00	0.00	0.00
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.84	0.00	0.00	0.04	0.22	0.53	0.00	0.00	0.00	0.00
Control-, isolating & check valves	0.04	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.11	0.18	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.13	0.00	1.94	0.62	0.00	0.04	0.00	0.04	5.78	0.00
Dry gas seal	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.04	0.00	0.00
Filter(s)	0.02	0.00	0.04	0.18	0.00	0.00	0.09	0.04	0.31	0.00
Gearbox/var.drive	0.09	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.09
Instrument, flow	0.57	0.00	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Instrument, general	0.84	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00
Instrument, level	2.07	0.00	0.00	0.22	0.00	0.04	0.00	0.04	0.00	0.00
Instrument, pressure	4.07	0.00	0.00	0.31	0.09	0.31	0.04	0.00	0.04	0.00
Instrument, speed	0.26	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
Instrument, temperature	4.65	0.00	0.04	0.11	0.09	0.13	0.00	0.00	0.04	0.00
Instrument, vibration	1.08	0.00	0.00	0.11	0.04	0.00	0.00	0.00	0.00	0.00
Internal piping	0.02	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.22	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.09	0.11	0.00	0.00	0.00	0.04	0.04	0.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Lube oil	0.07	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09	0.00
Lubrication	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.26	0.00	0.00	0.00	1.24	0.00	0.00
Oil tank w/heating system	0.02	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.18	0.00	0.31	0.44	0.04	0.00	0.00	0.00	0.22	0.04
Overhead tank	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.22	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.04	0.90	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.18	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.02	0.09	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.18	0.49	0.00	0.13	0.00	0.00	1.32	0.00
Pump w/motor/gear	0.00	0.00	0.00	0.40	0.00	0.09	0.00	0.00	0.13	0.18
Purge air	0.00	0.00	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04
Seal gas	0.00	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Seal oil	0.04	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.04	0.00
Seals	0.00	0.00	0.09	0.35	0.00	0.00	0.00	0.00	0.04	0.00
Shaft seals	0.00	0.00	0.09	0.53	0.00	0.09	0.04	0.22	0.01	0.00
Silencers	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Subunit	0.18	0.04	0.09	0.44	0.09	0.31	0.00	0.04	0.68	0.13
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.66	0.09	0.13	1.24	0.00	0.57	0.00	0.88	0.62	0.09
Valves	0.66	0.00	1.24	1.21	0.44	0.26	0.00	0.13	2.21	0.09
Total	18.23	0.22	5.12	10.77	1.63	3.27	0.22	2.91	11.65	0.71

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.09	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.26
Antisurge system	0.00	0.42	0.11	0.18	0.13	0.00	0.00	0.04	0.00	2.03
Base frame	0.00	0.00	0.00	0.88	0.13	0.00	0.00	0.00	0.04	1.06
Bearing	0.00	0.04	0.00	0.04	0.04	0.00	0.00	0.04	0.00	0.40
Buffer gas system	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Cabling & junction boxes	0.00	0.09	0.04	0.09	0.04	0.00	0.04	0.04	0.00	0.71
Casing	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.38
Check valves	0.00	0.00	0.22	0.04	0.00	0.00	0.00	0.04	0.00	0.31
Control unit	0.00	0.31	0.40	0.09	0.04	0.18	0.04	0.53	0.13	3.35
Control-, isolating & check valves	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.22
Cooler(s)	0.09	0.04	0.04	0.04	0.00	0.00	0.00	0.06	0.04	0.61
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.38
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.33
Cylinder liner	3.40	0.04	0.57	0.31	0.22	0.00	0.26	0.13	0.18	13.68
Dry gas seal	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.22
Filter(s)	0.00	0.31	0.44	7.33	0.00	0.00	0.04	0.15	0.00	8.95
Gearbox/var.drive	0.04	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.55
Instrument, flow	0.00	0.09	0.44	0.04	0.00	0.00	0.00	0.00	0.00	1.27
Instrument, general	0.00	0.04	0.26	0.18	0.00	0.00	0.00	0.09	0.00	1.50
Instrument, level	0.00	0.24	0.44	0.22	0.00	0.00	0.04	0.29	0.00	3.62
Instrument, pressure	0.00	0.18	0.75	0.29	0.00	0.00	0.04	0.44	0.00	6.57
Instrument, speed	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.49
Instrument, temperature	0.09	0.22	0.71	0.29	0.00	0.00	0.00	0.57	0.09	7.03
Instrument, vibration	0.00	0.09	0.71	0.00	0.00	0.00	0.00	0.49	0.40	2.91
Internal piping	0.09	0.04	0.00	0.26	0.00	0.00	0.00	0.00	0.04	0.55
Internal power supply	0.00	0.18	0.04	0.00	0.00	0.00	0.00	0.18	0.00	0.75
Interstage seals	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.38

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Lube oil	0.00	0.13	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.46
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Monitoring	0.00	0.22	0.35	0.18	0.00	0.00	0.00	0.09	0.00	1.81
Oil	0.00	0.09	0.00	0.09	0.00	0.00	0.09	0.09	0.00	1.85
Oil tank w/heating system	0.00	0.22	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.38
Other	0.00	0.40	0.09	0.49	0.09	0.00	0.57	0.04	0.09	3.00
Overhead tank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Packing	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.37
Piping	0.00	0.00	0.00	0.20	0.09	0.00	0.00	0.10	0.00	1.34
Piping, pipe support + bellows	0.07	0.09	0.00	0.22	0.04	0.00	0.00	0.00	0.04	0.86
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.24
Pump w/motor	0.11	0.09	0.35	0.22	0.00	0.04	0.13	0.09	0.04	3.20
Pump w/motor/gear	0.00	0.44	0.00	0.09	0.00	0.04	0.00	0.04	0.09	1.50
Purge air	0.00	0.00	0.26	0.13	0.00	0.00	0.00	0.00	0.00	0.53
Radial bearing	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.10
Reservoir w/heating system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.13
Rotor w/ impellers	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.17
Seal gas	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Seal oil	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.57
Seals	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.57
Shaft seals	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.06	0.00	1.13
Silencers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Subunit	0.13	0.53	0.09	0.22	0.00	0.00	0.09	0.32	0.09	3.47
Thrust bearing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.09
Unknown	0.44	0.26	0.26	0.71	0.22	0.00	0.13	0.93	0.26	7.50
Valves	0.22	1.37	1.92	1.13	0.04	0.04	0.35	0.29	0.04	11.65
Total	4.77	6.66	8.61	14.47	1.15	0.35	1.90	5.47	1.90	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Compressors

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.13	0.00	0.00	0.09	0.04	0.00	0.00	0.00	0.31	0.00
Breakage	0.26	0.04	0.09	0.09	0.00	0.04	0.00	0.00	0.00	0.00
Burst	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.13	0.00	0.04	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.04
Contamination	0.09	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.40	0.00	0.00	0.09	0.18	0.49	0.00	0.04	0.04	0.00
Corrosion	0.09	0.00	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.00
Deformation	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04
Earth/isolation fault	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.04	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.40	0.00	0.00	0.00	0.18	0.18	0.00	0.00	0.00	0.00
Instrument failure - general	6.27	0.00	0.09	0.35	0.35	0.75	0.09	0.04	0.62	0.00
Leakage	0.04	0.00	1.06	4.15	0.00	0.04	0.00	0.09	0.00	0.00
Looseness	0.18	0.00	0.09	0.44	0.09	0.13	0.00	0.00	0.00	0.04
Material failure - general	0.13	0.00	0.13	0.49	0.00	0.00	0.09	0.00	0.00	0.04
Mechanical Failure - general	0.44	0.09	3.18	2.56	0.13	0.35	0.04	0.13	9.14	0.13
Misc. external influences	0.18	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.26	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
No cause found	0.26	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.04
No power/ voltage	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.71	0.00	0.00	0.04	0.00	0.13	0.00	0.00	0.00	0.00
Open circuit	0.40	0.00	0.04	0.04	0.00	0.09	0.00	0.00	0.00	0.00
Other	0.00	0.04	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Out of adjustment	3.27	0.00	0.00	0.00	0.26	0.22	0.00	0.04	0.09	0.00
Overheating	0.00	0.00	0.13	0.04	0.04	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.18	0.04	0.00	0.00	0.04	0.09	0.00	0.13	0.00	0.00
Unknown	0.53	0.00	0.04	0.13	0.00	0.26	0.00	0.00	0.71	0.09
Vibration	0.31	0.00	0.04	0.18	0.00	0.00	0.00	0.00	0.04	0.13
Wear	0.18	0.00	0.09	1.50	0.26	0.00	0.00	2.38	0.40	0.13
Total	18.23	0.22	5.12	10.77	1.63	3.27	0.22	2.91	11.65	0.71

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Compressors

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.04	0.09	0.31	0.22	0.00	0.00	0.09	0.22	0.00	1.54
Breakage	0.00	0.22	0.04	0.35	0.04	0.00	0.09	0.00	0.04	1.32
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cavitation	0.00	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.18
Clearance/ alignment failure	0.00	0.09	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.66
Combined causes	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.22
Contamination	0.04	0.22	0.09	0.66	0.00	0.00	0.09	0.00	0.00	1.24
Control failure	0.13	0.35	0.40	0.09	0.04	0.00	0.00	0.44	0.00	2.69
Corrosion	0.00	0.13	0.04	0.35	0.00	0.00	0.00	0.04	0.00	0.79
Deformation	0.00	0.00	0.04	0.09	0.00	0.00	0.00	0.04	0.00	0.35
Earth/isolation fault	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.18
Electrical failure - general	0.04	0.40	0.04	0.09	0.00	0.04	0.04	0.13	0.00	1.06
Erosion	0.00	0.04	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.18
External influence - general	0.00	0.22	0.13	0.00	0.00	0.00	0.00	0.04	0.00	0.44
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Faulty power/voltage	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Faulty signal/indication/alarm	0.04	0.04	0.00	0.04	0.00	0.00	0.00	0.44	0.13	4.46
Instrument failure - general	0.26	0.44	4.19	1.10	0.04	0.13	0.00	1.28	0.04	16.06
Leakage	0.04	0.62	0.13	0.18	0.00	0.00	0.00	0.09	0.00	6.44
Looseness	0.00	0.04	0.00	0.22	0.00	0.00	0.00	0.00	0.09	1.32
Material failure - general	0.00	0.04	0.00	0.26	0.18	0.00	0.13	0.13	0.00	1.63
Mechanical Failure - general	3.57	0.97	1.54	9.31	0.71	0.00	0.44	0.71	0.53	33.98
Misc. external influences	0.04	0.04	0.13	0.13	0.00	0.00	0.04	0.09	0.09	1.10
Miscellaneous - general	0.00	0.22	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.35
No cause found	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.18	0.04	0.79
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.18
No signal/indication/alarm	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Open circuit	0.00	0.00	0.40	0.18	0.00	0.04	0.09	0.13	0.00	1.41
Other	0.04	0.44	0.04	0.53	0.00	0.00	0.13	0.09	0.00	1.41
Out of adjustment	0.09	0.40	0.35	0.00	0.00	0.00	0.00	0.26	0.13	5.12
Overheating	0.18	0.09	0.13	0.00	0.00	0.00	0.04	0.26	0.00	0.93
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.22
Software failure	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Sticking	0.00	0.31	0.00	0.18	0.00	0.04	0.00	0.00	0.00	1.02
Unknown	0.18	0.31	0.09	0.09	0.04	0.04	0.57	0.26	0.00	3.35
Vibration	0.00	0.00	0.13	0.18	0.04	0.00	0.00	0.31	0.44	1.81
Wear	0.00	0.44	0.00	0.09	0.00	0.00	0.00	0.09	0.26	5.83
Total	4.77	6.66	8.61	14.47	1.15	0.35	1.90	5.47	1.90	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.1.1	Machinery Compressors Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
65	18	1.9867	1.3303	7120

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**149***	**5.49**	**73.31**	**208.81**	**68.58**	**75.00**	**52.5**	**1.0**	**79.8**	**1818.0**
	149†	**14.88**	**181.63**	**509.93**	**166.51**	**112.00**				
Abnormal instrument reading	2*	0.00	1.21	4.91	1.85	1.01	2.5	17.0	17.0	17.0
	2†	0.05	12.03	45.57	16.80	1.50				
Breakdown	3*	0.00	1.67	8.49	3.66	1.51	6.5	25.5	518.0	1481.0
	3†	0.00	13.85	61.25	24.09	2.26				
Erratic output	6*	0.00	3.40	17.29	7.46	3.02	51.3	3.0	102.5	580.0
	6†	0.00	5.18	25.44	10.70	4.51				
External leakage - Process medium	2*	0.00	1.24	6.90	3.56	1.01	86.0	2.0	99.5	197.0
	2†	0.00	1.59	8.15	3.53	1.50				
External leakage - Utility medium	8*	0.04	4.92	16.83	6.20	4.03	35.2	1.0	46.4	123.5
	8†	0.21	30.08	103.62	38.19	6.01				
Fail to start on demand	49*	0.61	25.87	79.50	27.87	24.66	28.9	1.0	44.0	704.0
	49†	1.51	41.89	126.56	43.22	36.83				
Fail to stop on demand	1*	0.00	0.66	3.61	1.69	0.50	-	-	-	-
	1†	0.00	1.25	6.91	3.52	0.75				
High output	1*	0.00	0.47	2.62	1.31	0.50	7.0	14.0	14.0	14.0
	1†	0.00	0.76	4.27	2.26	0.75				
Internal leakage	5*	0.00	3.21	17.65	8.32	2.52	113.4	2.0	171.4	304.0
	5†	0.00	6.45	33.73	15.13	3.76				
Low output	2*	0.00	1.24	6.90	3.56	1.01	621.0	619.0	791.5	964.0
	2†	0.00	1.59	8.15	3.53	1.50				
Other	2*	0.00	1.30	5.77	2.27	1.01	-	59.0	59.0	59.0
	2†	0.00	2.06	9.32	3.71	1.50				
Overheating	1*	0.00	0.47	2.62	1.31	0.50	223.0	447.0	447.0	447.0
	1†	0.00	0.76	4.27	2.26	0.75				
Parameter deviation	2*	0.00	0.91	3.80	1.45	1.01	4.0	4.0	6.0	8.0
	2†	0.00	1.39	5.73	2.18	1.50				
Spurious stop	60*	0.10	23.38	88.28	32.56	30.20	39.8	1.0	47.4	1818.0
	60†	0.19	44.02	164.94	60.87	45.10				
Vibration	5*	0.01	2.84	10.53	3.89	2.52	13.0	21.0	57.3	100.0
	5†	0.16	4.11	12.40	4.22	3.76				
Degraded	**209***	**10.58**	**114.20**	**313.45**	**101.31**	**105.20**	**19.4**	**0.5**	**23.7**	**410.0**
	209†	**15.47**	**174.03**	**481.45**	**156.19**	**157.11**				
Abnormal instrument reading	14*	0.04	7.26	26.24	9.70	7.05	5.0	2.0	16.4	29.0
	14†	0.06	12.25	45.27	16.72	10.52				
Erratic output	5*	0.00	2.10	10.59	4.54	2.52	11.1	4.0	18.6	35.0
	5†	0.00	3.45	17.98	8.00	3.76				
External leakage - Process medium	20*	0.03	9.88	38.25	14.14	10.07	3.7	0.5	13.6	98.0
	20†	0.06	15.11	57.67	21.25	15.03				

Comments

(cont.)

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Taxonomy no	Item
1.1.1	Machinery Compressors Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
65	18	1.9867	1.3303	7120

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	59*	0.46	32.04	101.63	36.55	29.70	21.4	2.0	24.1	218.0
	59†	0.63	48.64	155.65	56.23	44.35				
Fail to stop on demand	3*	0.00	1.56	8.14	3.66	1.51	3.5	7.0	7.0	7.0
	3†	0.00	2.48	13.72	6.99	2.26				
High output	4*	0.00	1.85	8.58	3.46	2.01	4.7	3.0	4.4	7.0
	4†	0.01	2.68	10.00	3.69	3.01				
Internal leakage	10*	0.00	4.71	21.89	8.86	5.03	54.6	2.0	69.1	216.0
	10†	0.00	7.77	36.94	15.15	7.52				
Low output	11*	0.26	6.77	20.41	6.93	5.54	8.0	2.0	14.1	50.0
	11†	0.08	10.75	36.54	13.44	8.27				
Minor in-service problems	2*	0.00	0.94	4.23	1.68	1.01	2.0	2.0	2.0	2.0
	2†	0.00	1.36	5.33	1.98	1.50				
Noise	3*	0.01	1.36	4.92	1.82	1.51	18.2	5.0	29.7	64.0
	3†	0.01	2.08	7.78	2.87	2.26				
Other	58*	0.32	34.29	113.48	41.52	29.19	28.5	1.0	27.3	410.0
	58†	0.45	50.08	166.62	61.04	43.60				
Overheating	2*	0.19	1.03	2.40	0.71	1.01	13.0	26.0	26.0	26.0
	2†	0.00	1.76	7.36	2.81	1.50				
Parameter deviation	9*	0.00	4.74	19.87	7.60	4.53	3.8	2.0	8.2	28.0
	9†	0.04	6.78	24.31	8.98	6.77				
Vibration	9*	0.13	5.42	16.66	5.84	4.53	18.7	6.0	30.3	96.0
	9†	0.07	8.66	29.42	10.82	6.77				
Incipient	**498***	**6.87**	**241.98**	**737.40**	**255.64**	**250.66**	**9.8**	**0.3**	**15.3**	**531.0**
	498†	**107.97**	**1028.64**	**2748.61**	**875.96**	**374.35**				
Abnormal instrument reading	211*	1.09	92.14	297.51	107.93	106.21	5.3	1.0	7.8	73.0
	211†	3.50	143.25	439.58	153.79	158.61				
Erratic output	5*	0.00	2.94	14.84	6.38	2.52	22.9	1.0	40.4	137.0
	5†	0.00	3.69	16.76	6.67	3.76				
External leakage - Process medium	2*	0.00	1.79	9.85	4.87	1.01	5.5	2.0	5.5	9.0
	2†	0.00	2.18	11.70	5.40	1.50				
External leakage - Utility medium	86*	0.52	41.94	134.90	48.86	43.29	13.9	0.3	25.5	370.0
	86†	21.01	242.21	673.13	218.83	64.65				
Fail to start on demand	1*	0.00	0.61	3.18	1.41	0.50	4.0	4.0	4.0	4.0
	1†	0.00	6.03	28.91	11.91	0.75				
Internal leakage	48*	0.00	33.59	177.09	120.69	24.16	1.9	1.0	3.0	15.5
	48†	4.31	476.62	1583.00	579.67	36.08				
Low output	1*	0.00	0.45	2.17	0.90	0.50	-	2.0	2.0	2.0
	1†	0.00	0.69	3.56	1.56	0.75				
Minor in-service problems	59*	0.03	29.67	122.39	46.47	29.70	5.6	1.0	9.0	78.0
	59†	0.26	57.98	216.15	79.79	44.35				

Comments

(cont.)

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Taxonomy no	Item
1.1.1	Machinery Compressors Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
65	18	1.9867	1.3303	7120

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	4*	0.07	1.85	5.58	1.90	2.01	7.7	4.0	7.7	11.0
	4†	0.73	2.90	6.24	1.75	3.01				
Other	51*	0.00	22.58	100.52	39.67	25.67	40.5	1.0	39.4	531.0
	51†	0.02	39.09	168.09	65.09	38.34				
Overheating	2*	0.00	1.42	6.75	2.77	1.01	6.5	2.0	50.0	98.0
	2†	0.00	5.83	28.75	12.15	1.50				
Parameter deviation	12*	0.00	6.42	30.56	12.54	6.04	7.1	2.0	19.7	92.0
	12†	0.00	10.06	48.10	19.78	9.02				
Structural deficiency	5*	0.00	2.64	11.66	4.58	2.52	13.3	4.0	30.0	64.0
	5†	0.00	3.98	16.42	6.23	3.76				
Unknown	2*	0.02	1.09	3.43	1.23	1.01	-	4.0	5.0	6.0
	2†	0.30	1.55	3.61	1.06	1.50				
Vibration	9*	0.12	5.24	16.12	5.66	4.53	2.7	1.0	20.1	119.0
	9†	0.02	9.33	36.69	13.66	6.77				
Unknown	**45***	**0.22**	**43.16**	**155.79**	**57.57**	**22.65**	**23.1**	**1.0**	**28.0**	**249.0**
	45†	**0.28**	**63.76**	**238.49**	**88.02**	**33.83**				
Abnormal instrument reading	21*	0.00	18.20	82.30	32.71	10.57	3.0	1.0	8.1	16.0
	21†	0.00	30.26	136.30	54.09	15.79				
External leakage - Utility medium	5*	0.00	2.91	15.13	6.71	2.52	7.0	7.0	85.5	164.0
	5†	0.00	5.35	27.90	12.45	3.76				
Low output	1*	0.00	1.36	7.63	4.00	0.50	-	12.0	12.0	12.0
	1†	0.00	1.55	8.66	4.50	0.75				
Noise	1*	0.00	0.66	3.61	1.69	0.50	14.0	-	-	-
	1†	0.00	1.25	6.91	3.52	0.75				
Other	13*	0.03	12.51	49.89	18.65	6.54	16.0	2.0	23.2	105.0
	13†	0.07	16.72	62.33	23.01	9.77				
Overheating	1*	0.00	0.45	2.17	0.90	0.50	-	3.0	3.0	3.0
	1†	0.00	0.69	3.56	1.56	0.75				
Unknown	2*	0.00	1.14	4.97	1.94	1.01	63.0	3.0	126.0	249.0
	2†	0.07	1.60	4.81	1.63	1.50				
Vibration	1*	0.00	1.92	10.57	5.14	0.50	-	9.0	9.0	9.0
	1†	0.00	2.15	11.88	6.00	0.75				
All modes	**901***	**71.73**	**474.00**	**1171.64**	**358.40**	**453.51**	**19.5**	**0.3**	**28.1**	**1818.0**
	901†	**269.12**	**1465.59**	**3449.98**	**1024.16**	**677.29**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $5.6 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Compressors - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.11	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Antisurge system	0.55	0.00	0.11	0.33	0.89	0.44	0.11	0.44	0.00	0.00
Bearing	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Buffer gas system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.11	0.00	0.00	0.11	0.00	0.22	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.11	0.44	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.11	0.00	0.00	0.11	0.22	1.00	0.00	0.00	0.00	0.00
Control-, isolating & check valves	0.11	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Dry gas seal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.11	0.00	0.00	0.22	0.11	0.33	0.00
Gearbox/var.drive	0.22	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.22
Instrument, flow	0.87	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	4.66	0.00	0.00	0.44	0.00	0.00	0.00	0.11	0.00	0.00
Instrument, pressure	5.70	0.00	0.00	0.33	0.22	0.78	0.11	0.00	0.11	0.00
Instrument, speed	0.44	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00
Instrument, temperature	6.31	0.00	0.00	0.28	0.22	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.66	0.00	0.00	0.28	0.11	0.00	0.00	0.00	0.00	0.00
Internal piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.44	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.22	0.11	0.00	0.00	0.00	0.11	0.09	0.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Lube oil	0.17	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.55	0.00	0.00	0.00	3.11	0.00	0.00
Oil tank w/heating system	0.06	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.33	0.00	0.11	0.67	0.00	0.00	0.00	0.00	0.22	0.11
Overhead tank	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.89	0.00	0.22	0.00	0.00	0.00	0.00
Pump w/motor/gear	0.00	0.00	0.00	1.00	0.00	0.22	0.00	0.00	0.00	0.44
Purge air	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Seal gas	0.00	0.00	0.33	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Seal oil	0.11	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.11	0.00
Seals	0.00	0.00	0.11	0.78	0.00	0.00	0.00	0.00	0.00	0.00
Shaft seals	0.00	0.00	0.11	0.22	0.00	0.22	0.11	0.55	0.04	0.00
Subunit	0.22	0.00	0.00	0.78	0.00	0.33	0.00	0.00	0.04	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.44	0.22	0.00	2.77	0.00	1.00	0.00	2.22	0.44	0.00
Valves	0.55	0.00	1.22	2.33	0.11	0.22	0.00	0.22	0.22	0.11
Total	27.52	0.33	2.66	17.54	1.78	5.55	0.55	6.99	1.66	0.89

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.55
Antisurge system	0.00	1.05	0.28	0.44	0.33	0.00	0.00	0.11	0.00	5.11
Bearing	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.44
Buffer gas system	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Cabling & junction boxes	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.55
Casing	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.67
Control unit	0.00	0.67	0.00	0.22	0.00	0.22	0.11	0.78	0.22	4.66
Control-, isolating & check valves	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.55
Cooler(s)	0.11	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.44
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.94
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Dry gas seal	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Filter(s)	0.00	0.67	0.44	1.22	0.00	0.00	0.11	0.22	0.00	3.44
Gearbox/var.drive	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.17
Instrument, flow	0.00	0.22	0.11	0.11	0.00	0.00	0.00	0.00	0.00	1.54
Instrument, general	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.89
Instrument, level	0.00	0.61	0.78	0.22	0.00	0.00	0.11	0.61	0.00	7.55
Instrument, pressure	0.00	0.44	0.00	0.17	0.00	0.00	0.11	0.33	0.00	8.31
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.89
Instrument, temperature	0.00	0.44	0.22	0.61	0.00	0.00	0.00	0.33	0.11	8.53
Instrument, vibration	0.00	0.11	0.11	0.00	0.00	0.00	0.00	1.11	0.78	4.16
Internal piping	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Internal power supply	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.33	0.00	1.44
Interstage seals	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.68

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Lube oil	0.00	0.33	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.94
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Monitoring	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.22	0.00	2.44
Oil	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.77
Oil tank w/heating system	0.00	0.55	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.94
Other	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.11	0.11	2.00
Overhead tank	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Packing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Piping, pipe support + bellows	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00	0.00	1.00
Pump w/motor	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.11	1.55
Pump w/motor/gear	0.00	1.11	0.00	0.22	0.00	0.11	0.00	0.11	0.22	3.44
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Radial bearing	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Reservoir w/heating system	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.22
Rotor w/ impellers	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Seal gas	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Seal oil	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.44
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89
Shaft seals	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.04	0.00	1.52
Subunit	0.00	1.00	0.00	0.11	0.00	0.00	0.00	0.15	0.11	2.74
Thrust bearing	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.22
Unknown	0.22	0.33	0.00	0.78	0.22	0.00	0.00	1.11	0.33	11.10
Valves	0.00	3.22	0.50	1.22	0.00	0.11	0.00	0.39	0.00	10.43
Total	0.67	13.76	2.55	6.77	0.55	0.44	0.44	6.66	2.66	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Compressors - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.22	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.67	0.00
Breakage	0.44	0.11	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00
Burst	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.22	0.00	0.11	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.22	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.00	0.00	0.00	0.22	0.33	0.55	0.00	0.11	0.00	0.00
Corrosion	0.11	0.00	0.00	0.11	0.00	0.11	0.00	0.11	0.00	0.00
Deformation	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	8.10	0.00	0.00	0.00	0.44	0.44	0.00	0.00	0.00	0.00
Instrument failure - general	4.11	0.00	0.00	0.22	0.33	1.11	0.22	0.00	0.00	0.00
Leakage	0.11	0.00	1.89	8.99	0.00	0.00	0.00	0.22	0.00	0.00
Looseness	0.44	0.00	0.11	0.89	0.00	0.33	0.00	0.00	0.00	0.11
Material failure - general	0.33	0.00	0.22	0.78	0.00	0.00	0.22	0.00	0.00	0.00
Mechanical Failure - general	0.22	0.11	0.00	1.44	0.00	0.78	0.11	0.22	0.33	0.33
Misc. external influences	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.11	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
No cause found	0.67	0.00	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.00
No power/ voltage	0.11	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.44	0.00	0.00	0.11	0.00	0.33	0.00	0.00	0.00	0.00
Open circuit	0.44	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.11	0.00	0.00	0.11	0.00	0.00	0.00	0.00
Out of adjustment	6.88	0.00	0.00	0.00	0.55	0.33	0.00	0.11	0.22	0.00
Overheating	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.44	0.11	0.00	0.00	0.11	0.22	0.00	0.33	0.00	0.00
Unknown	0.78	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.33	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.33
Wear	0.44	0.00	0.11	3.11	0.00	0.00	0.00	5.88	0.22	0.11
Total	27.52	0.33	2.66	17.54	1.78	5.55	0.55	6.99	1.66	0.89

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Compressors - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.11	0.22	0.44	0.00	0.00	0.00	0.33	0.00	2.11
Breakage	0.00	0.55	0.11	0.44	0.11	0.00	0.11	0.00	0.00	2.22
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Clearance/ alignment failure	0.00	0.22	0.00	0.11	0.00	0.00	0.00	0.00	0.22	1.22
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Contamination	0.11	0.44	0.11	1.22	0.00	0.00	0.00	0.00	0.00	2.22
Control failure	0.22	0.89	0.67	0.00	0.00	0.00	0.00	0.67	0.00	4.66
Corrosion	0.00	0.33	0.00	0.55	0.00	0.00	0.00	0.00	0.00	1.33
Deformation	0.00	0.00	0.11	0.22	0.00	0.00	0.00	0.00	0.00	0.67
Earth/isolation fault	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.22
Electrical failure - general	0.11	0.78	0.00	0.11	0.00	0.11	0.00	0.22	0.00	1.78
Erosion	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Faulty power/voltage	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Faulty signal/indication/alarm	0.11	0.11	0.00	0.11	0.00	0.00	0.00	1.00	0.33	10.65
Instrument failure - general	0.00	0.89	0.22	0.67	0.00	0.00	0.00	1.55	0.00	9.32
Leakage	0.00	1.55	0.22	0.11	0.00	0.00	0.00	0.11	0.00	13.21
Looseness	0.00	0.11	0.00	0.44	0.00	0.00	0.00	0.00	0.22	2.66
Material failure - general	0.00	0.00	0.00	0.55	0.33	0.00	0.00	0.33	0.00	2.77
Mechanical Failure - general	0.00	1.78	0.11	0.67	0.11	0.00	0.00	0.22	0.22	6.66
Misc. external influences	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.11	0.00	0.55
Miscellaneous - general	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.33
No cause found	0.00	0.33	0.11	0.00	0.00	0.00	0.00	0.44	0.11	1.89
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.44
No signal/indication/alarm	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22
Open circuit	0.00	0.00	0.00	0.22	0.00	0.11	0.11	0.22	0.00	1.33
Other	0.11	1.00	0.11	0.11	0.00	0.00	0.11	0.11	0.00	1.78
Out of adjustment	0.00	1.00	0.44	0.00	0.00	0.00	0.00	0.33	0.33	10.21
Overheating	0.00	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Sticking	0.00	0.78	0.00	0.33	0.00	0.11	0.00	0.00	0.00	2.44
Unknown	0.00	0.78	0.00	0.00	0.00	0.11	0.11	0.33	0.00	2.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.78	2.00
Wear	0.00	1.00	0.00	0.22	0.00	0.00	0.00	0.00	0.44	11.54
Total	0.67	13.76	2.55	6.77	0.55	0.44	0.44	6.66	2.66	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.1.1.1	Machinery Compressors Centrifugal Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	9	1.1503	0.8560	3751

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**89***	**0.65**	**80.37**	**270.60**	**99.39**	**77.37**	**66.9**	**1.0**	**89.3**	**1818.0**
	89†	**0.92**	**113.56**	**382.31**	**140.42**	**103.97**				
Erratic output	4*	0.00	3.94	21.13	9.74	3.48	74.8	3.0	149.5	580.0
	4†	0.00	6.25	33.05	15.03	4.67				
External leakage - Process medium	2*	0.00	2.30	11.71	5.06	1.74	86.0	2.0	99.5	197.0
	2†	0.00	2.66	12.83	5.30	2.34				
External leakage - Utility medium	1*	0.00	0.81	4.01	1.69	0.87	123.5	123.5	123.5	123.5
	1†	0.00	1.10	5.41	2.28	1.17				
Fail to start on demand	30*	0.11	25.66	96.28	35.53	26.08	34.7	1.0	43.0	704.0
	30†	0.16	35.03	130.39	48.14	35.05				
High output	1*	0.06	0.91	2.63	0.87	0.87	7.0	14.0	14.0	14.0
	1†	0.00	1.35	5.54	2.10	1.17				
Internal leakage	4*	0.00	4.71	25.03	11.45	3.48	141.5	91.0	213.8	304.0
	4†	0.00	5.27	27.98	12.81	4.67				
Low output	2*	0.00	2.30	11.71	5.06	1.74	621.0	619.0	791.5	964.0
	2†	0.00	2.66	12.83	5.30	2.34				
Other	1*	0.00	1.24	6.11	2.58	0.87	-	59.0	59.0	59.0
	1†	0.00	1.53	7.17	2.92	1.17				
Overheating	1*	0.06	0.91	2.63	0.87	0.87	223.0	447.0	447.0	447.0
	1†	0.00	1.35	5.54	2.10	1.17				
Parameter deviation	1*	0.00	0.81	4.01	1.69	0.87	4.0	4.0	4.0	4.0
	1†	0.00	1.10	5.41	2.28	1.17				
Spurious stop	41*	0.25	36.99	127.49	46.99	35.64	45.9	1.0	61.1	1818.0
	41†	0.41	55.38	188.85	69.51	47.90				
Vibration	1*	0.00	1.02	4.34	1.67	0.87	13.0	21.0	21.0	21.0
	1†	0.08	1.22	3.53	1.17	1.17				
Degraded	**102***	**31.03**	**115.39**	**243.48**	**67.29**	**88.67**	**17.5**	**0.5**	**25.8**	**410.0**
	102†	**48.04**	**151.33**	**301.60**	**79.67**	**119.15**				
Abnormal instrument reading	2*	0.00	2.60	13.39	5.83	1.74	-	14.0	14.0	14.0
	2†	0.00	5.31	26.32	11.17	2.34				
Erratic output	4*	0.00	3.94	21.13	9.74	3.48	11.1	10.0	22.3	35.0
	4†	0.00	6.25	33.05	15.03	4.67				
External leakage - Process medium	7*	1.11	6.40	15.27	4.57	6.09	3.7	0.5	6.1	12.0
	7†	0.38	8.91	26.78	9.05	8.18				
External leakage - Utility medium	26*	3.12	29.44	78.46	24.97	22.60	10.9	2.0	20.4	218.0
	26†	5.69	34.98	84.96	25.72	30.37				
Fail to stop on demand	2*	0.00	1.79	7.90	3.11	1.74	3.5	7.0	7.0	7.0
	2†	0.00	2.35	11.35	4.69	2.34				
High output	3*	0.54	2.66	6.10	1.79	2.61	4.7	3.0	4.7	7.0
	3†	0.01	3.19	12.71	4.75	3.50				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.1	Machinery Compressors Centrifugal Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	9	1.1503	0.8560	3751

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Internal leakage	8*	0.00	7.25	35.34	14.75	6.95	54.6	2.0	69.1	216.0
	8†	0.00	10.77	53.17	22.48	9.35				
Low output	6*	0.04	5.61	19.03	7.00	5.22	5.6	2.0	5.6	15.0
	6†	0.46	7.01	20.35	6.73	7.01				
Minor in-service problems	2*	0.01	1.65	6.21	2.29	1.74	2.0	2.0	2.0	2.0
	2†	0.02	2.15	7.35	2.71	2.34				
Noise	3*	0.02	2.43	8.31	3.06	2.61	18.2	5.0	29.7	64.0
	3†	0.01	3.42	13.15	4.85	3.50				
Other	25*	2.22	34.86	101.62	33.65	21.73	30.3	4.0	36.3	410.0
	25†	3.46	45.26	128.52	42.16	29.20				
Parameter deviation	8*	0.05	8.01	28.34	10.47	6.95	2.8	2.0	6.9	28.0
	8†	0.08	10.19	34.29	12.60	9.35				
Vibration	6*	0.10	7.88	25.30	9.16	5.22	18.7	6.0	34.3	96.0
	6†	0.06	11.71	41.82	15.45	7.01				
Incipient	**269***	**14.94**	**266.41**	**788.37**	**262.32**	**233.86**	**10.5**	**0.3**	**13.6**	**531.0**
	269†	**14.30**	**366.15**	**1103.28**	**374.72**	**314.24**				
Abnormal instrument reading	149*	7.60	141.51	420.76	140.20	129.53	5.6	1.0	7.4	73.0
	149†	11.50	192.98	567.07	188.29	174.06				
Erratic output	3*	0.00	2.34	10.94	4.44	2.61	9.0	1.0	9.0	16.0
	3†	0.03	3.03	9.86	3.59	3.50				
External leakage - Process medium	1*	0.00	0.81	4.01	1.69	0.87	2.0	2.0	2.0	2.0
	1†	0.00	1.10	5.41	2.28	1.17				
External leakage - Utility medium	25*	0.47	23.96	74.42	26.35	21.73	6.6	0.3	9.3	40.0
	25†	0.64	31.89	98.89	34.98	29.20				
Internal leakage	1*	0.06	0.91	2.63	0.87	0.87	2.0	4.0	4.0	4.0
	1†	0.00	1.35	5.54	2.10	1.17				
Minor in-service problems	37*	0.30	38.74	131.48	48.36	32.17	4.8	1.0	7.3	72.0
	37†	0.24	52.47	194.97	71.99	43.22				
Noise	4*	0.34	3.21	8.55	2.72	3.48	7.7	4.0	7.7	11.0
	4†	0.41	4.37	11.97	3.87	4.67				
Other	34*	0.11	38.98	153.01	56.91	29.56	45.3	1.0	49.5	531.0
	34†	0.19	59.26	230.24	85.26	39.72				
Parameter deviation	3*	0.00	4.83	20.66	7.99	2.61	-	2.0	35.7	92.0
	3†	0.00	5.44	22.70	8.67	3.50				
Structural deficiency	4*	0.00	3.74	16.27	6.33	3.48	13.3	4.0	21.5	50.0
	4†	0.00	5.40	24.91	10.02	4.67				
Unknown	1*	0.00	1.24	6.11	2.58	0.87	-	4.0	4.0	4.0
	1†	0.00	1.53	7.17	2.92	1.17				
Vibration	7*	0.18	7.22	22.11	7.72	6.09	2.7	1.0	19.3	119.0
	7†	0.30	9.14	27.70	9.51	8.18				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.1	Machinery Compressors Centrifugal Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	9	1.1503	0.8560	3751

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**7***	**0.01**	**7.92**	**32.62**	**12.38**	**6.09**	**12.8**	**3.0**	**41.2**	**164.0**
	7†	**0.02**	**14.92**	**61.45**	**23.32**	**8.18**				
Abnormal instrument reading	2*	0.00	2.60	13.39	5.83	1.74	-	3.0	6.5	10.0
	2†	0.00	5.31	26.32	11.17	2.34				
External leakage - Utility medium	2*	0.35	1.79	4.17	1.23	1.74	7.0	7.0	85.5	164.0
	2†	0.01	2.79	10.91	4.05	2.34				
Other	2*	0.12	1.95	5.75	1.91	1.74	30.0	60.0	60.0	60.0
	2†	0.01	3.41	13.60	5.09	2.34				
Unknown	1*	0.06	0.91	2.63	0.87	0.87	1.5	3.0	3.0	3.0
	1†	0.00	1.35	5.54	2.10	1.17				
All modes	**467***	**49.33**	**471.49**	**1260.79**	**401.97**	**405.99**	**24.0**	**0.3**	**30.6**	**1818.0**
	467†	**61.94**	**650.36**	**1774.99**	**572.11**	**545.54**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $6.7 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.1.1.1	Machinery Compressors Centrifugal Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	3	0.1705	0.1258	1299

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**27***	**21.19**	**151.76**	**381.84**	**117.91**	**158.38**	**25.7**	**1.0**	**49.2**	**580.0**
	27†	**10.11**	**256.43**	**772.46**	**262.19**	**214.67**				
Erratic output	2*	0.15	11.47	36.68	13.24	11.73	146.8	7.0	293.5	580.0
	2†	0.05	21.40	84.78	31.63	15.90				
Fail to start on demand	12*	39.95	69.68	106.12	20.32	70.39	7.0	1.0	11.0	60.0
	12†	20.54	103.00	237.56	69.73	95.41				
High output	1*	0.00	5.73	24.83	9.64	5.87	7.0	14.0	14.0	14.0
	1†	0.06	9.57	33.16	12.23	7.95				
Overheating	1*	0.00	5.73	24.83	9.64	5.87	223.0	447.0	447.0	447.0
	1†	0.06	9.57	33.16	12.23	7.95				
Spurious stop	11*	9.89	62.11	151.68	46.07	64.53	6.1	1.0	10.0	26.0
	11†	3.56	101.57	307.09	105.05	87.46				
Degraded	**13***	**33.28**	**74.98**	**130.28**	**30.06**	**76.26**	**31.4**	**1.0**	**33.6**	**148.0**
	13†	**15.97**	**115.01**	**289.72**	**89.52**	**103.36**				
Erratic output	3*	0.08	17.05	63.54	23.46	17.60	9.5	10.0	19.0	35.0
	3†	0.06	33.26	134.26	50.52	23.85				
External leakage - Process medium	3*	1.15	17.08	49.40	16.32	17.60	4.0	1.0	6.0	12.0
	3†	2.42	23.18	62.04	19.79	23.85				
External leakage - Utility medium	2*	1.02	11.94	33.27	10.83	11.73	2.0	2.0	3.0	4.0
	2†	0.79	18.42	55.36	18.68	15.90				
Fail to stop on demand	1*	0.00	5.67	24.34	9.42	5.87	-	-	-	-
	1†	0.04	7.10	25.51	9.43	7.95				
Internal leakage	2*	1.30	11.52	30.23	9.53	11.73	149.0	136.0	142.0	148.0
	2†	0.35	16.38	50.64	17.87	15.90				
Noise	1*	0.00	5.73	24.83	9.64	5.87	2.5	5.0	5.0	5.0
	1†	0.06	9.57	33.16	12.23	7.95				
Other	1*	0.00	5.67	24.34	9.42	5.87	-	-	-	-
	1†	0.04	7.10	25.51	9.43	7.95				
Incipient	**61***	**10.12**	**344.86**	**1049.53**	**363.13**	**357.83**	**5.3**	**0.3**	**9.2**	**72.0**
	61†	**6.35**	**643.71**	**2116.99**	**773.08**	**485.00**				
Abnormal instrument reading	24*	18.72	136.28	344.07	106.43	140.79	4.9	1.0	7.6	59.0
	24†	7.40	237.17	720.04	248.17	190.82				
Erratic output	1*	0.00	5.67	24.34	9.42	5.87	16.0	16.0	16.0	16.0
	1†	0.04	7.10	25.51	9.43	7.95				
External leakage - Utility medium	6*	14.48	34.98	62.68	14.97	35.20	3.2	0.3	5.7	20.0
	6†	21.68	49.60	86.81	20.19	47.71				
Minor in-service problems	17*	0.17	96.13	387.31	145.62	99.72	4.6	1.0	8.7	72.0
	17†	0.51	196.74	775.32	288.75	135.17				
Noise	1*	0.39	6.08	17.71	5.87	5.87	-	-	-	-
	1†	0.59	8.39	24.12	7.95	7.95				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.1.1	Machinery Compressors Centrifugal Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	3	0.1705	0.1258	1299

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Other	10*	0.03	56.01	239.18	92.37	58.66	6.0	3.0	12.0	50.0
	10†	0.14	116.50	479.28	181.80	79.51				
Structural deficiency	2*	1.30	11.52	30.23	9.53	11.73	14.5	4.0	27.0	50.0
	2†	0.35	16.38	50.64	17.87	15.90				
Unknown	**2***	**0.15**	**11.47**	**36.68**	**13.24**	**11.73**	**15.8**	**3.0**	**31.5**	**60.0**
	2†	**0.05**	**21.40**	**84.78**	**31.63**	**15.90**				
Other	1*	0.00	5.73	24.83	9.64	5.87	30.0	60.0	60.0	60.0
	1†	0.06	9.57	33.16	12.23	7.95				
Unknown	1*	0.00	5.73	24.83	9.64	5.87	1.5	3.0	3.0	3.0
	1†	0.06	9.57	33.16	12.23	7.95				
All modes	**103***	**42.72**	**579.49**	**1654.84**	**544.05**	**604.20**	**13.8**	**0.3**	**22.9**	**580.0**
	103†	**17.00**	**1047.22**	**3293.44**	**1177.95**	**818.94**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 8.5 10^{-3}

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Taxonomy no	Item
1.1.1.1.2	Machinery Compressors Centrifugal Electric driven (1000-3000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	5	0.2012	0.1677	815

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**37***	**6.74**	**179.76**	**542.30**	**184.69**	**183.93**	**13.0**	**1.0**	**17.8**	**197.0**
	37†	**9.60**	**205.57**	**616.59**	**206.86**	**220.58**				
Erratic output	2*	1.42	9.32	23.00	7.03	9.94	2.8	3.0	5.5	8.0
	2†	0.37	11.01	33.32	11.43	11.92				
External leakage - Process medium	1*	0.01	5.92	24.21	9.17	4.97	170.0	197.0	197.0	197.0
	1†	0.04	6.44	22.59	8.34	5.96				
Fail to start on demand	12*	0.52	59.18	197.29	72.31	59.65	13.7	1.0	15.9	128.0
	12†	0.77	67.25	217.74	79.08	71.54				
Other	1*	0.33	5.15	15.01	4.97	4.97	-	59.0	59.0	59.0
	1†	0.36	6.10	17.95	5.96	5.96				
Parameter deviation	1*	0.00	4.67	22.15	9.08	4.97	4.0	4.0	4.0	4.0
	1†	0.00	5.79	28.78	12.25	5.96				
Spurious stop	20*	1.29	96.59	308.46	111.33	99.42	4.6	2.0	7.6	25.0
	20†	1.89	110.62	346.70	123.70	119.23				
Degraded	**32***	**107.07**	**157.62**	**216.14**	**33.34**	**159.07**	**14.9**	**0.5**	**28.4**	**410.0**
	32†	**105.55**	**187.43**	**288.32**	**56.17**	**190.78**				
Erratic output	1*	0.00	4.40	19.18	7.47	4.97	16.0	32.0	32.0	32.0
	1†	0.00	5.36	24.72	9.94	5.96				
External leakage - Process medium	2*	0.03	10.34	40.67	15.14	9.94	3.3	0.5	3.3	6.0
	2†	0.05	12.05	44.83	16.55	11.92				
External leakage - Utility medium	8*	5.21	41.11	105.47	32.87	39.77	7.0	2.0	6.9	24.0
	8†	6.40	48.30	122.84	38.13	47.69				
Fail to stop on demand	1*	0.00	4.40	19.18	7.47	4.97	3.5	7.0	7.0	7.0
	1†	0.00	5.36	24.72	9.94	5.96				
High output	1*	0.03	5.44	19.06	7.04	4.97	4.0	4.0	4.0	4.0
	1†	0.35	6.08	17.94	5.96	5.96				
Internal leakage	5*	0.00	19.15	87.79	35.11	24.85	26.6	2.0	52.6	216.0
	5†	0.00	24.19	113.93	46.50	29.81				
Low output	3*	4.11	14.96	31.33	8.61	14.91	2.0	2.0	2.0	2.0
	3†	4.11	17.90	39.63	11.32	17.89				
Other	6*	6.26	30.66	70.28	20.55	29.83	42.0	5.0	74.8	410.0
	6†	7.36	36.00	82.49	24.12	35.77				
Parameter deviation	5*	0.21	23.52	78.37	28.72	24.85	2.9	2.0	7.9	28.0
	5†	0.15	29.23	105.88	39.12	29.81				
Incipient	**130***	**54.56**	**661.08**	**1853.59**	**604.93**	**646.23**	**6.7**	**1.0**	**8.7**	**172.0**
	130†	**71.85**	**744.21**	**2025.40**	**651.89**	**775.03**				
Abnormal instrument reading	84*	6.34	443.06	1406.82	506.19	417.56	4.2	1.0	5.8	44.0
	84†	9.69	488.18	1515.06	536.28	500.79				
Erratic output	2*	0.00	12.01	53.70	21.24	9.94	5.5	1.0	5.5	10.0
	2†	0.01	12.65	54.44	21.09	11.92				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.1.2	Machinery Compressors Centrifugal Electric driven (1000-3000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	5	0.2012	0.1677	815

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	1*	0.00	4.67	22.15	9.08	4.97	2.0	2.0	2.0	2.0
	1†	0.00	5.79	28.78	12.25	5.96				
External leakage - Utility medium	10*	8.14	47.52	113.86	34.17	49.71	11.1	2.0	13.1	40.0
	10†	31.44	58.63	92.68	18.85	59.62				
Internal leakage	1*	0.00	4.40	19.18	7.47	4.97	2.0	4.0	4.0	4.0
	1†	0.00	5.36	24.72	9.94	5.96				
Minor in-service problems	13*	21.09	67.37	134.96	35.80	64.62	4.8	1.0	5.5	20.0
	13†	36.29	78.07	132.64	29.81	77.50				
Other	16*	4.16	70.95	208.91	69.41	79.54	20.8	1.0	25.3	172.0
	16†	1.90	85.84	264.75	93.15	95.39				
Structural deficiency	2*	1.42	9.32	23.00	7.03	9.94	12.0	8.0	16.0	24.0
	2†	0.37	11.01	33.32	11.43	11.92				
Vibration	1*	0.03	5.44	19.06	7.04	4.97	3.0	3.0	3.0	3.0
	1†	0.35	6.08	17.94	5.96	5.96				
All modes	**199***	**111.37**	**991.89**	**2607.76**	**823.08**	**989.22**	**9.1**	**0.5**	**13.4**	**410.0**
	199†	**150.01**	**1128.97**	**2869.65**	**890.57**	**1186.39**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.5 \cdot 10^{-2}$

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Taxonomy no	Item
1.1.1.1.3	Machinery Compressors Centrifugal Electric driven (3000-10000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	7	0.7261	0.5100	1637

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**25***	**0.21**	**47.73**	**178.54**	**65.90**	**34.43**	**219.3**	**2.0**	**228.3**	**1818.0**
	25†	**0.43**	**63.81**	**220.36**	**81.24**	**49.02**				
External leakage - Process medium	1*	0.00	1.82	7.78	3.00	1.38	2.0	2.0	2.0	2.0
	1†	0.16	2.10	5.98	1.96	1.96				
External leakage - Utility medium	1*	0.12	1.49	4.21	1.38	1.38	123.5	123.5	123.5	123.5
	1†	0.00	2.22	11.60	5.18	1.96				
Fail to start on demand	6*	0.17	11.09	34.99	12.54	8.26	168.5	2.0	172.8	704.0
	6†	1.10	13.85	39.09	12.80	11.77				
Internal leakage	4*	0.00	8.30	41.96	18.04	5.51	141.5	91.0	213.8	304.0
	4†	0.00	9.29	47.16	20.33	7.84				
Low output	2*	0.00	4.05	19.64	8.14	2.75	621.0	619.0	791.5	964.0
	2†	0.00	4.70	21.49	8.58	3.92				
Spurious stop	10*	0.27	18.56	58.89	21.18	13.77	265.5	2.0	203.1	1818.0
	10†	0.20	29.40	101.55	37.44	19.61				
Vibration	1*	0.00	1.82	7.78	3.00	1.38	13.0	21.0	21.0	21.0
	1†	0.16	2.10	5.98	1.96	1.96				
Degraded	**44***	**12.11**	**101.55**	**263.37**	**82.47**	**60.60**	**13.6**	**2.0**	**25.1**	**218.0**
	44†	**20.75**	**136.75**	**337.82**	**103.30**	**86.28**				
Abnormal instrument reading	2*	0.00	3.67	17.49	7.18	2.75	-	14.0	14.0	14.0
	2†	0.00	7.29	34.95	14.39	3.92				
External leakage - Process medium	2*	0.00	3.67	17.49	7.18	2.75	-	8.0	9.0	10.0
	2†	0.00	7.29	34.95	14.39	3.92				
External leakage - Utility medium	11*	0.29	27.48	89.68	32.67	15.15	16.7	3.0	32.7	218.0
	11†	0.35	31.97	104.14	37.91	21.57				
High output	2*	0.50	3.11	7.59	2.30	2.75	5.0	3.0	5.0	7.0
	2†	0.01	4.26	17.03	6.37	3.92				
Internal leakage	1*	0.12	1.49	4.21	1.38	1.38	6.0	6.0	6.0	6.0
	1†	0.00	1.97	9.51	3.93	1.96				
Low output	3*	0.00	6.19	30.79	13.11	4.13	8.0	4.0	8.0	15.0
	3†	0.00	7.03	34.49	14.49	5.88				
Minor in-service problems	2*	0.00	3.25	13.25	5.01	2.75	2.0	2.0	2.0	2.0
	2†	0.01	4.17	16.12	5.95	3.92				
Noise	2*	0.00	2.51	10.15	3.82	2.75	26.0	20.0	42.0	64.0
	2†	0.01	3.61	14.08	5.22	3.92				
Other	13*	0.32	35.48	117.88	43.17	17.90	14.7	4.0	26.3	109.0
	13†	0.56	48.80	158.08	57.42	25.49				
Parameter deviation	1*	0.12	1.49	4.21	1.38	1.38	2.5	2.0	2.0	2.0
	1†	0.00	2.22	11.60	5.18	1.96				
Vibration	5*	0.26	10.80	33.15	11.60	6.89	18.7	6.0	38.4	96.0
	5†	0.14	16.37	54.75	20.08	9.80				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.1.3	Machinery Compressors Centrifugal Electric driven (3000-10000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	7	0.7261	0.5100	1637

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**66***	**19.08**	**151.80**	**389.98**	**121.62**	**90.90**	**31.2**	**1.0**	**27.3**	**531.0**
	66†	**30.65**	**204.81**	**507.54**	**155.48**	**129.42**				
Abnormal instrument reading	35*	8.49	75.24	197.58	62.31	48.20	12.6	1.0	11.7	73.0
	35†	11.10	105.90	283.08	90.23	68.63				
External leakage - Utility medium	9*	0.15	21.47	73.81	27.20	12.40	4.2	2.0	7.9	32.0
	9†	0.19	25.77	88.12	32.45	17.65				
Minor in-service problems	3*	0.03	5.53	20.46	7.56	4.13	6.7	4.0	6.7	11.0
	3†	0.16	6.81	20.91	7.33	5.88				
Noise	3*	0.45	4.15	10.97	3.48	4.13	7.7	4.0	7.7	11.0
	3†	1.00	5.87	14.07	4.22	5.88				
Other	8*	0.90	20.66	62.07	20.93	11.02	401.5	3.0	155.0	531.0
	8†	1.94	29.27	84.84	28.04	15.69				
Parameter deviation	1*	0.00	2.94	14.22	5.88	1.38	-	2.0	2.0	2.0
	1†	0.00	3.57	17.11	7.04	1.96				
Unknown	1*	0.00	2.94	14.22	5.88	1.38	-	4.0	4.0	4.0
	1†	0.00	3.57	17.11	7.04	1.96				
Vibration	6*	0.20	12.12	38.05	13.60	8.26	2.6	1.0	22.0	119.0
	6†	0.49	15.71	47.68	16.43	11.77				
Unknown	**5***	**0.00**	**8.95**	**39.87**	**15.74**	**6.89**	**7.0**	**3.0**	**46.0**	**164.0**
	5†	**0.00**	**17.33**	**76.62**	**30.12**	**9.80**				
Abnormal instrument reading	2*	0.00	3.67	17.49	7.18	2.75	-	3.0	6.5	10.0
	2†	0.00	7.29	34.95	14.39	3.92				
External leakage - Utility medium	2*	0.66	3.01	6.75	1.95	2.75	7.0	7.0	85.5	164.0
	2†	0.12	4.84	14.85	5.19	3.92				
Other	1*	0.01	1.66	6.27	2.31	1.38	-	-	-	-
	1†	0.00	3.17	14.90	6.08	1.96				
All modes	**140***	**37.91**	**313.94**	**812.41**	**254.16**	**192.82**	**69.6**	**1.0**	**63.5**	**1818.0**
	140†	**60.61**	**429.18**	**1077.31**	**332.28**	**274.53**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.2 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.1.1.4	Machinery Compressors Centrifugal Electric driven (20000-30000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0526	0.0526	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**13***	**146.27**	**247.34**	**393.19**	**247.34**	**247.34**	-	**6.0**	**15.6**	**40.0**
	13†	**146.27**	**247.34**	**393.19**	**247.34**	**247.34**				
External leakage - Utility medium	5*	37.48	95.13	200.06	95.13	95.13	-	6.0	19.0	35.0
	5†	37.48	95.13	200.06	95.13	95.13				
Other	5*	37.48	95.13	200.06	95.13	95.13	-	7.0	16.0	40.0
	5†	37.48	95.13	200.06	95.13	95.13				
Parameter deviation	2*	6.75	38.05	119.77	38.05	38.05	-	6.0	7.0	8.0
	2†	6.75	38.05	119.77	38.05	38.05				
Vibration	1*	0.95	19.03	90.28	19.03	19.03	-	14.0	14.0	14.0
	1†	0.95	19.03	90.28	19.03	19.03				
Incipient	**12***	**131.75**	**228.31**	**369.86**	**228.31**	**228.31**	-	**2.0**	**14.3**	**92.0**
	12†	**131.75**	**228.31**	**369.86**	**228.31**	**228.31**				
Abnormal instrument reading	6*	49.75	114.16	225.27	114.16	114.16	-	2.0	5.8	19.0
	6†	49.75	114.16	225.27	114.16	114.16				
Minor in-service problems	4*	25.97	76.10	174.18	76.10	76.10	-	3.0	7.8	12.0
	4†	25.97	76.10	174.18	76.10	76.10				
Parameter deviation	2*	6.75	38.05	119.77	38.05	38.05	-	13.0	52.5	92.0
	2†	6.75	38.05	119.77	38.05	38.05				
All modes	**25***	**330.69**	**475.65**	**664.29**	**475.65**	**475.65**	-	**2.0**	**15.0**	**92.0**
	25†	**330.69**	**475.65**	**664.29**	**475.65**	**475.65**				

Comments

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Taxonomy no	Item
1.1.1.2	Machinery Compressors Centrifugal Turbine driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
22	8	0.5999	0.4095	2469

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**44***	**41.52**	**73.49**	**112.84**	**21.92**	**73.34**	**5.6**	**1.0**	**75.3**	**1481.0**
	44†	**53.93**	**107.71**	**176.46**	**37.79**	**107.46**				
Breakdown	1*	0.01	1.46	5.26	1.94	1.67	-	1481.0	1481.0	1481.0
	1†	0.01	2.12	8.25	3.06	2.44				
Erratic output	2*	0.00	4.87	24.17	10.26	3.33	4.3	3.0	8.5	14.0
	2†	0.00	5.69	27.64	11.48	4.88				
External leakage - Utility medium	3*	0.01	5.27	21.25	8.00	5.00	0.5	1.0	28.0	55.0
	3†	0.01	7.59	30.75	11.59	7.33				
Fail to start on demand	15*	3.26	31.57	84.69	27.05	25.00	3.0	2.0	54.5	203.0
	15†	7.81	41.97	98.46	29.18	36.63				
Fail to stop on demand	1*	0.12	1.76	5.06	1.67	1.67	-	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
Other	1*	0.12	1.76	5.06	1.67	1.67	-	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
Parameter deviation	1*	0.01	1.46	5.26	1.94	1.67	-	8.0	8.0	8.0
	1†	0.01	2.12	8.25	3.06	2.44				
Spurious stop	16*	15.79	25.69	37.54	6.67	26.67	10.0	2.0	16.2	80.0
	16†	9.69	35.70	75.08	20.70	39.07				
Vibration	4*	2.22	6.60	12.87	3.33	6.67	-	40.0	69.3	100.0
	4†	0.01	9.18	38.21	14.56	9.77				
Degraded	**104***	**12.78**	**149.69**	**417.19**	**135.80**	**173.35**	**33.2**	**1.0**	**21.0**	**180.0**
	104†	**9.82**	**232.74**	**699.80**	**236.44**	**253.99**				
Abnormal instrument reading	12*	1.62	19.24	53.74	17.51	20.00	5.0	2.0	16.7	29.0
	12†	13.64	29.29	49.74	11.17	29.31				
Erratic output	1*	0.01	1.46	5.26	1.94	1.67	-	4.0	4.0	4.0
	1†	0.01	2.12	8.25	3.06	2.44				
External leakage - Process medium	13*	0.83	19.78	59.48	20.11	21.67	-	1.0	17.7	98.0
	13†	0.63	28.14	86.74	30.49	31.75				
External leakage - Utility medium	33*	0.61	43.20	137.31	49.43	55.01	100.0	2.0	28.4	88.0
	33†	0.52	69.45	236.40	87.00	80.59				
Fail to stop on demand	1*	0.12	1.76	5.06	1.67	1.67	-	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
High output	1*	0.01	1.46	5.26	1.94	1.67	-	3.5	3.5	3.5
	1†	0.01	2.12	8.25	3.06	2.44				
Internal leakage	2*	0.00	3.87	18.21	7.43	3.33	-	-	-	-
	2†	0.00	6.70	33.59	14.37	4.88				
Low output	2*	0.02	5.27	20.55	7.62	3.33	3.0	6.0	19.0	32.0
	2†	0.07	5.88	19.05	6.92	4.88				
Other	33*	0.89	47.68	148.57	52.77	55.01	25.4	1.0	19.8	180.0
	33†	0.75	72.08	235.68	85.91	80.59				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.2	Machinery Compressors Centrifugal Turbine driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
22	8	0.5999	0.4095	2469

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Overheating	2*	0.73	3.54	8.08	2.36	3.33	13.0	26.0	26.0	26.0
	2†	0.07	5.98	19.29	6.99	4.88				
Parameter deviation	1*	0.01	1.90	7.10	2.62	1.67	9.0	18.0	18.0	18.0
	1†	0.00	3.19	14.93	6.07	2.44				
Vibration	3*	0.07	4.64	14.76	5.32	5.00	-	10.0	18.0	26.0
	3†	0.02	6.89	27.39	10.23	7.33				
Incipient	**147***	**20.07**	**236.67**	**660.45**	**215.10**	**245.03**	**17.0**	**1.0**	**23.7**	**370.0**
	147†	**15.25**	**391.87**	**1180.91**	**401.18**	**359.00**				
Abnormal instrument reading	59*	28.71	92.07	184.69	49.04	98.35	2.9	2.0	9.0	46.0
	59†	21.66	142.62	352.24	107.70	144.09				
Erratic output	2*	0.00	4.87	24.17	10.26	3.33	43.8	38.0	87.5	137.0
	2†	0.00	5.69	27.64	11.48	4.88				
External leakage - Process medium	1*	0.00	4.68	22.76	9.45	1.67	9.0	9.0	9.0	9.0
	1†	0.00	4.85	24.47	10.51	2.44				
External leakage - Utility medium	37*	0.32	54.46	192.19	70.98	61.67	40.8	1.0	46.5	370.0
	37†	0.40	90.52	338.56	124.96	90.36				
Low output	1*	0.01	1.46	5.26	1.94	1.67	-	2.0	2.0	2.0
	1†	0.01	2.12	8.25	3.06	2.44				
Minor in-service problems	18*	0.05	37.86	154.48	58.42	30.00	6.5	2.0	14.0	78.0
	18†	0.10	66.50	270.30	102.05	43.96				
Other	16*	6.71	24.23	50.63	13.89	26.67	23.0	1.0	21.3	64.0
	16†	3.70	34.92	93.13	29.65	39.07				
Overheating	1*	0.00	2.14	9.59	3.80	1.67	1.0	2.0	2.0	2.0
	1†	0.06	2.59	7.96	2.79	2.44				
Parameter deviation	9*	0.00	19.00	96.34	41.50	15.00	7.1	4.0	13.8	50.0
	9†	0.00	34.87	170.38	71.31	21.98				
Structural deficiency	1*	0.00	3.36	16.71	7.11	1.67	-	64.0	64.0	64.0
	1†	0.00	3.58	17.57	7.38	2.44				
Unknown	1*	0.00	1.53	6.81	2.69	1.67	-	6.0	6.0	6.0
	1†	0.00	2.23	10.53	4.30	2.44				
Vibration	1*	0.12	1.76	5.06	1.67	1.67	-	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
Unknown	**38***	**6.81**	**100.35**	**290.03**	**95.77**	**63.34**	**29.3**	**1.0**	**24.4**	**249.0**
	38†	**5.39**	**141.72**	**427.38**	**145.42**	**92.80**				
Abnormal instrument reading	19*	0.31	44.43	152.77	56.30	31.67	3.0	1.0	8.5	16.0
	19†	0.36	70.19	254.24	93.94	46.40				
External leakage - Utility medium	3*	0.00	5.79	29.37	12.65	5.00	-	-	-	-
	3†	0.00	10.34	53.35	23.25	7.33				
Low output	1*	0.00	3.36	16.71	7.11	1.67	-	12.0	12.0	12.0
	1†	0.00	3.58	17.57	7.38	2.44				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.2	Machinery Compressors Centrifugal Turbine driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
22	8	0.5999	0.4095	2469

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	1*	0.12	1.76	5.06	1.67	1.67	14.0	-	-	-
	1†	0.00	2.97	13.11	5.15	2.44				
Other	11*	0.96	30.24	91.76	31.59	18.34	2.0	2.0	19.5	105.0
	11†	2.32	37.08	108.29	35.88	26.86				
Overheating	1*	0.01	1.46	5.26	1.94	1.67	-	3.0	3.0	3.0
	1†	0.01	2.12	8.25	3.06	2.44				
Unknown	1*	0.00	2.14	9.59	3.80	1.67	124.5	249.0	249.0	249.0
	1†	0.06	2.59	7.96	2.79	2.44				
Vibration	1*	0.00	4.68	22.76	9.45	1.67	-	9.0	9.0	9.0
	1†	0.00	4.85	24.47	10.51	2.44				
All modes	**333***	**171.84**	**564.28**	**1141.65**	**305.35**	**555.07**	**18.7**	**1.0**	**29.7**	**1481.0**
	333†	**160.16**	**878.17**	**2070.53**	**615.17**	**813.25**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $4.5 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.1.2.1	Machinery Compressors Centrifugal Turbine driven (3000-10000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	4	0.1601	0.1246	563

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**9***	**5.28**	**71.74**	**204.89**	**67.36**	**56.23**	-	**8.0**	**78.6**	**203.0**
	9†	**8.93**	**88.85**	**239.78**	**76.83**	**72.23**				
Fail to start on demand	7*	4.51	56.68	159.93	52.33	43.73	-	8.0	87.5	203.0
	7†	8.07	68.38	177.69	55.68	56.18				
Spurious stop	1*	0.00	5.91	24.82	9.50	6.25	-	36.0	36.0	36.0
	1†	0.14	8.92	28.14	10.08	8.03				
Vibration	1*	0.03	7.77	29.39	10.84	6.25	-	68.0	68.0	68.0
	1†	0.55	8.60	25.07	8.30	8.03				
Degraded	**14***	**13.63**	**96.66**	**242.71**	**74.87**	**87.47**	-	**1.0**	**19.4**	**40.0**
	14†	**4.93**	**145.64**	**440.85**	**151.15**	**112.35**				
Abnormal instrument reading	3*	5.44	19.14	39.68	10.82	18.74	-	2.0	13.3	20.0
	3†	2.21	27.84	78.59	25.72	24.08				
External leakage - Process medium	2*	0.82	17.08	51.18	17.13	12.50	-	40.0	40.0	40.0
	2†	3.03	18.07	43.57	13.13	16.05				
External leakage - Utility medium	5*	0.01	26.82	115.99	45.01	31.24	-	5.0	19.4	40.0
	5†	0.01	50.41	227.09	90.11	40.13				
Low output	1*	0.03	7.77	29.39	10.84	6.25	-	32.0	32.0	32.0
	1†	0.55	8.60	25.07	8.30	8.03				
Other	3*	3.79	19.81	46.15	13.63	18.74	-	1.0	7.3	16.0
	3†	1.65	30.06	89.19	29.70	24.08				
Incipient	**11***	**11.58**	**77.70**	**192.72**	**59.07**	**68.73**	**9.0**	**2.0**	**14.9**	**64.0**
	11†	**8.66**	**110.37**	**312.08**	**102.21**	**88.28**				
Abnormal instrument reading	4*	4.74	25.29	59.22	17.53	24.99	-	3.0	5.3	8.0
	4†	0.43	38.75	125.98	45.82	32.10				
External leakage - Process medium	1*	0.01	10.42	44.14	16.99	6.25	9.0	9.0	9.0	9.0
	1†	0.01	10.98	44.93	17.01	8.03				
External leakage - Utility medium	1*	0.03	7.77	29.39	10.84	6.25	-	15.0	15.0	15.0
	1†	0.55	8.60	25.07	8.30	8.03				
Minor in-service problems	1*	0.03	7.77	29.39	10.84	6.25	-	39.0	39.0	39.0
	1†	0.55	8.60	25.07	8.30	8.03				
Other	2*	0.98	12.02	33.79	11.04	12.50	-	2.0	5.0	8.0
	2†	0.02	19.52	81.42	31.06	16.05				
Structural deficiency	1*	0.03	7.77	29.39	10.84	6.25	-	64.0	64.0	64.0
	1†	0.55	8.60	25.07	8.30	8.03				
Unknown	1*	0.00	5.91	24.82	9.50	6.25	-	6.0	6.0	6.0
	1†	0.14	8.92	28.14	10.08	8.03				
Unknown	**13***	**6.19**	**133.52**	**400.55**	**134.46**	**81.22**	-	**1.0**	**16.6**	**105.0**
	13†	**9.63**	**151.18**	**440.64**	**145.92**	**104.33**				
Abnormal instrument reading	6*	0.93	50.43	157.26	55.89	37.49	-	1.0	9.3	16.0
	6†	1.73	67.49	206.59	72.06	48.15				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.2.1	Machinery Compressors Centrifugal Turbine driven (3000-10000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	4	0.1601	0.1246	563

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.03	7.77	29.39	10.84	6.25	-	12.0	12.0	12.0
	1†	0.55	8.60	25.07	8.30	8.03				
Other	5*	0.91	54.57	171.25	61.16	31.24	-	2.0	27.8	105.0
	5†	0.91	56.19	176.73	63.21	40.13				
Vibration	1*	0.01	10.42	44.14	16.99	6.25	-	9.0	9.0	9.0
	1†	0.01	10.98	44.93	17.01	8.03				
All modes	**47***	**62.65**	**388.92**	**946.95**	**287.11**	**293.65**	**9.0**	**1.0**	**27.8**	**203.0**
	47†	**60.52**	**507.13**	**1315.06**	**411.78**	**377.18**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.2 \cdot 10^{-2}$

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Taxonomy no	Item
1.1.1.2.2	Machinery Compressors Centrifugal Turbine driven (10000-20000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	5	0.4399	0.2849	1906

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**35***	**58.51**	**79.26**	**102.60**	**13.45**	**79.57**	**5.6**	**1.0**	**74.2**	**1481.0**
	35†	**62.66**	**123.44**	**200.83**	**42.59**	**122.87**				
Breakdown	1*	0.02	1.97	6.69	2.46	2.27	-	1481.0	1481.0	1481.0
	1†	0.02	3.05	10.49	3.86	3.51				
Erratic output	2*	0.00	7.15	32.44	12.91	4.55	4.3	3.0	8.5	14.0
	2†	0.00	8.57	37.81	14.85	7.02				
External leakage - Utility medium	3*	0.06	7.38	24.65	9.04	6.82	0.5	1.0	28.0	55.0
	3†	0.14	11.23	35.97	13.00	10.53				
Fail to start on demand	8*	1.45	17.36	48.58	15.84	18.19	3.0	2.0	5.1	8.0
	8†	9.45	28.28	55.27	14.36	28.08				
Fail to stop on demand	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-
	1†	0.00	4.53	18.90	7.21	3.51				
Other	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-
	1†	0.00	4.53	18.90	7.21	3.51				
Parameter deviation	1*	0.02	1.97	6.69	2.46	2.27	-	8.0	8.0	8.0
	1†	0.02	3.05	10.49	3.86	3.51				
Spurious stop	15*	5.88	32.29	76.16	22.63	34.10	10.0	2.0	14.8	80.0
	15†	31.87	52.04	76.23	13.60	52.66				
Vibration	3*	1.05	6.79	16.70	5.09	6.82	-	40.0	70.0	100.0
	3†	2.77	10.38	21.96	6.08	10.53				
Degraded	**90***	**23.42**	**216.01**	**572.79**	**181.73**	**204.60**	**33.2**	**1.0**	**21.4**	**180.0**
	90†	**44.20**	**341.86**	**873.59**	**271.78**	**315.94**				
Abnormal instrument reading	9*	3.20	20.75	51.05	15.57	20.46	5.0	10.0	18.3	29.0
	9†	16.65	32.27	52.05	10.91	31.59				
Erratic output	1*	0.02	1.97	6.69	2.46	2.27	-	4.0	4.0	4.0
	1†	0.02	3.05	10.49	3.86	3.51				
External leakage - Process medium	11*	0.02	24.23	101.14	38.60	25.01	-	1.0	13.6	98.0
	11†	0.05	34.75	141.65	53.54	38.62				
External leakage - Utility medium	28*	7.08	65.38	173.43	55.04	63.65	100.0	2.0	31.0	88.0
	28†	11.65	105.18	277.49	87.77	98.29				
Fail to stop on demand	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-
	1†	0.00	4.53	18.90	7.21	3.51				
High output	1*	0.02	1.97	6.69	2.46	2.27	-	3.5	3.5	3.5
	1†	0.02	3.05	10.49	3.86	3.51				
Internal leakage	2*	0.00	5.51	24.33	9.56	4.55	-	-	-	-
	2†	0.00	10.26	46.44	18.46	7.02				
Low output	1*	0.00	3.13	13.55	5.26	2.27	3.0	6.0	6.0	6.0
	1†	0.04	3.91	12.82	4.68	3.51				
Other	30*	1.63	76.32	235.85	83.14	68.20	25.4	2.0	21.2	180.0
	30†	4.82	114.07	342.97	115.86	105.31				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.2.2	Machinery Compressors Centrifugal Turbine driven (10000-20000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	5	0.4399	0.2849	1906

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Overheating	2*	0.99	4.96	11.44	3.36	4.55	13.0	26.0	26.0	26.0
	2†	0.32	9.03	27.31	9.35	7.02				
Parameter deviation	1*	0.01	2.75	10.86	4.04	2.27	9.0	18.0	18.0	18.0
	1†	0.00	4.90	21.30	8.28	3.51				
Vibration	3*	0.37	6.84	20.34	6.78	6.82	-	10.0	18.0	26.0
	3†	0.17	10.78	34.01	12.19	10.53				
Incipient	**136***	**71.37**	**337.52**	**766.15**	**222.68**	**309.18**	**17.2**	**1.0**	**24.6**	**370.0**
	136†	**88.26**	**583.11**	**1441.26**	**440.86**	**477.43**				
Abnormal instrument reading	55*	69.37	132.98	213.29	44.33	125.04	2.9	2.0	9.4	46.0
	55†	85.02	215.98	395.63	96.67	193.08				
Erratic output	2*	0.00	7.15	32.44	12.91	4.55	43.8	38.0	87.5	137.0
	2†	0.00	8.57	37.81	14.85	7.02				
External leakage - Utility medium	36*	4.54	77.77	229.10	76.12	81.84	40.8	1.0	47.5	370.0
	36†	4.68	136.19	412.03	141.13	126.38				
Low output	1*	0.02	1.97	6.69	2.46	2.27	-	2.0	2.0	2.0
	1†	0.02	3.05	10.49	3.86	3.51				
Minor in-service problems	17*	0.25	51.33	187.95	69.43	38.65	6.5	2.0	11.7	78.0
	17†	0.61	97.65	340.96	125.84	59.68				
Other	14*	9.74	30.04	59.40	15.59	31.83	23.0	1.0	23.6	64.0
	14†	8.89	46.81	109.31	32.31	49.15				
Overheating	1*	0.00	3.13	13.55	5.26	2.27	1.0	2.0	2.0	2.0
	1†	0.04	3.91	12.82	4.68	3.51				
Parameter deviation	9*	0.01	28.98	127.65	50.07	20.46	7.1	4.0	13.8	50.0
	9†	0.04	54.90	231.47	88.86	31.59				
Vibration	1*	0.03	2.52	8.19	2.98	2.27	-	-	-	-
	1†	0.00	4.53	18.90	7.21	3.51				
Unknown	**25***	**0.65**	**70.55**	**233.66**	**85.50**	**56.83**	**29.3**	**2.0**	**35.6**	**249.0**
	25†	**1.01**	**128.15**	**433.21**	**159.24**	**87.76**				
Abnormal instrument reading	13*	0.02	37.81	162.52	62.93	29.55	3.0	4.0	6.0	8.0
	13†	0.09	73.80	303.75	115.24	45.64				
External leakage - Utility medium	3*	0.00	8.41	38.96	15.73	6.82	-	-	-	-
	3†	0.00	15.97	73.42	29.44	10.53				
Noise	1*	0.03	2.52	8.19	2.98	2.27	14.0	-	-	-
	1†	0.00	4.53	18.90	7.21	3.51				
Other	6*	0.39	16.08	49.37	17.28	13.64	2.0	2.0	11.2	36.0
	6†	1.35	24.77	73.54	24.49	21.06				
Overheating	1*	0.02	1.97	6.69	2.46	2.27	-	3.0	3.0	3.0
	1†	0.02	3.05	10.49	3.86	3.51				
Unknown	1*	0.00	3.13	13.55	5.26	2.27	124.5	249.0	249.0	249.0
	1†	0.04	3.91	12.82	4.68	3.51				

Comments

(cont.)

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Taxonomy no	Item
1.1.1.2.2	Machinery Compressors Centrifugal Turbine driven (10000-20000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	5	0.4399	0.2849	1906

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	**286***	**292.23**	**701.91**	**1254.69**	**298.76**	**650.19**	**18.9**	**1.0**	**30.2**	**1481.0**
	286†	**371.45**	**1179.56**	**2357.72**	**624.28**	**1004.00**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $2.1 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.1.3	Machinery Compressors Centrifugal Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	3	0.2365	0.0648	900

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**16***	**7.87**	**67.65**	**176.21**	**55.29**	**67.65**	**8.5**	**1.0**	**23.2**	**84.5**
	16†	**9.71**	**865.69**	**2808.94**	**1021.04**	**246.91**				
Abnormal instrument reading	2*	0.85	8.46	22.84	7.32	8.46	2.5	17.0	17.0	17.0
	2†	3.56	109.67	332.46	114.30	30.86				
Breakdown	2*	0.07	8.46	28.24	10.36	8.46	6.5	25.5	36.5	47.5
	2†	0.17	117.40	478.24	180.72	30.86				
External leakage - Utility medium	4*	2.62	16.91	41.59	12.68	16.91	21.8	18.5	36.4	84.5
	4†	2.60	236.71	769.63	279.97	61.73				
Fail to start on demand	4*	5.77	16.91	32.79	8.46	16.91	4.3	1.0	5.8	10.5
	4†	0.99	123.74	417.36	153.35	61.73				
Internal leakage	1*	0.21	4.23	12.66	4.23	4.23	1.0	2.0	2.0	2.0
	1†	0.08	55.50	226.62	85.72	15.43				
Spurious stop	3*	0.05	12.68	48.72	17.94	12.68	4.3	6.0	6.0	6.0
	3†	0.26	179.18	729.42	275.56	46.30				
Degraded	**3***	**3.47**	**12.68**	**26.62**	**7.32**	**12.68**	**13.7**	**11.0**	**30.5**	**50.0**
	3†	**9.91**	**54.63**	**128.96**	**38.34**	**46.30**				
Low output	3*	3.47	12.68	26.62	7.32	12.68	13.7	11.0	30.5	50.0
	3†	9.91	54.63	128.96	38.34	46.30				
Incipient	**82***	**3.40**	**346.69**	**1140.75**	**416.64**	**346.69**	**3.4**	**1.0**	**6.9**	**98.0**
	82†	**37.88**	**4941.54**	**16757.28**	**6162.92**	**1265.43**				
Abnormal instrument reading	3*	3.47	12.68	26.62	7.32	12.68	4.0	6.0	6.0	6.0
	3†	0.51	120.52	452.91	167.11	46.30				
External leakage - Utility medium	24*	9.83	101.47	275.96	88.79	101.47	4.9	1.0	9.2	53.0
	24†	35.85	1469.37	4509.04	1577.57	370.37				
Fail to start on demand	1*	0.21	4.23	12.66	4.23	4.23	4.0	4.0	4.0	4.0
	1†	0.08	55.50	226.62	85.72	15.43				
Internal leakage	47*	0.06	198.71	870.90	340.50	198.71	1.9	1.0	3.0	15.5
	47†	4.29	2895.34	11773.26	4445.64	725.31				
Minor in-service problems	4*	5.77	16.91	32.79	8.46	16.91	8.5	2.0	9.5	15.5
	4†	8.77	174.40	522.05	174.28	61.73				
Other	1*	0.21	4.23	12.66	4.23	4.23	6.0	3.0	3.0	3.0
	1†	0.08	55.50	226.62	85.72	15.43				
Overheating	1*	0.21	4.23	12.66	4.23	4.23	12.0	98.0	98.0	98.0
	1†	0.08	55.50	226.62	85.72	15.43				
Vibration	1*	0.21	4.23	12.66	4.23	4.23	3.0	25.5	25.5	25.5
	1†	0.08	55.50	226.62	85.72	15.43				
All modes	**101***	**34.37**	**427.03**	**1202.45**	**393.13**	**427.03**	**4.5**	**1.0**	**9.6**	**98.0**
	101†	**94.73**	**5889.87**	**18535.59**	**6632.54**	**1558.64**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $4.4 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.1.3.1	Machinery Compressors Centrifugal Unknown Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	3	0.2365	0.0648	900

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**16***	**7.87**	**67.65**	**176.21**	**55.29**	**67.65**	**8.5**	**1.0**	**23.2**	**84.5**
	16†	**9.71**	**865.69**	**2808.94**	**1021.04**	**246.91**				
Abnormal instrument reading	2*	0.85	8.46	22.84	7.32	8.46	2.5	17.0	17.0	17.0
	2†	3.56	109.67	332.46	114.30	30.86				
Breakdown	2*	0.07	8.46	28.24	10.36	8.46	6.5	25.5	36.5	47.5
	2†	0.17	117.40	478.24	180.72	30.86				
External leakage - Utility medium	4*	2.62	16.91	41.59	12.68	16.91	21.8	18.5	36.4	84.5
	4†	2.60	236.71	769.63	279.97	61.73				
Fail to start on demand	4*	5.77	16.91	32.79	8.46	16.91	4.3	1.0	5.8	10.5
	4†	0.99	123.74	417.36	153.35	61.73				
Internal leakage	1*	0.21	4.23	12.66	4.23	4.23	1.0	2.0	2.0	2.0
	1†	0.08	55.50	226.62	85.72	15.43				
Spurious stop	3*	0.05	12.68	48.72	17.94	12.68	4.3	6.0	6.0	6.0
	3†	0.26	179.18	729.42	275.56	46.30				
Degraded	**3***	**3.47**	**12.68**	**26.62**	**7.32**	**12.68**	**13.7**	**11.0**	**30.5**	**50.0**
	3†	**9.91**	**54.63**	**128.96**	**38.34**	**46.30**				
Low output	3*	3.47	12.68	26.62	7.32	12.68	13.7	11.0	30.5	50.0
	3†	9.91	54.63	128.96	38.34	46.30				
Incipient	**82***	**3.40**	**346.69**	**1140.75**	**416.64**	**346.69**	**3.4**	**1.0**	**6.9**	**98.0**
	82†	**37.88**	**4941.54**	**16757.28**	**6162.92**	**1265.43**				
Abnormal instrument reading	3*	3.47	12.68	26.62	7.32	12.68	4.0	6.0	6.0	6.0
	3†	0.51	120.52	452.91	167.11	46.30				
External leakage - Utility medium	24*	9.83	101.47	275.96	88.79	101.47	4.9	1.0	9.2	53.0
	24†	35.85	1469.37	4509.04	1577.57	370.37				
Fail to start on demand	1*	0.21	4.23	12.66	4.23	4.23	4.0	4.0	4.0	4.0
	1†	0.08	55.50	226.62	85.72	15.43				
Internal leakage	47*	0.06	198.71	870.90	340.50	198.71	1.9	1.0	3.0	15.5
	47†	4.29	2895.34	11773.26	4445.64	725.31				
Minor in-service problems	4*	5.77	16.91	32.79	8.46	16.91	8.5	2.0	9.5	15.5
	4†	8.77	174.40	522.05	174.28	61.73				
Other	1*	0.21	4.23	12.66	4.23	4.23	6.0	3.0	3.0	3.0
	1†	0.08	55.50	226.62	85.72	15.43				
Overheating	1*	0.21	4.23	12.66	4.23	4.23	12.0	98.0	98.0	98.0
	1†	0.08	55.50	226.62	85.72	15.43				
Vibration	1*	0.21	4.23	12.66	4.23	4.23	3.0	25.5	25.5	25.5
	1†	0.08	55.50	226.62	85.72	15.43				
All modes	**101***	**34.37**	**427.03**	**1202.45**	**393.13**	**427.03**	**4.5**	**1.0**	**9.6**	**98.0**
	101†	**94.73**	**5889.87**	**18535.59**	**6632.54**	**1558.64**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $4.4 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.2	Machinery Compressors Reciprocating

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**367***	**0.01**	**347.08**	**1678.18**	**693.22**	**501.19**	**8.9**	**0.5**	**13.0**	**250.0**
	367†	**0.20**	**451.95**	**1951.42**	**756.79**	**727.25**				
Abnormal instrument reading	1*	0.00	1.86	7.90	3.05	1.37	16.0	16.0	16.0	16.0
	1†	0.19	2.19	6.09	1.98	1.98				
Breakdown	2*	0.09	2.27	6.84	2.32	2.73	116.5	74.0	140.5	207.0
	2†	0.07	3.41	10.62	3.77	3.96				
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	20.0	8.0	14.0	20.0
	2†	0.05	13.26	50.59	18.64	3.96				
External leakage - Process medium	40*	0.00	36.68	201.99	100.72	54.63	3.8	0.5	6.7	81.0
	40†	0.00	45.55	246.92	114.85	79.26				
External leakage - Utility medium	16*	0.00	17.39	82.87	34.03	21.85	3.4	1.0	6.9	50.0
	16†	0.06	24.15	95.41	35.56	31.71				
Fail to start on demand	11*	0.01	15.40	65.18	25.07	15.02	39.4	4.0	42.0	204.0
	11†	0.01	37.42	166.98	65.98	21.80				
Fail to stop on demand	2*	0.00	4.52	19.93	7.83	2.73	3.5	3.5	10.8	18.0
	2†	0.00	9.20	40.96	16.16	3.96				
Low output	140*	0.00	122.03	663.02	308.86	191.19	6.2	0.5	10.9	168.0
	140†	0.00	140.44	752.91	347.39	277.42				
Noise	2*	0.00	3.81	17.89	7.30	2.73	29.0	4.0	18.5	33.0
	2†	0.00	8.72	39.92	15.93	3.96				
Other	1*	0.00	4.19	20.60	8.68	1.37	-	1.0	1.0	1.0
	1†	0.00	10.07	44.20	17.30	1.98				
Overheating	64*	0.00	58.83	305.92	135.89	87.40	3.8	0.5	8.2	36.0
	64†	0.00	72.66	356.65	149.99	126.82				
Parameter deviation	46*	0.00	42.79	231.70	107.70	62.82	15.9	0.5	21.1	250.0
	46†	0.00	53.10	275.04	121.17	91.15				
Spurious stop	30*	7.43	43.47	104.22	31.29	40.97	12.0	1.0	13.9	48.0
	30†	31.64	63.24	103.64	22.20	59.45				
Structural deficiency	5*	0.03	7.26	26.79	9.89	6.83	11.4	2.0	13.8	36.0
	5†	1.56	10.08	24.79	7.56	9.91				
Vibration	5*	0.03	6.68	24.11	8.91	6.83	4.0	1.0	7.6	28.0
	5†	2.93	9.77	19.90	5.35	9.91				
Degraded	**241***	**0.80**	**269.46**	**1051.97**	**390.37**	**329.12**	**7.3**	**0.3**	**8.5**	**128.0**
	241†	**5.86**	**463.96**	**1488.90**	**538.67**	**477.57**				
Erratic output	8*	1.34	24.58	72.95	24.29	10.93	36.0	8.0	29.4	96.0
	8†	4.82	50.60	138.09	44.51	15.85				
External leakage - Process medium	24*	0.00	24.42	126.96	56.38	32.78	2.2	0.5	3.9	24.0
	24†	0.00	34.68	157.98	62.96	47.56				
External leakage - Utility medium	8*	0.12	9.58	30.71	11.10	10.93	4.9	0.3	7.3	22.0
	8†	1.51	14.10	37.49	11.91	15.85				

Comments

(cont.)

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Taxonomy no	Item
1.1.2	Machinery Compressors Reciprocating

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Fail to start on demand	1*	0.00	1.40	6.51	2.63	1.37	1.0	1.0	1.0	1.0
	1†	0.01	1.94	7.53	2.79	1.98				
Fail to stop on demand	2*	0.31	2.83	7.47	2.36	2.73	3.3	0.5	3.3	6.0
	2†	0.01	3.74	14.92	5.58	3.96				
Internal leakage	2*	0.31	2.83	7.47	2.36	2.73	2.3	1.0	4.0	7.0
	2†	0.01	3.74	14.92	5.58	3.96				
Low output	92*	0.27	107.04	422.57	157.47	125.64	11.3	0.5	12.1	128.0
	92†	0.26	214.65	883.00	334.94	182.31				
Other	1*	0.00	4.19	20.60	8.68	1.37	-	30.0	30.0	30.0
	1†	0.00	10.07	44.20	17.30	1.98				
Overheating	23*	0.24	28.56	95.52	35.04	31.41	7.8	1.0	10.3	48.0
	23†	6.99	41.71	100.53	30.29	45.58				
Parameter deviation	65*	0.00	57.31	304.91	201.91	88.77	1.8	0.3	2.1	10.0
	65†	0.00	68.55	366.56	239.26	128.80				
Structural deficiency	5*	0.03	6.68	24.11	8.91	6.83	3.7	0.5	5.4	10.0
	5†	2.93	9.77	19.90	5.35	9.91				
Unknown	6*	0.06	12.24	44.50	16.44	8.19	33.0	4.0	33.5	64.0
	6†	0.17	31.03	111.15	41.07	11.89				
Vibration	4*	0.11	5.80	17.99	6.37	5.46	1.2	1.0	1.2	1.5
	4†	0.01	8.86	36.49	13.85	7.93				
Incipient	**454***	**0.03**	**427.59**	**1970.30**	**791.74**	**619.99**	**3.6**	**0.3**	**4.5**	**116.0**
	454†	**1.91**	**615.73**	**2397.46**	**888.66**	**899.65**				
Abnormal instrument reading	98*	0.00	90.60	433.07	178.08	133.83	3.1	0.3	3.4	24.0
	98†	0.22	127.28	513.02	192.92	194.20				
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	8.0	5.0	6.5	8.0
	2†	0.05	13.26	50.59	18.64	3.96				
External leakage - Process medium	20*	0.65	28.02	86.20	30.24	27.31	13.0	1.0	14.8	115.0
	20†	7.08	42.08	101.31	30.50	39.63				
External leakage - Utility medium	22*	13.36	31.27	55.28	13.01	30.04	9.7	0.3	10.7	116.0
	22†	8.35	49.40	118.81	35.74	43.60				
Minor in-service problems	236*	0.00	200.63	1099.31	514.60	322.29	1.6	0.3	2.7	29.0
	236†	0.00	231.74	1249.76	579.27	467.66				
Noise	4*	0.37	6.24	18.33	6.09	5.46	19.7	5.0	16.8	33.0
	4†	1.06	9.64	25.49	8.07	7.93				
Other	9*	0.18	21.82	73.45	26.97	12.29	1.7	1.0	6.9	20.0
	9†	0.60	46.30	148.35	53.63	17.83				
Overheating	8*	2.69	11.66	25.80	7.37	10.93	13.9	2.0	13.3	51.0
	8†	2.18	17.48	45.00	14.05	15.85				
Parameter deviation	22*	0.02	23.21	97.82	37.55	30.04	5.5	1.0	5.6	24.0
	22†	0.99	34.14	103.93	35.98	43.60				

Comments

(cont.)

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Taxonomy no	Item
1.1.2	Machinery Compressors Reciprocating

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	6*	0.22	8.18	24.96	8.68	8.19	1.4	0.5	2.7	8.0
	6†	0.21	10.83	33.62	11.90	11.89				
Unknown	17*	0.00	23.23	134.17	72.82	23.22	14.5	2.0	14.5	32.0
	17†	0.00	74.82	387.69	170.92	33.69				
Vibration	10*	3.21	13.18	28.69	8.11	13.66	1.8	1.0	2.7	8.0
	10†	1.61	17.28	47.36	15.30	19.82				
Unknown	**12***	**0.04**	**14.45**	**56.56**	**21.01**	**16.39**	**5.7**	**0.8**	**10.2**	**24.0**
	12†	**2.02**	**21.18**	**57.77**	**18.61**	**23.78**				
Unknown	12*	0.04	14.45	56.56	21.01	16.39	5.7	0.8	10.2	24.0
	12†	2.02	21.18	57.77	18.61	23.78				
All modes	**1074***	**0.16**	**1038.22**	**4671.32**	**1852.75**	**1466.68**	**6.3**	**0.3**	**8.5**	**250.0**
	1074†	**6.30**	**1501.47**	**5666.15**	**2089.96**	**2128.25**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.9 \cdot 10^{-4}$

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Maintainable item versus failure mode, to be continued
Item: Compressors - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.84	0.00	0.00	0.00	0.09	0.19	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
Cylinder liner	0.28	0.00	4.10	1.30	0.00	0.00	0.00	0.09	12.20	0.00
Filter(s)	0.00	0.00	0.09	0.09	0.00	0.00	0.00	0.00	0.19	0.00
Gearbox/var.drive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.37	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Instrument, general	0.84	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.09	0.00
Instrument, level	0.28	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	2.05	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Instrument, vibration	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal piping	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.09	0.00	0.47	0.28	0.09	0.00	0.00	0.00	0.19	0.00
Packing	0.00	0.00	0.47	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.09	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.09	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.05	0.19	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.37	0.28	0.00	0.09	0.00	0.00	2.79	0.00
Pump w/motor/gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00
Seals	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.09	0.00
Silencers	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Subunit	0.00	0.09	0.09	0.09	0.19	0.37	0.00	0.00	1.12	0.19
Unknown	0.19	0.00	0.19	0.09	0.00	0.19	0.00	0.00	0.93	0.19
Valves	0.74	0.00	1.30	0.42	0.19	0.09	0.00	0.09	3.63	0.09
Total	9.22	0.19	7.82	4.28	1.12	1.12	0.00	0.19	21.60	0.56

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.09
Base frame	0.00	0.00	0.00	1.86	0.19	0.00	0.00	0.00	0.09	2.14
Cabling & junction boxes	0.00	0.00	0.09	0.09	0.09	0.00	0.09	0.09	0.00	0.74
Casing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Check valves	0.00	0.00	0.47	0.09	0.00	0.00	0.00	0.09	0.00	0.65
Control unit	0.00	0.00	0.74	0.00	0.09	0.19	0.00	0.28	0.09	2.51
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.28
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.47
Cylinder liner	7.17	0.09	1.21	0.65	0.47	0.00	0.56	0.28	0.37	28.77
Filter(s)	0.00	0.00	0.09	14.25	0.00	0.00	0.00	0.09	0.00	14.80
Gearbox/var.drive	0.00	0.09	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.19
Instrument, flow	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	1.30
Instrument, general	0.00	0.00	0.56	0.19	0.00	0.00	0.00	0.09	0.00	1.86
Instrument, level	0.00	0.00	0.28	0.09	0.00	0.00	0.00	0.09	0.00	0.84
Instrument, pressure	0.00	0.00	1.30	0.28	0.00	0.00	0.00	0.19	0.00	4.19
Instrument, speed	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Instrument, temperature	0.19	0.09	1.12	0.00	0.00	0.00	0.00	0.28	0.09	3.96
Instrument, vibration	0.00	0.09	1.30	0.00	0.00	0.00	0.00	0.09	0.19	2.47
Internal piping	0.09	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.09	0.74
Internal power supply	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Monitoring	0.00	0.00	0.74	0.28	0.00	0.00	0.00	0.00	0.00	1.40
Oil	0.00	0.00	0.00	0.09	0.00	0.00	0.19	0.19	0.00	0.56
Other	0.00	0.47	0.19	0.56	0.09	0.00	1.02	0.00	0.09	3.54
Packing	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.65
Piping	0.00	0.00	0.00	0.28	0.19	0.00	0.00	0.19	0.00	1.30
Piping, pipe support + bellows	0.09	0.00	0.00	0.37	0.09	0.00	0.00	0.00	0.09	0.93
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.51
Pump w/motor	0.00	0.09	0.28	0.28	0.00	0.09	0.19	0.09	0.00	4.56
Pump w/motor/gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Seals	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.37
Silencers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Subunit	0.19	0.00	0.19	0.28	0.00	0.00	0.19	0.19	0.09	3.26
Unknown	0.74	0.00	0.47	0.84	0.28	0.00	0.19	0.47	0.28	5.03
Valves	0.37	0.09	2.33	0.65	0.00	0.00	0.74	0.09	0.09	10.94
Total	8.85	1.02	12.38	21.97	1.49	0.37	3.26	2.79	1.77	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Compressors - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.09	0.28	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	6.52	0.00	0.19	0.47	0.00	0.28	0.00	0.09	1.02	0.00
Leakage	0.00	0.00	0.28	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.09	0.37	0.00	0.00	0.00	0.00	0.00	0.09
Mechanical Failure - general	0.56	0.09	6.70	2.33	0.09	0.09	0.00	0.09	18.62	0.00
Misc. external influences	0.19	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.37	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Open circuit	0.37	0.00	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.47	0.00	0.09	0.09	0.00	0.47	0.00	0.00	1.40	0.19
Vibration	0.19	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.09	0.00
Wear	0.00	0.00	0.09	0.09	0.56	0.00	0.00	0.00	0.09	0.00
Total	9.22	0.19	7.82	4.28	1.12	1.12	0.00	0.19	21.60	0.56

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Compressors - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.09	0.00	0.00	0.19	0.00	0.00	0.28
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.09	0.28
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Combined causes	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.37
Contamination	0.00	0.00	0.09	0.28	0.00	0.00	0.19	0.00	0.00	0.56
Control failure	0.09	0.00	0.09	0.09	0.09	0.00	0.00	0.37	0.00	1.12
Corrosion	0.00	0.00	0.09	0.28	0.00	0.00	0.00	0.09	0.00	0.47
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.09
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.28
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Instrument failure - general	0.56	0.19	7.64	1.02	0.09	0.28	0.00	0.37	0.09	18.81
Leakage	0.09	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.93
Looseness	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.28
Material failure - general	0.00	0.00	0.00	0.09	0.00	0.00	0.28	0.00	0.00	0.93
Mechanical Failure - general	7.36	0.37	2.33	17.97	1.12	0.00	0.93	0.65	0.93	60.24
Misc. external influences	0.00	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.19	1.02
Miscellaneous - general	0.00	0.37	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.47
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Open circuit	0.00	0.00	0.74	0.19	0.00	0.00	0.09	0.09	0.00	1.68
Other	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.09	0.00	1.21
Out of adjustment	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.09	0.00	0.56
Overheating	0.37	0.00	0.19	0.00	0.00	0.00	0.09	0.56	0.00	1.49
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.37
Software failure	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.84
Unknown	0.37	0.00	0.09	0.19	0.09	0.00	0.93	0.00	0.00	4.38
Vibration	0.00	0.00	0.19	0.37	0.09	0.00	0.00	0.37	0.28	1.68
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.02
Total	8.85	1.02	12.38	21.97	1.49	0.37	3.26	2.79	1.77	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.1.2.1	Machinery Compressors Reciprocating Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**367***	**0.01**	**347.08**	**1678.18**	**693.22**	**501.19**	**8.9**	**0.5**	**13.0**	**250.0**
	367†	**0.20**	**451.95**	**1951.42**	**756.79**	**727.25**				
Abnormal instrument reading	1*	0.00	1.86	7.90	3.05	1.37	16.0	16.0	16.0	16.0
	1†	0.19	2.19	6.09	1.98	1.98				
Breakdown	2*	0.09	2.27	6.84	2.32	2.73	116.5	74.0	140.5	207.0
	2†	0.07	3.41	10.62	3.77	3.96				
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	20.0	8.0	14.0	20.0
	2†	0.05	13.26	50.59	18.64	3.96				
External leakage - Process medium	40*	0.00	36.68	201.99	100.72	54.63	3.8	0.5	6.7	81.0
	40†	0.00	45.55	246.92	114.85	79.26				
External leakage - Utility medium	16*	0.00	17.39	82.87	34.03	21.85	3.4	1.0	6.9	50.0
	16†	0.06	24.15	95.41	35.56	31.71				
Fail to start on demand	11*	0.01	15.40	65.18	25.07	15.02	39.4	4.0	42.0	204.0
	11†	0.01	37.42	166.98	65.98	21.80				
Fail to stop on demand	2*	0.00	4.52	19.93	7.83	2.73	3.5	3.5	10.8	18.0
	2†	0.00	9.20	40.96	16.16	3.96				
Low output	140*	0.00	122.03	663.02	308.86	191.19	6.2	0.5	10.9	168.0
	140†	0.00	140.44	752.91	347.39	277.42				
Noise	2*	0.00	3.81	17.89	7.30	2.73	29.0	4.0	18.5	33.0
	2†	0.00	8.72	39.92	15.93	3.96				
Other	1*	0.00	4.19	20.60	8.68	1.37	-	1.0	1.0	1.0
	1†	0.00	10.07	44.20	17.30	1.98				
Overheating	64*	0.00	58.83	305.92	135.89	87.40	3.8	0.5	8.2	36.0
	64†	0.00	72.66	356.65	149.99	126.82				
Parameter deviation	46*	0.00	42.79	231.70	107.70	62.82	15.9	0.5	21.1	250.0
	46†	0.00	53.10	275.04	121.17	91.15				
Spurious stop	30*	7.43	43.47	104.22	31.29	40.97	12.0	1.0	13.9	48.0
	30†	31.64	63.24	103.64	22.20	59.45				
Structural deficiency	5*	0.03	7.26	26.79	9.89	6.83	11.4	2.0	13.8	36.0
	5†	1.56	10.08	24.79	7.56	9.91				
Vibration	5*	0.03	6.68	24.11	8.91	6.83	4.0	1.0	7.6	28.0
	5†	2.93	9.77	19.90	5.35	9.91				
Degraded	**241***	**0.80**	**269.46**	**1051.97**	**390.37**	**329.12**	**7.3**	**0.3**	**8.5**	**128.0**
	241†	**5.86**	**463.96**	**1488.90**	**538.67**	**477.57**				
Erratic output	8*	1.34	24.58	72.95	24.29	10.93	36.0	8.0	29.4	96.0
	8†	4.82	50.60	138.09	44.51	15.85				
External leakage - Process medium	24*	0.00	24.42	126.96	56.38	32.78	2.2	0.5	3.9	24.0
	24†	0.00	34.68	157.98	62.96	47.56				
External leakage - Utility medium	8*	0.12	9.58	30.71	11.10	10.93	4.9	0.3	7.3	22.0
	8†	1.51	14.10	37.49	11.91	15.85				

Comments

(cont.)

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Taxonomy no	Item
1.1.2.1	Machinery Compressors Reciprocating Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Fail to start on demand	1*	0.00	1.40	6.51	2.63	1.37	1.0	1.0	1.0	1.0
	1†	0.01	1.94	7.53	2.79	1.98				
Fail to stop on demand	2*	0.31	2.83	7.47	2.36	2.73	3.3	0.5	3.3	6.0
	2†	0.01	3.74	14.92	5.58	3.96				
Internal leakage	2*	0.31	2.83	7.47	2.36	2.73	2.3	1.0	4.0	7.0
	2†	0.01	3.74	14.92	5.58	3.96				
Low output	92*	0.27	107.04	422.57	157.47	125.64	11.3	0.5	12.1	128.0
	92†	0.26	214.65	883.00	334.94	182.31				
Other	1*	0.00	4.19	20.60	8.68	1.37	-	30.0	30.0	30.0
	1†	0.00	10.07	44.20	17.30	1.98				
Overheating	23*	0.24	28.56	95.52	35.04	31.41	7.8	1.0	10.3	48.0
	23†	6.99	41.71	100.53	30.29	45.58				
Parameter deviation	65*	0.00	57.31	304.91	201.91	88.77	1.8	0.3	2.1	10.0
	65†	0.00	68.55	366.56	239.26	128.80				
Structural deficiency	5*	0.03	6.68	24.11	8.91	6.83	3.7	0.5	5.4	10.0
	5†	2.93	9.77	19.90	5.35	9.91				
Unknown	6*	0.06	12.24	44.50	16.44	8.19	33.0	4.0	33.5	64.0
	6†	0.17	31.03	111.15	41.07	11.89				
Vibration	4*	0.11	5.80	17.99	6.37	5.46	1.2	1.0	1.2	1.5
	4†	0.01	8.86	36.49	13.85	7.93				
Incipient	**454***	**0.03**	**427.59**	**1970.30**	**791.74**	**619.99**	**3.6**	**0.3**	**4.5**	**116.0**
	454†	**1.91**	**615.73**	**2397.46**	**888.66**	**899.65**				
Abnormal instrument reading	98*	0.00	90.60	433.07	178.08	133.83	3.1	0.3	3.4	24.0
	98†	0.22	127.28	513.02	192.92	194.20				
Erratic output	2*	0.00	5.04	21.49	8.30	2.73	8.0	5.0	6.5	8.0
	2†	0.05	13.26	50.59	18.64	3.96				
External leakage - Process medium	20*	0.65	28.02	86.20	30.24	27.31	13.0	1.0	14.8	115.0
	20†	7.08	42.08	101.31	30.50	39.63				
External leakage - Utility medium	22*	13.36	31.27	55.28	13.01	30.04	9.7	0.3	10.7	116.0
	22†	8.35	49.40	118.81	35.74	43.60				
Minor in-service problems	236*	0.00	200.63	1099.31	514.60	322.29	1.6	0.3	2.7	29.0
	236†	0.00	231.74	1249.76	579.27	467.66				
Noise	4*	0.37	6.24	18.33	6.09	5.46	19.7	5.0	16.8	33.0
	4†	1.06	9.64	25.49	8.07	7.93				
Other	9*	0.18	21.82	73.45	26.97	12.29	1.7	1.0	6.9	20.0
	9†	0.60	46.30	148.35	53.63	17.83				
Overheating	8*	2.69	11.66	25.80	7.37	10.93	13.9	2.0	13.3	51.0
	8†	2.18	17.48	45.00	14.05	15.85				
Parameter deviation	22*	0.02	23.21	97.82	37.55	30.04	5.5	1.0	5.6	24.0
	22†	0.99	34.14	103.93	35.98	43.60				

Comments

(cont.)

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Taxonomy no	Item
1.1.2.1	Machinery Compressors Reciprocating Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	10	0.7323	0.5046	36658

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	6*	0.22	8.18	24.96	8.68	8.19	1.4	0.5	2.7	8.0
	6†	0.21	10.83	33.62	11.90	11.89				
Unknown	17*	0.00	23.23	134.17	72.82	23.22	14.5	2.0	14.5	32.0
	17†	0.00	74.82	387.69	170.92	33.69				
Vibration	10*	3.21	13.18	28.69	8.11	13.66	1.8	1.0	2.7	8.0
	10†	1.61	17.28	47.36	15.30	19.82				
Unknown	**12***	**0.04**	**14.45**	**56.56**	**21.01**	**16.39**	**5.7**	**0.8**	**10.2**	**24.0**
	12†	**2.02**	**21.18**	**57.77**	**18.61**	**23.78**				
Unknown	12*	0.04	14.45	56.56	21.01	16.39	5.7	0.8	10.2	24.0
	12†	2.02	21.18	57.77	18.61	23.78				
All modes	**1074***	**0.16**	**1038.22**	**4671.32**	**1852.75**	**1466.68**	**6.3**	**0.3**	**8.5**	**250.0**
	1074†	**6.30**	**1501.47**	**5666.15**	**2089.96**	**2128.25**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.9 \cdot 10^{-4}$

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Taxonomy no	Item
1.1.2.1.1	Machinery Compressors Reciprocating Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
18	8	0.3669	0.2195	36658

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**28***	**12.57**	**82.29**	**202.98**	**62.02**	**76.31**	**30.7**	**1.0**	**28.0**	**204.0**
	28†	**18.43**	**170.90**	**453.76**	**144.08**	**127.56**				
Abnormal instrument reading	1*	0.00	3.09	15.62	6.72	2.73	16.0	16.0	16.0	16.0
	1†	0.01	4.80	18.97	7.07	4.56				
Erratic output	2*	0.05	6.84	23.40	8.62	5.45	20.0	8.0	14.0	20.0
	2†	0.08	18.37	69.19	25.52	9.11				
Fail to start on demand	8*	0.00	17.77	82.71	33.51	21.80	52.3	8.0	55.6	204.0
	8†	0.00	45.19	233.41	102.06	36.45				
Fail to stop on demand	1*	0.00	5.55	27.02	11.25	2.73	-	18.0	18.0	18.0
	1†	0.00	13.68	63.85	25.91	4.56				
Noise	1*	0.00	5.55	27.02	11.25	2.73	-	4.0	4.0	4.0
	1†	0.00	13.68	63.85	25.91	4.56				
Other	1*	0.00	5.55	27.02	11.25	2.73	-	1.0	1.0	1.0
	1†	0.00	13.68	63.85	25.91	4.56				
Spurious stop	13*	0.77	34.55	106.55	37.48	35.43	18.1	1.0	17.4	38.0
	13†	17.70	62.23	128.92	35.15	59.23				
Structural deficiency	1*	0.00	3.09	15.62	6.72	2.73	36.0	36.0	36.0	36.0
	1†	0.01	4.80	18.97	7.07	4.56				
Degraded	**63***	**0.21**	**147.48**	**600.92**	**227.11**	**171.69**	**28.3**	**2.0**	**27.9**	**128.0**
	63†	**0.10**	**367.60**	**1618.72**	**634.87**	**287.02**				
Erratic output	8*	3.56	32.07	84.56	26.73	21.80	36.0	8.0	29.4	96.0
	8†	6.99	67.41	180.63	57.66	36.45				
External leakage - Process medium	1*	0.00	2.68	11.56	4.48	2.73	-	-	-	-
	1†	0.10	5.76	17.99	6.40	4.56				
External leakage - Utility medium	1*	0.03	2.38	7.56	2.73	2.73	6.0	6.0	6.0	6.0
	1†	0.05	3.92	12.59	4.56	4.56				
Low output	40*	0.00	73.02	401.36	191.40	109.01	28.9	2.0	28.8	128.0
	40†	0.00	202.49	1113.74	525.67	182.23				
Other	1*	0.00	5.55	27.02	11.25	2.73	-	30.0	30.0	30.0
	1†	0.00	13.68	63.85	25.91	4.56				
Overheating	4*	0.06	10.85	39.02	14.42	10.90	23.5	2.5	23.5	48.0
	4†	0.11	16.54	56.97	21.00	18.22				
Parameter deviation	1*	0.00	2.68	11.56	4.48	2.73	1.0	10.0	10.0	10.0
	1†	0.10	5.76	17.99	6.40	4.56				
Unknown	6*	1.70	17.60	47.91	15.42	16.35	33.0	4.0	33.5	64.0
	6†	0.22	42.56	153.69	56.79	27.34				
Vibration	1*	0.00	2.68	11.56	4.48	2.73	-	-	-	-
	1†	0.10	5.76	17.99	6.40	4.56				
Incipient	**59***	**0.70**	**130.36**	**467.91**	**172.89**	**160.79**	**16.4**	**1.0**	**15.8**	**116.0**
	59†	**0.21**	**315.28**	**1334.85**	**513.53**	**268.80**				

Comments

(cont.)

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Taxonomy no	Item
1.1.2.1.1	Machinery Compressors Reciprocating Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
18	8	0.3669	0.2195	36658

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Abnormal instrument reading	8*	6.25	20.78	42.23	11.34	21.80	4.8	2.0	4.8	9.0
	8†	0.05	39.87	163.47	61.93	36.45				
Erratic output	2*	0.05	6.84	23.40	8.62	5.45	8.0	5.0	6.5	8.0
	2†	0.08	18.37	69.19	25.52	9.11				
External leakage - Process medium	6*	0.08	16.64	61.16	22.59	16.35	30.2	6.0	30.2	115.0
	6†	1.90	30.93	90.53	30.02	27.34				
External leakage - Utility medium	9*	2.86	23.66	61.21	19.15	24.53	19.1	1.0	20.1	116.0
	9†	0.20	45.66	171.19	63.17	41.00				
Minor in-service problems	5*	0.79	11.25	32.32	10.65	13.63	9.4	2.0	9.4	20.0
	5†	0.05	20.52	81.20	30.28	22.78				
Noise	3*	2.33	8.60	18.11	4.99	8.18	19.7	5.0	19.7	33.0
	3†	0.13	15.60	52.15	19.13	13.67				
Other	4*	0.03	25.86	106.13	40.22	10.90	-	4.0	12.8	20.0
	4†	0.25	62.60	239.91	88.37	18.22				
Overheating	2*	0.99	5.49	12.96	3.85	5.45	41.5	51.0	51.0	51.0
	2†	0.00	13.35	60.91	24.29	9.11				
Parameter deviation	2*	0.12	4.48	13.72	4.78	5.45	3.5	2.0	3.5	5.0
	2†	0.89	7.83	20.51	6.46	9.11				
Unknown	17*	0.00	30.22	175.28	95.66	46.33	14.5	2.0	14.5	32.0
	17†	0.00	95.16	524.98	264.13	77.45				
Vibration	1*	0.03	2.38	7.56	2.73	2.73	-	-	-	-
	1†	0.05	3.92	12.59	4.56	4.56				
All modes	**150***	**1.91**	**349.46**	**1249.08**	**461.50**	**408.79**	**23.7**	**1.0**	**22.7**	**204.0**
	150†	**1.22**	**843.29**	**3433.54**	**1297.25**	**683.38**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.9 \cdot 10^{-4}$

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Taxonomy no	Item
1.1.2.1.2	Machinery Compressors Reciprocating Electric driven (1000-3000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.1248	0.0583	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**26.31**	**56.07**	**105.33**	**56.07**	**56.07**	**43.3**	**4.0**	**51.0**	**207.0**
	7†	**56.30**	**119.98**	**225.39**	**119.98**	**119.98**				
Breakdown	2*	2.84	16.02	50.42	16.02	16.02	116.5	74.0	140.5	207.0
	2†	6.08	34.28	107.89	34.28	34.28				
External leakage - Process medium	1*	0.40	8.01	38.01	8.01	8.01	8.0	8.0	8.0	8.0
	1†	0.86	17.14	81.33	17.14	17.14				
Fail to start on demand	2*	2.84	16.02	50.42	16.02	16.02	5.5	4.0	6.5	9.0
	2†	6.08	34.28	107.89	34.28	34.28				
Noise	1*	0.40	8.01	38.01	8.01	8.01	29.0	33.0	33.0	33.0
	1†	0.86	17.14	81.33	17.14	17.14				
Spurious stop	1*	0.40	8.01	38.01	8.01	8.01	22.0	22.0	22.0	22.0
	1†	0.86	17.14	81.33	17.14	17.14				
Degraded	**1***	**0.40**	**8.01**	**38.01**	**8.01**	**8.01**	**9.0**	**22.0**	**22.0**	**22.0**
	1†	**0.86**	**17.14**	**81.33**	**17.14**	**17.14**				
External leakage - Utility medium	1*	0.40	8.01	38.01	8.01	8.01	9.0	22.0	22.0	22.0
	1†	0.86	17.14	81.33	17.14	17.14				
Incipient	**10***	**43.45**	**80.10**	**135.85**	**80.10**	**80.10**	**4.4**	**2.0**	**4.8**	**8.0**
	10†	**92.98**	**171.40**	**290.69**	**171.40**	**171.40**				
Abnormal instrument reading	2*	2.84	16.02	50.42	16.02	16.02	5.0	2.0	5.0	8.0
	2†	6.08	34.28	107.89	34.28	34.28				
External leakage - Utility medium	3*	6.57	24.03	62.12	24.03	24.03	3.0	2.0	3.0	4.0
	3†	14.05	51.42	132.92	51.42	51.42				
Minor in-service problems	2*	2.84	16.02	50.42	16.02	16.02	5.5	3.0	5.5	8.0
	2†	6.08	34.28	107.89	34.28	34.28				
Noise	1*	0.40	8.01	38.01	8.01	8.01	-	8.0	8.0	8.0
	1†	0.86	17.14	81.33	17.14	17.14				
Other	1*	0.40	8.01	38.01	8.01	8.01	4.0	4.0	4.0	4.0
	1†	0.86	17.14	81.33	17.14	17.14				
Vibration	1*	0.40	8.01	38.01	8.01	8.01	6.0	6.0	6.0	6.0
	1†	0.86	17.14	81.33	17.14	17.14				
All modes	**18***	**93.18**	**144.18**	**213.78**	**144.18**	**144.18**	**20.7**	**2.0**	**23.7**	**207.0**
	18†	**199.39**	**308.52**	**457.46**	**308.52**	**308.52**				

Comments

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Taxonomy no	Item
1.1.2.1.3	Machinery Compressors Reciprocating Electric driven (3000-10000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	2	0.2405	0.2268	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**332***	**1181.54**	**1380.57**	**1592.47**	**125.03**	**1380.57**	**6.6**	**0.5**	**11.0**	**250.0**
	332†	**1252.81**	**1463.84**	**1688.52**	**132.57**	**1463.84**				
External leakage - Process medium	39*	20.24	162.18	417.18	130.18	162.18	3.7	0.5	6.6	81.0
	39†	21.46	171.96	442.34	138.03	171.96				
External leakage - Utility medium	16*	29.93	66.53	114.84	26.30	66.53	3.4	1.0	6.9	50.0
	16†	31.74	70.55	121.77	27.89	70.55				
Fail to start on demand	1*	0.21	4.16	12.45	4.16	4.16	4.0	4.0	4.0	4.0
	1†	0.22	4.41	13.21	4.41	4.41				
Fail to stop on demand	1*	0.21	4.16	12.45	4.16	4.16	3.5	3.5	3.5	3.5
	1†	0.22	4.41	13.21	4.41	4.41				
Low output	140*	415.09	582.17	772.40	109.07	582.17	6.2	0.5	10.9	168.0
	140†	440.12	617.28	818.99	115.65	617.28				
Overheating	64*	213.88	266.13	323.11	33.27	266.13	3.8	0.5	8.2	36.0
	64†	226.78	282.19	342.60	35.27	282.19				
Parameter deviation	46*	63.14	191.28	375.72	98.05	191.28	15.9	0.5	21.1	250.0
	46†	66.95	202.82	398.38	103.97	202.82				
Spurious stop	16*	41.73	66.53	96.04	16.63	66.53	6.8	1.0	10.8	48.0
	16†	44.24	70.55	101.83	17.64	70.55				
Structural deficiency	4*	0.14	16.63	55.56	20.37	16.63	3.2	2.0	6.3	12.0
	4†	0.15	17.64	58.91	21.60	17.64				
Vibration	5*	5.90	20.79	43.11	11.76	20.79	4.0	1.0	7.6	28.0
	5†	6.25	22.05	45.71	12.47	22.05				
Degraded	**177***	**293.37**	**736.03**	**1341.07**	**325.95**	**736.03**	**2.4**	**0.3**	**3.8**	**41.0**
	177†	**311.07**	**780.42**	**1421.96**	**345.61**	**780.42**				
External leakage - Process medium	23*	15.16	95.64	233.80	71.06	95.64	2.2	0.5	3.9	24.0
	23†	16.08	101.41	247.90	75.34	101.41				
External leakage - Utility medium	6*	9.23	24.95	46.91	11.76	24.95	3.9	0.3	4.7	8.0
	6†	9.79	26.46	49.74	12.47	26.46				
Fail to start on demand	1*	0.21	4.16	12.45	4.16	4.16	1.0	1.0	1.0	1.0
	1†	0.22	4.41	13.21	4.41	4.41				
Fail to stop on demand	2*	0.42	8.32	24.91	8.32	8.32	3.3	0.5	3.3	6.0
	2†	0.44	8.82	26.41	8.82	8.82				
Internal leakage	2*	0.42	8.32	24.91	8.32	8.32	2.3	1.0	4.0	7.0
	2†	0.44	8.82	26.41	8.82	8.82				
Low output	52*	153.85	216.23	287.32	40.74	216.23	2.5	0.5	4.8	40.0
	52†	163.13	229.28	304.65	43.20	229.28				
Overheating	19*	51.73	79.01	110.99	18.13	79.01	4.6	1.0	7.7	41.0
	19†	54.85	83.77	117.68	19.22	83.77				
Parameter deviation	64*	2.30	266.13	888.91	325.95	266.13	1.8	0.3	1.9	6.0
	64†	2.43	282.19	942.53	345.61	282.19				

Comments

(cont.)

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Taxonomy no
1.1.2.1.3

Item
Machinery
Compressors
Reciprocating
Electric driven
(3000-10000)kW

Population	Installations
12	2

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
0.2405	0.2268

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Structural deficiency	5*	5.90	20.79	43.11	11.76	20.79	3.7	0.5	5.4	10.0
	5†	6.25	22.05	45.71	12.47	22.05				
Vibration	3*	3.41	12.48	26.18	7.20	12.48	1.2	1.0	1.2	1.5
	3†	3.62	13.23	27.76	7.64	13.23				
Incipient	**385***	**1138.37**	**1600.96**	**2128.16**	**302.16**	**1600.96**	**2.0**	**0.3**	**3.0**	**37.5**
	385†	**1207.03**	**1697.53**	**2256.53**	**320.39**	**1697.53**				
Abnormal instrument reading	88*	304.22	365.93	432.38	39.01	365.93	2.9	0.3	3.3	24.0
	88†	322.57	388.01	458.46	41.36	388.01				
External leakage - Process medium	14*	21.40	58.22	109.73	27.58	58.22	3.4	1.0	6.2	37.5
	14†	22.69	61.73	116.35	29.25	61.73				
External leakage - Utility medium	10*	21.04	41.58	67.76	14.40	41.58	1.7	0.3	3.0	14.0
	10†	22.31	44.09	71.85	15.27	44.09				
Minor in-service problems	229*	489.85	952.26	1538.61	323.18	952.26	1.4	0.3	2.5	29.0
	229†	519.40	1009.70	1631.41	342.67	1009.70				
Other	4*	5.68	16.63	32.25	8.32	16.63	1.1	1.0	1.8	3.0
	4†	6.02	17.64	34.19	8.82	17.64				
Overheating	6*	9.23	24.95	46.91	11.76	24.95	2.8	2.0	5.7	12.0
	6†	9.79	26.46	49.74	12.47	26.46				
Parameter deviation	20*	48.60	83.17	125.24	23.52	83.17	5.7	1.0	5.9	24.0
	20†	51.53	88.18	132.79	24.94	88.18				
Structural deficiency	6*	9.23	24.95	46.91	11.76	24.95	1.4	0.5	2.7	8.0
	6†	9.79	26.46	49.74	12.47	26.46				
Vibration	8*	16.55	33.27	54.68	11.76	33.27	1.2	1.0	2.2	8.0
	8†	17.55	35.27	57.98	12.47	35.27				
Unknown	**12***	**28.80**	**49.90**	**75.72**	**14.40**	**49.90**	**5.7**	**0.8**	**10.2**	**24.0**
	12†	**30.53**	**52.91**	**80.29**	**15.27**	**52.91**				
Unknown	12*	28.80	49.90	75.72	14.40	49.90	5.7	0.8	10.2	24.0
	12†	30.53	52.91	80.29	15.27	52.91				
All modes	**906***	**3042.26**	**3767.47**	**4556.77**	**461.18**	**3767.47**	**3.9**	**0.3**	**6.3**	**250.0**
	906†	**3225.76**	**3994.71**	**4831.63**	**489.00**	**3994.71**				

Comments

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Taxonomy no	Item
1.1.3	Machinery Compressors Screw

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	16	1.1045	0.5904	38694

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**79***	**0.00**	**116.04**	**609.99**	**275.74**	**71.53**	**14.7**	**1.0**	**23.2**	**163.0**
	79†	**0.00**	**140.09**	**769.79**	**373.30**	**133.81**				
Erratic output	4*	0.00	7.41	40.83	20.46	3.62	6.8	7.0	9.8	15.0
	4†	0.00	9.79	53.89	26.82	6.78				
External leakage - Process medium	2*	0.00	2.28	10.91	4.49	1.81	17.5	12.0	29.0	46.0
	2†	0.00	3.54	15.62	6.14	3.39				
External leakage - Utility medium	7*	0.00	12.88	71.55	36.87	6.34	14.1	13.0	38.9	96.0
	7†	0.00	16.30	92.68	49.60	11.86				
Fail to start on demand	12*	0.00	18.90	83.77	32.98	10.86	5.9	1.0	8.7	32.0
	12†	0.03	27.27	112.54	42.74	20.33				
Low output	11*	0.00	18.29	100.56	47.65	9.96	16.2	2.0	26.7	163.0
	11†	0.00	22.94	126.59	63.76	18.63				
Noise	1*	0.00	1.12	6.21	3.17	0.91	73.0	76.0	76.0	76.0
	1†	0.00	1.64	7.89	3.25	1.69				
Other	1*	0.00	1.12	6.21	3.17	0.91	7.0	7.0	7.0	7.0
	1†	0.00	1.64	7.89	3.25	1.69				
Overheating	4*	0.00	5.63	25.58	10.18	3.62	20.1	2.0	20.5	70.0
	4†	0.05	7.60	26.26	9.68	6.78				
Parameter deviation	2*	0.01	2.51	9.48	3.50	1.81	10.8	11.0	21.5	32.0
	2†	0.00	4.39	21.73	9.22	3.39				
Spurious stop	34*	0.00	47.83	248.15	109.74	30.78	15.8	2.0	23.6	148.0
	34†	0.00	60.01	319.53	146.54	57.59				
Structural deficiency	1*	0.00	1.62	8.57	3.89	0.91	21.5	43.0	43.0	43.0
	1†	0.01	1.96	7.66	2.85	1.69				
Degraded	**94***	**0.00**	**145.59**	**799.98**	**386.44**	**85.11**	**9.7**	**1.0**	**16.4**	**123.0**
	94†	**0.00**	**166.70**	**964.75**	**528.61**	**159.22**				
Abnormal instrument reading	1*	0.00	1.12	6.21	3.17	0.91	5.0	5.0	5.0	5.0
	1†	0.00	1.64	7.89	3.25	1.69				
Erratic output	5*	0.00	8.35	44.28	20.22	4.53	6.9	2.0	10.6	35.0
	5†	0.00	11.16	58.03	25.80	8.47				
External leakage - Process medium	5*	0.00	8.41	44.47	20.24	4.53	2.5	1.0	4.6	15.0
	5†	0.00	11.79	60.36	26.12	8.47				
External leakage - Utility medium	28*	0.00	45.78	251.84	124.36	25.35	10.7	1.0	18.0	111.0
	28†	0.00	53.70	311.26	169.39	47.43				
Internal leakage	1*	0.00	1.12	6.21	3.17	0.91	48.0	48.0	48.0	48.0
	1†	0.00	1.64	7.89	3.25	1.69				
Low output	6*	0.00	5.88	32.94	19.24	5.43	6.5	2.0	6.5	12.0
	6†	0.00	8.04	44.34	22.21	10.16				
Noise	1*	0.00	1.12	6.21	3.17	0.91	15.0	15.0	15.0	15.0
	1†	0.00	1.64	7.89	3.25	1.69				

Comments

(cont.)

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Taxonomy no	Item
1.1.3	Machinery Compressors Screw

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	16	1.1045	0.5904	38694

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Other	9*	0.00	13.26	66.10	28.18	8.15	16.1	1.0	30.4	123.0
	9†	0.00	19.67	93.62	38.43	15.24				
Overheating	3*	0.00	3.12	16.57	7.58	2.72	11.0	16.0	20.0	24.0
	3†	0.00	5.15	21.86	8.42	5.08				
Parameter deviation	33*	0.00	58.51	328.77	173.25	29.88	8.4	2.0	15.7	101.0
	33†	0.00	67.77	360.86	238.35	55.90				
Structural deficiency	2*	0.00	3.64	20.01	9.49	1.81	6.3	8.0	12.5	17.0
	2†	0.00	4.93	25.67	11.43	3.39				
Incipient	**112***	**0.00**	**179.70**	**987.42**	**477.83**	**101.41**	**15.0**	**1.0**	**28.2**	**961.0**
	112†	**0.00**	**212.34**	**1217.73**	**657.06**	**189.71**				
Abnormal instrument reading	65*	0.00	107.89	596.67	303.32	58.85	6.3	1.0	10.5	176.0
	65†	0.00	123.75	677.24	416.91	110.10				
External leakage - Process medium	1*	0.00	1.62	8.57	3.89	0.91	1.0	2.0	2.0	2.0
	1†	0.01	1.96	7.66	2.85	1.69				
External leakage - Utility medium	5*	0.01	5.97	24.61	9.34	4.53	5.5	1.0	10.4	38.0
	5†	0.32	9.68	29.33	10.08	8.47				
Minor in-service problems	31*	0.00	52.11	287.82	145.62	28.07	3.5	1.0	6.2	23.0
	31†	0.00	61.03	342.85	199.27	52.51				
Other	4*	0.00	5.75	26.89	10.93	3.62	321.2	1.0	482.0	961.0
	4†	0.00	10.80	49.56	19.84	6.78				
Parameter deviation	4*	0.00	5.74	26.06	10.37	3.62	4.3	2.0	5.7	8.0
	4†	0.03	8.75	34.18	12.69	6.78				
Structural deficiency	2*	0.00	2.32	11.72	5.05	1.81	6.5	10.0	13.0	16.0
	2†	0.00	3.97	18.51	7.51	3.39				
Unknown	**6***	**0.06**	**15.65**	**60.26**	**22.21**	**5.43**	**5.0**	**8.0**	**11.7**	**16.0**
	6†	**0.15**	**32.53**	**119.50**	**44.14**	**10.16**				
Other	2*	0.00	6.20	32.48	14.61	1.81	-	8.0	9.0	10.0
	2†	0.00	14.83	73.00	30.79	3.39				
Unknown	4*	0.00	9.57	43.26	17.19	3.62	5.0	8.0	13.0	16.0
	4†	0.00	18.10	81.69	32.45	6.78				
All modes	**291***	**0.00**	**456.85**	**2473.49**	**1149.61**	**263.47**	**13.1**	**1.0**	**22.6**	**961.0**
	291†	**0.00**	**544.54**	**3034.94**	**1575.81**	**492.90**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.8 \cdot 10^{-4}$

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Maintainable item versus failure mode, to be continued
Item: Compressors - Screw

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Base frame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.69	0.34	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Dry gas seal	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.17	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.69	0.00
Instrument, flow	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.69	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
Instrument, pressure	6.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	9.28	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00
Instrument, vibration	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal piping	0.17	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.34	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lube oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00
Monitoring	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.34	0.00
Piping	0.00	0.00	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Purge air	0.00	0.00	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Seals	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Shaft seals	0.00	0.00	0.34	3.44	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.69	0.00	0.34	0.69	0.00	0.00	0.00	0.34	1.03	0.34
Unknown	0.00	0.00	0.34	0.69	0.00	0.69	0.00	0.00	0.00	0.00
Valves	0.69	0.00	1.03	0.69	2.41	1.03	0.00	0.00	3.09	0.00
Total	22.68	0.00	2.75	13.75	3.09	4.12	0.00	0.34	5.84	0.69

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Compressors - Screw

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Base frame	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.34
Bearing	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.72
Cabling & junction boxes	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Casing	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.69
Control unit	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.69	0.00	2.41
Cooler(s)	0.34	0.34	0.34	0.00	0.00	0.00	0.00	0.46	0.00	2.35
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Dry gas seal	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.03
Filter(s)	0.00	0.34	1.72	0.69	0.00	0.00	0.00	0.11	0.00	4.41
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Instrument, general	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	2.06
Instrument, level	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	1.72
Instrument, pressure	0.00	0.00	1.03	0.69	0.00	0.00	0.00	1.72	0.00	9.97
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Instrument, temperature	0.00	0.00	0.69	0.34	0.00	0.00	0.00	2.41	0.00	13.75
Instrument, vibration	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Internal piping	0.34	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	1.20
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	1.03
Interstage seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Lube oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Monitoring	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	1.37
Oil	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.69	0.00	1.37	0.34	0.00	0.69	0.00	0.00	4.12
Piping	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.11	0.00	3.89
Piping, pipe support + bellows	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Pump w/motor	0.86	0.00	1.72	0.34	0.00	0.00	0.34	0.00	0.00	3.26
Purge air	0.00	0.00	2.06	1.03	0.00	0.00	0.00	0.00	0.00	3.78
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Reservoir w/heating system	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	1.03
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Shaft seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	4.12
Subunit	0.34	1.03	0.00	0.34	0.00	0.00	0.00	1.37	0.00	6.53
Unknown	0.00	1.03	0.34	0.00	0.00	0.00	0.34	2.06	0.00	5.50
Valves	0.34	0.34	4.81	2.58	0.34	0.00	0.00	0.69	0.00	18.04
Total	2.41	5.50	13.40	10.65	1.72	0.00	1.37	11.68	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Compressors - Screw

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.34	0.00	0.00	0.34	0.34	0.00	0.00	0.00	0.34	0.00
Breakage	0.69	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.34	0.00
Corrosion	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.34	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	12.03	0.00	0.00	0.34	1.72	1.37	0.00	0.00	1.03	0.00
Leakage	0.00	0.00	1.37	3.44	0.00	0.34	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.34	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.69	0.00	0.00	6.87	0.69	0.00	0.00	0.00	1.37	0.00
Misc. external influences	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00
No signal/indication/alarm	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.09	0.00	0.00	0.00	0.34	0.69	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.34	0.00
Vibration	0.69	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	1.72	0.00	0.00	0.00	0.34	2.06	0.69
Total	22.68	0.00	2.75	13.75	3.09	4.12	0.00	0.34	5.84	0.69

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Compressors - Screw

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.34	0.34	1.72	0.00	0.00	0.00	0.00	0.69	0.00	4.47
Breakage	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	2.41
Cavitation	0.00	0.34	0.00	0.34	0.34	0.00	0.00	0.00	0.00	1.37
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Contamination	0.00	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69
Control failure	0.00	0.00	0.69	0.34	0.00	0.00	0.00	0.00	0.00	2.41
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Earth/isolation fault	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Electrical failure - general	0.00	0.69	0.34	0.34	0.00	0.00	0.00	0.34	0.00	2.41
External influence - general	0.00	1.72	1.03	0.00	0.00	0.00	0.00	0.34	0.00	3.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	1.37
Instrument failure - general	0.00	0.00	3.78	2.75	0.00	0.00	0.00	3.78	0.00	26.80
Leakage	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.34	0.00	5.84
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Material failure - general	0.00	0.34	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.69
Mechanical Failure - general	0.69	0.69	3.09	4.12	1.03	0.00	0.00	2.41	0.00	21.65
Misc. external influences	0.34	0.00	0.69	0.69	0.00	0.00	0.00	0.34	0.00	3.09
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Open circuit	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.34	0.00	0.00	0.00	0.00	0.69	0.00	0.00	1.03
Out of adjustment	0.69	0.00	0.69	0.00	0.00	0.00	0.00	0.69	0.00	6.19
Overheating	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.34
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Sticking	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.34
Unknown	0.00	0.00	0.34	0.00	0.00	0.00	0.69	1.03	0.00	2.75
Vibration	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	1.72
Wear	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.69	0.00	5.84
Total	2.41	5.50	13.40	10.65	1.72	0.00	1.37	11.68	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.1.3.1	Machinery Compressors Screw Diesel driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0245	0.0010	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**14.47**	**81.54**	**256.65**	**81.54**	**81.54**	**34.5**	**15.0**	**69.0**	**123.0**
	2†	**355.00**	**2000.00**	**6295.00**	**2000.00**	**2000.00**				
Other	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Incipient	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**103.3**	**5.0**	**206.6**	**961.0**
	5†	**1970.00**	**5000.00**	**10515.00**	**5000.00**	**5000.00**				
Abnormal instrument reading	1*	2.04	40.77	193.45	40.77	40.77	14.0	28.0	28.0	28.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	11.5	23.0	23.0	23.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Other	2*	14.47	81.54	256.65	81.54	81.54	241.5	5.0	483.0	961.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	8.0	16.0	16.0	16.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
All modes	**7***	**133.93**	**285.39**	**536.12**	**285.39**	**285.39**	**83.6**	**5.0**	**167.3**	**961.0**
	7†	**3285.00**	**7000.00**	**13150.00**	**7000.00**	**7000.00**				

Comments

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Taxonomy no	Item
1.1.3.1.1	Machinery Compressors Screw Diesel driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0245	0.0010	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**14.47**	**81.54**	**256.65**	**81.54**	**81.54**	**34.5**	**15.0**	**69.0**	**123.0**
	2†	**355.00**	**2000.00**	**6295.00**	**2000.00**	**2000.00**				
Other	2*	14.47	81.54	256.65	81.54	81.54	34.5	15.0	69.0	123.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Incipient	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**103.3**	**5.0**	**206.6**	**961.0**
	5†	**1970.00**	**5000.00**	**10515.00**	**5000.00**	**5000.00**				
Abnormal instrument reading	1*	2.04	40.77	193.45	40.77	40.77	14.0	28.0	28.0	28.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	11.5	23.0	23.0	23.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Other	2*	14.47	81.54	256.65	81.54	81.54	241.5	5.0	483.0	961.0
	2†	355.00	2000.00	6295.00	2000.00	2000.00				
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	8.0	16.0	16.0	16.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
All modes	**7***	**133.93**	**285.39**	**536.12**	**285.39**	**285.39**	**83.6**	**5.0**	**167.3**	**961.0**
	7†	**3285.00**	**7000.00**	**13150.00**	**7000.00**	**7000.00**				

Comments

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Taxonomy no	Item
1.1.3.2	Machinery Compressors Screw Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	16	1.0800	0.5894	38694

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**79***	**0.00**	**119.07**	**623.23**	**280.02**	**73.15**	**14.7**	**1.0**	**23.2**	**163.0**
	79†	**0.00**	**140.31**	**771.01**	**373.65**	**134.04**				
Erratic output	4*	0.00	7.43	41.04	20.71	3.70	6.8	7.0	9.8	15.0
	4†	0.00	9.79	53.91	26.83	6.79				
External leakage - Process medium	2*	0.43	2.02	4.58	1.33	1.85	17.5	12.0	29.0	46.0
	2†	0.00	3.55	15.81	6.24	3.39				
External leakage - Utility medium	7*	0.00	12.91	71.93	37.34	6.48	14.1	13.0	38.9	96.0
	7†	0.00	16.30	92.72	49.64	11.88				
Fail to start on demand	12*	0.01	19.39	85.34	33.45	11.11	5.9	1.0	8.7	32.0
	12†	0.03	27.31	112.65	42.77	20.36				
Low output	11*	0.00	18.32	100.68	48.26	10.19	16.2	2.0	26.7	163.0
	11†	0.00	22.95	126.63	63.80	18.66				
Noise	1*	0.00	1.14	6.30	3.17	0.93	73.0	76.0	76.0	76.0
	1†	0.00	1.64	7.89	3.25	1.70				
Other	1*	0.00	1.14	6.30	3.17	0.93	7.0	7.0	7.0	7.0
	1†	0.00	1.64	7.89	3.25	1.70				
Overheating	4*	0.00	5.69	25.77	10.24	3.70	20.1	2.0	20.5	70.0
	4†	0.05	7.60	26.23	9.67	6.79				
Parameter deviation	2*	0.01	2.90	11.70	4.40	1.85	10.8	11.0	21.5	32.0
	2†	0.00	4.42	21.89	9.28	3.39				
Spurious stop	34*	0.00	49.58	255.89	111.67	31.48	15.8	2.0	23.6	148.0
	34†	0.00	60.15	320.06	146.70	57.69				
Structural deficiency	1*	0.00	1.64	8.64	3.90	0.93	21.5	43.0	43.0	43.0
	1†	0.01	1.96	7.64	2.83	1.70				
Degraded	**92***	**0.00**	**145.57**	**800.25**	**391.94**	**85.19**	**9.2**	**1.0**	**15.2**	**111.0**
	92†	**0.00**	**163.88**	**929.89**	**529.52**	**156.10**				
Abnormal instrument reading	1*	0.00	1.14	6.30	3.17	0.93	5.0	5.0	5.0	5.0
	1†	0.00	1.64	7.89	3.25	1.70				
Erratic output	5*	0.00	8.39	44.63	20.45	4.63	6.9	2.0	10.6	35.0
	5†	0.00	11.16	58.06	25.82	8.48				
External leakage - Process medium	5*	0.00	8.86	46.23	20.66	4.63	2.5	1.0	4.6	15.0
	5†	0.00	11.83	60.47	26.16	8.48				
External leakage - Utility medium	28*	0.00	45.81	252.37	126.02	25.93	10.7	1.0	18.0	111.0
	28†	0.00	53.70	311.42	169.53	47.51				
Internal leakage	1*	0.00	1.14	6.30	3.17	0.93	48.0	48.0	48.0	48.0
	1†	0.00	1.64	7.89	3.25	1.70				
Low output	6*	0.00	5.91	33.01	19.44	5.56	6.5	2.0	6.5	12.0
	6†	0.00	8.05	44.37	22.22	10.18				
Noise	1*	0.00	1.14	6.30	3.17	0.93	15.0	15.0	15.0	15.0
	1†	0.00	1.64	7.89	3.25	1.70				

Comments

(cont.)

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Taxonomy no	Item
1.1.3.2	Machinery Compressors Screw Electric driven

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	16	1.0800	0.5894	38694

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Other	7*	0.00	12.12	62.14	26.92	6.48	10.0	1.0	17.5	46.0
	7†	0.00	16.03	80.33	34.37	11.88				
Overheating	3*	0.00	3.17	16.69	7.58	2.78	11.0	16.0	20.0	24.0
	3†	0.00	5.15	21.87	8.42	5.09				
Parameter deviation	33*	0.00	58.96	332.10	175.64	30.56	8.4	2.0	15.7	101.0
	33†	0.00	67.80	360.97	238.56	55.99				
Structural deficiency	2*	0.00	3.67	20.15	9.58	1.85	6.3	8.0	12.5	17.0
	2†	0.00	4.93	25.68	11.43	3.39				
Incipient	**107***	**0.00**	**179.22**	**985.45**	**484.37**	**99.08**	**10.3**	**1.0**	**18.8**	**961.0**
	107†	**0.00**	**205.40**	**1177.72**	**656.93**	**181.55**				
Abnormal instrument reading	64*	0.00	108.32	600.47	307.63	59.26	6.2	1.0	10.2	176.0
	64†	0.00	122.36	663.52	417.49	108.59				
External leakage - Process medium	1*	0.00	1.64	8.64	3.90	0.93	1.0	2.0	2.0	2.0
	1†	0.01	1.96	7.64	2.83	1.70				
External leakage - Utility medium	5*	0.01	6.74	28.31	10.85	4.63	5.5	1.0	10.4	38.0
	5†	0.29	9.74	29.63	10.25	8.48				
Minor in-service problems	30*	0.00	51.24	285.27	147.80	27.78	3.1	1.0	5.5	23.0
	30†	0.00	59.42	325.43	199.95	50.90				
Other	2*	0.00	3.80	17.66	7.15	1.85	480.5	1.0	481.0	961.0
	2†	0.00	6.96	33.79	14.02	3.39				
Parameter deviation	4*	0.00	6.55	29.66	11.80	3.70	4.3	2.0	5.7	8.0
	4†	0.02	8.82	34.52	12.83	6.79				
Structural deficiency	1*	0.00	1.30	6.11	2.49	0.93	5.0	10.0	10.0	10.0
	1†	0.00	2.01	11.08	5.54	1.70				
Unknown	**6***	**0.06**	**15.73**	**60.80**	**22.46**	**5.56**	**5.0**	**8.0**	**11.7**	**16.0**
	6†	**0.15**	**32.54**	**119.59**	**44.18**	**10.18**				
Other	2*	0.00	6.23	32.72	14.79	1.85	-	8.0	9.0	10.0
	2†	0.00	14.83	73.04	30.82	3.39				
Unknown	4*	0.00	9.62	43.68	17.39	3.70	5.0	8.0	13.0	16.0
	4†	0.00	18.10	81.74	32.47	6.79				
All modes	**284***	**0.00**	**459.38**	**2500.47**	**1166.09**	**262.97**	**11.2**	**1.0**	**18.8**	**961.0**
	284†	**0.00**	**535.36**	**3002.40**	**1577.16**	**481.86**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.8 \cdot 10^{-4}$

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Taxonomy no	Item
1.1.3.2.1	Machinery Compressors Screw Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
30	14	1.0025	0.5511	37994

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**29***	**0.00**	**35.24**	**180.04**	**77.85**	**28.93**	**22.8**	**2.0**	**27.7**	**108.0**
	29†	**0.00**	**47.42**	**228.74**	**94.40**	**52.63**				
External leakage - Process medium	2*	0.26	2.35	6.22	1.97	2.00	17.5	12.0	29.0	46.0
	2†	0.00	3.90	17.02	6.64	3.63				
Fail to start on demand	6*	0.02	9.43	38.08	14.33	5.99	6.9	3.0	9.2	19.0
	6†	0.05	13.06	49.92	18.39	10.89				
Low output	2*	0.00	2.58	12.33	5.06	2.00	29.0	10.0	29.0	48.0
	2†	0.00	3.45	16.75	6.96	3.63				
Noise	1*	0.00	1.29	7.10	3.39	1.00	73.0	76.0	76.0	76.0
	1†	0.00	1.78	8.47	3.48	1.81				
Other	1*	0.00	1.29	7.10	3.39	1.00	7.0	7.0	7.0	7.0
	1†	0.00	1.78	8.47	3.48	1.81				
Overheating	2*	0.00	2.58	12.33	5.06	2.00	38.5	7.0	38.5	70.0
	2†	0.00	3.45	16.75	6.96	3.63				
Parameter deviation	1*	0.00	1.50	6.96	2.81	1.00	5.5	11.0	11.0	11.0
	1†	0.00	2.23	12.24	5.93	1.81				
Spurious stop	14*	0.00	16.83	82.60	34.74	13.97	24.9	2.0	31.6	108.0
	14†	0.01	23.13	100.89	39.30	25.41				
Degraded	**21***	**0.00**	**23.09**	**126.78**	**59.41**	**20.95**	**11.8**	**2.0**	**14.1**	**48.0**
	21†	**0.00**	**29.80**	**156.95**	**71.13**	**38.11**				
Abnormal instrument reading	1*	0.00	1.29	7.10	3.39	1.00	5.0	5.0	5.0	5.0
	1†	0.00	1.78	8.47	3.48	1.81				
Erratic output	1*	0.00	1.29	7.10	3.39	1.00	4.0	4.0	4.0	4.0
	1†	0.00	1.78	8.47	3.48	1.81				
External leakage - Process medium	1*	0.00	1.50	6.96	2.81	1.00	7.5	15.0	15.0	15.0
	1†	0.00	2.23	12.24	5.93	1.81				
External leakage - Utility medium	5*	0.00	5.81	32.35	16.74	4.99	17.0	2.0	17.0	39.0
	5†	0.00	7.81	40.97	18.48	9.07				
Internal leakage	1*	0.00	1.29	7.10	3.39	1.00	48.0	48.0	48.0	48.0
	1†	0.00	1.78	8.47	3.48	1.81				
Low output	6*	0.00	6.79	38.53	20.56	5.99	6.5	2.0	6.5	12.0
	6†	0.00	8.99	49.44	23.48	10.89				
Noise	1*	0.00	1.29	7.10	3.39	1.00	15.0	15.0	15.0	15.0
	1†	0.00	1.78	8.47	3.48	1.81				
Other	2*	0.00	3.38	17.72	7.98	2.00	11.0	2.0	22.0	42.0
	2†	0.00	4.46	20.89	8.50	3.63				
Overheating	2*	0.00	1.86	8.53	3.42	2.00	11.0	16.0	20.0	24.0
	2†	0.03	3.44	11.50	4.22	3.63				
Parameter deviation	1*	0.00	1.50	6.96	2.81	1.00	1.0	2.0	2.0	2.0
	1†	0.00	2.23	12.24	5.93	1.81				

Comments

(cont.)

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Taxonomy no	Item
1.1.3.2.1	Machinery Compressors Screw Electric driven (100-1000) kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
30	14	1.0025	0.5511	37994

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**19***	**0.01**	**26.90**	**118.17**	**46.27**	**18.95**	**34.5**	**1.0**	**62.8**	**961.0**
	19†	**0.08**	**37.66**	**149.90**	**56.01**	**34.48**				
Abnormal instrument reading	8*	0.02	11.05	44.68	16.83	7.98	7.3	2.0	11.1	29.0
	8†	0.52	14.95	45.23	15.49	14.52				
External leakage - Utility medium	3*	0.00	3.69	16.82	6.71	2.99	8.3	2.0	16.0	38.0
	3†	0.56	5.68	15.39	4.94	5.44				
Minor in-service problems	3*	0.00	3.75	19.84	9.04	2.99	4.7	3.0	4.7	7.0
	3†	0.01	5.21	21.11	7.96	5.44				
Other	2*	0.00	4.41	19.48	7.65	2.00	480.5	1.0	481.0	961.0
	2†	0.00	7.94	36.79	14.85	3.63				
Parameter deviation	2*	0.00	3.38	17.72	7.98	2.00	4.0	8.0	8.0	8.0
	2†	0.00	4.46	20.89	8.50	3.63				
Structural deficiency	1*	0.00	1.50	6.96	2.81	1.00	5.0	10.0	10.0	10.0
	1†	0.00	2.23	12.24	5.93	1.81				
Unknown	**4***	**0.02**	**14.38**	**58.13**	**21.89**	**3.99**	**-**	**8.0**	**12.5**	**16.0**
	4†	**0.18**	**33.90**	**122.50**	**45.26**	**7.26**				
Other	2*	0.00	7.21	36.39	15.64	2.00	-	8.0	9.0	10.0
	2†	0.00	16.99	79.38	32.24	3.63				
Unknown	2*	0.00	7.21	36.39	15.64	2.00	-	16.0	16.0	16.0
	2†	0.00	16.99	79.38	32.24	3.63				
All modes	**73***	**0.01**	**96.86**	**446.69**	**179.62**	**72.82**	**22.3**	**1.0**	**31.7**	**961.0**
	73†	**0.14**	**140.26**	**584.42**	**222.81**	**132.47**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $2.6 \cdot 10^{-5}$

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Taxonomy no	Item
1.1.3.2.2	Machinery Compressors Screw Electric driven (1000-3000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0320	700

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**50***	**1111.22**	**1425.96**	**1804.90**	**1425.96**	**1425.96**	**10.1**	**1.0**	**20.7**	**163.0**
	50†	**1219.15**	**1564.46**	**1980.19**	**1564.46**	**1564.46**				
Erratic output	4*	38.93	114.08	261.09	114.08	114.08	6.8	7.0	9.8	15.0
	4†	42.71	125.16	286.45	125.16	125.16				
External leakage - Utility medium	7*	93.69	199.63	375.03	199.63	199.63	14.1	13.0	38.9	96.0
	7†	102.78	219.02	411.45	219.02	219.02				
Fail to start on demand	6*	74.58	171.12	337.67	171.12	171.12	5.0	1.0	8.3	32.0
	6†	81.82	187.73	370.46	187.73	187.73				
Low output	9*	133.90	256.67	447.90	256.67	256.67	13.3	2.0	26.2	163.0
	9†	146.90	281.60	491.40	281.60	281.60				
Overheating	2*	10.12	57.04	179.53	57.04	57.04	1.8	2.0	2.5	3.0
	2†	11.11	62.58	196.96	62.58	62.58				
Parameter deviation	1*	1.43	28.52	135.32	28.52	28.52	16.0	32.0	32.0	32.0
	1†	1.56	31.29	148.47	31.29	31.29				
Spurious stop	20*	377.98	570.39	828.78	570.39	570.39	9.5	2.0	17.9	148.0
	20†	414.69	625.78	909.27	625.78	625.78				
Structural deficiency	1*	1.43	28.52	135.32	28.52	28.52	21.5	43.0	43.0	43.0
	1†	1.56	31.29	148.47	31.29	31.29				
Degraded	**71***	**1646.44**	**2024.87**	**2466.99**	**2024.87**	**2024.87**	**8.3**	**1.0**	**15.5**	**111.0**
	71†	**1806.34**	**2221.53**	**2706.58**	**2221.53**	**2221.53**				
Erratic output	4*	38.93	114.08	261.09	114.08	114.08	7.6	2.0	12.3	35.0
	4†	42.71	125.16	286.45	125.16	125.16				
External leakage - Process medium	4*	38.93	114.08	261.09	114.08	114.08	1.3	1.0	2.0	3.0
	4†	42.71	125.16	286.45	125.16	125.16				
External leakage - Utility medium	23*	448.28	655.94	929.27	655.94	655.94	9.2	1.0	18.2	111.0
	23†	491.82	719.65	1019.53	719.65	719.65				
Other	5*	56.18	142.60	299.88	142.60	142.60	9.5	1.0	15.3	46.0
	5†	61.64	156.45	329.01	156.45	156.45				
Overheating	1*	1.43	28.52	135.32	28.52	28.52	-	-	-	-
	1†	1.56	31.29	148.47	31.29	31.29				
Parameter deviation	32*	664.40	912.62	1225.81	912.62	912.62	8.7	2.0	16.2	101.0
	32†	728.93	1001.25	1344.86	1001.25	1001.25				
Structural deficiency	2*	10.12	57.04	179.53	57.04	57.04	6.3	8.0	12.5	17.0
	2†	11.11	62.58	196.96	62.58	62.58				
Incipient	**88***	**2086.41**	**2509.70**	**2996.39**	**2509.70**	**2509.70**	**5.0**	**1.0**	**8.5**	**176.0**
	88†	**2289.05**	**2753.44**	**3287.41**	**2753.44**	**2753.44**				
Abnormal instrument reading	56*	1262.96	1597.08	1995.22	1597.08	1597.08	6.0	1.0	10.1	176.0
	56†	1385.62	1752.19	2189.00	1752.19	1752.19				
External leakage - Process medium	1*	1.43	28.52	135.32	28.52	28.52	1.0	2.0	2.0	2.0
	1†	1.56	31.29	148.47	31.29	31.29				

Comments

(cont.)

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Taxonomy no	Item
1.1.3.2.2	Machinery Compressors Screw Electric driven (1000-3000)kW

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0320	700

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	2*	10.12	57.04	179.53	57.04	57.04	1.3	1.0	2.0	3.0
	2†	11.11	62.58	196.96	62.58	62.58				
Minor in-service problems	27*	543.50	770.02	1061.86	770.02	770.02	2.9	1.0	5.6	23.0
	27†	596.28	844.81	1164.99	844.81	844.81				
Parameter deviation	2*	10.12	57.04	179.53	57.04	57.04	4.5	2.0	4.5	7.0
	2†	11.11	62.58	196.96	62.58	62.58				
Unknown	**2***	**10.12**	**57.04**	**179.53**	**57.04**	**57.04**	**5.0**	**8.0**	**10.0**	**12.0**
	2†	**11.11**	**62.58**	**196.96**	**62.58**	**62.58**				
Unknown	2*	10.12	57.04	179.53	57.04	57.04	5.0	8.0	10.0	12.0
	2†	11.11	62.58	196.96	62.58	62.58				
All modes	**211***	**5352.71**	**6017.57**	**6744.98**	**6017.57**	**6017.57**	**7.4**	**1.0**	**14.0**	**176.0**
	211†	**5872.57**	**6602.00**	**7400.06**	**6602.00**	**6602.00**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $8.6 \cdot 10^{-3}$

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Taxonomy no	Item
1.1.3.2.3	Machinery Compressors Screw Electric driven Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0424	0.0064	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.04 0.27	11.49 68.55	44.12 263.23	16.25 96.94	0.00 0.00	-	-	-	-

Comments

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Gas Turbines

Inventory description

The boundary shown in Figure 11 applies to gas turbines that are driving compressors, generators, and pumps. The corresponding subdivision in Subunits and Maintainable Items is shown in Table 6.

Gas turbines are generally installed in acoustic hoods. These hoods have their own dedicated ventilation system. Failure of the ventilation system of the hood may cause shutdown of the turbine. The hood is included within the boundary of the turbine system. External fuel supply (main supply) is not included, but local fuel supply equipment should be included. If there are subunits, which are common to the driver (i.e. the gas turbine), and the *driven unit* (e.g. a compressor), these are to be regarded as a part of the *driven unit.*

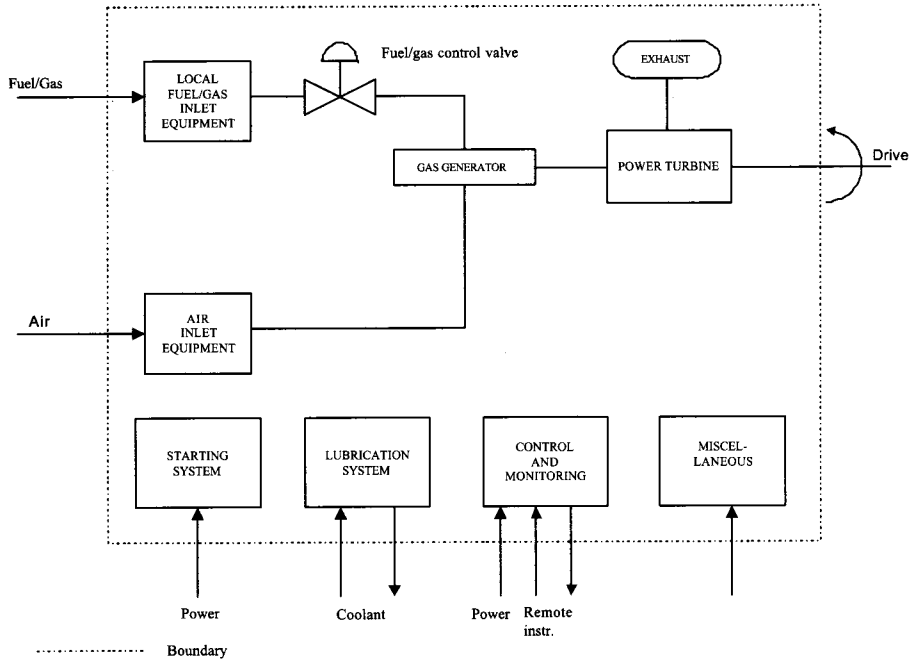

Figure 11 Gas Turbines, Boundary Definition

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Table 6 Gas Turbines, Subdivision in Maintainable Items

GAS TURBINE					
Starting system	Gas generator	Power turbine	Control and Monitoring	Lubrication system	Miscellaneous
• Instruments • Start energy (battery, air) • Starting unit • Start control	• Air inlet • Compr. rotor • Compr. stator • Combustion chambers • Burners/Fuel nozzles • Fuel control • Fuel filter • Fuel pump • Fuel scrubber/ coalescer • HP turbine • Instruments • Casing • Thrust bearing • Radial bearing • Seals • Valves & piping	• Rotor • Stator • Casing • Instruments • Radial bearing • Thrust bearing • Seals • Exhaust • Valves & pip-ing	• Instruments • Cabling & junction boxes • Control unit • Actuating device • Monitoring • Internal power supply • Valves	• Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & pip-ing • Oil • Seals	• Hood • Purge air

(For all subunits the MIs "Unknown" and "Subunit" are included.)

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List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELF	External leakage - Fuel
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

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Taxonomy no	Item
1.2	Machinery Gas Turbines

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
84	23	2.5723	1.7836	11096

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**941***	**33.48**	**354.75**	**969.98**	**312.92**	**365.81**	**27.0**	**0.1**	**39.4**	**3001.0**
	941†	**17.72**	**553.77**	**1679.62**	**577.96**	**527.59**				
Abnormal instrument reading	4*	0.00	2.66	13.56	5.86	1.56	33.7	4.0	62.8	163.0
	4†	0.00	3.49	17.11	7.19	2.24				
Breakdown	26*	2.04	9.17	20.51	5.90	10.11	66.9	2.0	79.4	301.0
	26†	2.59	13.25	30.69	9.03	14.58				
Erratic output	21*	0.04	10.06	37.46	13.83	8.16	35.2	1.0	47.0	284.0
	21†	0.13	13.46	44.51	16.28	11.77				
External leakage - Fuel	40*	0.04	19.09	76.34	28.58	15.55	19.0	0.3	46.4	1113.0
	40†	0.06	28.70	114.45	42.78	22.43				
External leakage - Utility medium	15*	0.03	7.72	29.04	10.71	5.83	21.3	1.0	28.9	100.0
	15†	0.07	9.66	32.85	12.09	8.41				
Fail to start on demand	299*	16.57	110.77	274.55	84.11	116.24	27.8	1.0	33.3	511.0
	299†	13.14	174.06	495.20	162.57	167.64				
Fail to stop on demand	8*	1.24	3.02	5.43	1.30	3.11	5.6	2.0	6.3	12.0
	8†	0.00	4.60	19.20	7.32	4.49				
High output	5*	0.03	1.68	5.31	1.90	1.94	11.9	5.0	24.0	52.0
	5†	0.00	2.47	13.61	6.87	2.80				
Internal leakage	6*	0.00	2.00	9.57	3.94	2.33	39.4	6.0	68.0	343.0
	6†	0.06	3.38	10.56	3.76	3.36				
Low output	27*	0.00	12.03	57.28	23.51	10.50	29.1	2.0	42.4	604.0
	27†	0.00	16.55	77.40	31.45	15.14				
Other	12*	0.09	5.00	15.63	5.57	4.67	34.8	2.0	42.5	115.0
	12†	0.11	7.58	24.13	8.69	6.73				
Overheating	54*	0.00	16.36	87.40	57.21	20.99	18.6	0.1	31.8	243.0
	54†	0.00	25.48	137.01	88.07	30.28				
Parameter deviation	31*	0.05	14.48	56.09	20.74	12.05	22.3	1.0	34.5	249.0
	31†	0.10	20.27	73.93	27.31	17.38				
Spurious stop	370*	0.62	126.98	463.12	171.11	143.84	20.7	1.0	29.4	1024.0
	370†	0.44	200.23	797.43	297.98	207.45				
Structural deficiency	5*	0.00	2.28	10.29	4.08	1.94	346.5	12.0	693.2	3001.0
	5†	0.01	2.98	11.34	4.18	2.80				
Unknown	3*	0.01	1.17	4.28	1.58	1.17	68.0	68.0	68.0	68.0
	3†	0.00	1.46	7.93	3.70	1.68				
Vibration	15*	0.00	5.28	23.17	9.07	5.83	41.8	3.0	87.8	326.0
	15†	1.42	8.57	20.72	6.26	8.41				
Degraded	**704***	**46.77**	**266.17**	**633.28**	**189.13**	**273.68**	**18.9**	**1.0**	**29.6**	**939.0**
	704†	**57.76**	**369.56**	**906.51**	**276.08**	**394.71**				
Abnormal instrument reading	34*	0.07	11.84	41.85	15.46	13.22	9.0	1.0	14.1	70.0
	34†	0.12	17.50	59.93	22.07	19.06				
Erratic output	58*	5.47	22.08	47.87	13.49	22.55	14.0	1.0	21.0	150.0
	58†	12.70	31.50	57.13	13.82	32.52				

Comments

(cont.)

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Taxonomy no	Item
1.2	Machinery Gas Turbines

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
84	23	2.5723	1.7836	11096

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Fuel	55*	0.11	17.09	59.10	21.79	21.38	11.6	2.0	16.3	84.0
	55†	0.00	25.88	118.40	47.25	30.84				
External leakage - Utility medium	112*	9.74	41.91	92.52	26.38	43.54	27.8	1.0	43.3	939.0
	112†	11.22	60.72	142.74	42.34	62.79				
Fail to start on demand	1*	0.00	0.34	1.71	0.73	0.39	6.0	10.0	10.0	10.0
	1†	0.00	0.56	2.97	1.95	0.56				
High output	4*	0.00	1.36	7.04	3.07	1.56	4.0	2.0	4.0	8.0
	4†	0.76	2.24	4.35	1.12	2.24				
Internal leakage	12*	0.01	4.67	18.78	7.05	4.67	24.5	2.0	25.0	109.0
	12†	0.02	7.23	28.09	10.40	6.73				
Low output	76*	0.55	32.57	102.18	36.49	29.55	19.5	1.0	29.8	520.0
	76†	1.20	44.19	134.90	46.89	42.61				
Minor in-service problems	12*	0.00	6.64	29.97	11.90	4.67	4.0	1.0	11.8	36.0
	12†	0.00	9.23	40.46	15.82	6.73				
Noise	4*	0.00	1.40	6.88	2.90	1.56	55.0	10.0	91.3	312.0
	4†	0.00	2.11	9.94	4.06	2.24				
Other	119*	6.58	50.37	128.43	39.92	46.26	24.5	1.0	34.8	354.0
	119†	11.71	70.04	168.92	50.91	66.72				
Overheating	92*	0.00	28.92	162.17	85.17	35.77	11.8	1.0	22.6	110.0
	92†	0.00	41.24	237.87	128.97	51.58				
Parameter deviation	69*	0.00	29.83	147.60	62.53	26.82	7.0	1.0	11.4	76.0
	69†	0.00	39.07	188.66	77.90	38.69				
Structural deficiency	30*	0.00	12.94	57.28	22.54	11.66	31.8	2.0	63.7	490.0
	30†	0.02	17.01	70.93	27.06	16.82				
Unknown	14*	0.00	4.57	25.40	13.10	5.44	41.3	2.0	41.3	116.0
	14†	0.00	5.83	32.05	15.54	7.85				
Vibration	12*	0.09	4.51	13.97	4.94	4.67	75.8	3.0	81.5	560.0
	12†	0.15	6.51	20.05	7.04	6.73				
Incipient	**1593***	**131.55**	**569.36**	**1258.95**	**359.36**	**619.28**	**12.0**	**0.5**	**18.9**	**1519.0**
	1593†	**262.37**	**1359.67**	**3162.33**	**932.68**	**893.14**				
Abnormal instrument reading	538*	31.35	187.83	453.16	136.61	209.15	8.1	0.5	11.4	184.0
	538†	50.01	483.37	1295.86	413.75	301.64				
Erratic output	14*	0.03	5.79	21.13	7.81	5.44	8.2	1.0	12.2	28.0
	14†	0.24	7.51	22.76	7.83	7.85				
External leakage - Fuel	30*	0.00	9.96	49.69	21.20	11.66	11.1	2.0	11.2	32.0
	30†	0.00	14.15	67.98	28.01	16.82				
External leakage - Utility medium	164*	0.91	48.68	151.65	53.85	63.76	10.6	1.0	17.4	235.0
	164†	0.74	124.79	440.19	162.56	91.95				
Fail to start on demand	2*	0.00	0.84	3.12	1.15	0.78	2.5	1.0	4.5	8.0
	2†	0.21	1.13	2.67	0.79	1.12				
Internal leakage	13*	0.00	3.68	18.44	7.90	5.05	10.0	2.0	12.4	48.0
	13†	0.00	6.87	37.75	18.48	7.29				

Comments

(cont.)

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Taxonomy no	Item
1.2	Machinery Gas Turbines

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
84	23	2.5723	1.7836	11096

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	5*	0.00	1.72	9.12	4.17	1.94	10.0	8.0	14.5	28.0
	5†	0.00	3.30	18.12	8.49	2.80				
Minor in-service problems	407*	4.04	156.96	480.42	167.54	158.22	10.2	1.0	15.4	963.0
	407†	10.86	286.87	865.22	294.48	228.19				
Noise	11*	0.89	4.01	8.97	2.58	4.28	36.1	6.0	82.4	294.0
	11†	0.08	5.82	18.64	6.74	6.17				
Other	238*	1.74	92.23	287.15	101.92	92.52	21.4	1.0	37.2	1519.0
	238†	3.28	152.79	472.03	166.36	133.44				
Overheating	20*	0.53	7.33	20.99	6.91	7.78	18.9	1.0	31.5	165.0
	20†	2.95	10.60	22.13	6.06	11.21				
Parameter deviation	64*	0.00	26.25	129.40	54.65	24.88	10.6	1.0	14.2	215.0
	64†	0.00	33.27	163.49	68.83	35.88				
Structural deficiency	39*	0.17	16.68	54.60	19.91	15.16	23.2	1.0	43.1	175.0
	39†	0.26	25.29	82.77	30.18	21.87				
Unknown	35*	0.00	10.77	56.46	39.25	13.61	25.3	5.0	24.4	222.0
	35†	0.00	12.61	65.31	48.33	19.62				
Vibration	13*	0.00	5.45	23.07	8.88	5.05	13.8	3.0	20.9	57.0
	13†	0.00	11.19	53.17	21.80	7.29				
Unknown	**25***	**1.33**	**11.46**	**29.85**	**9.37**	**9.72**	**6.9**	**1.0**	**24.1**	**212.0**
	25†	**2.82**	**16.37**	**39.18**	**11.75**	**14.02**				
Abnormal instrument reading	5*	0.00	2.59	11.91	4.78	1.94	2.3	1.0	3.3	7.0
	5†	0.00	3.31	13.89	5.32	2.80				
External leakage - Fuel	1*	0.00	0.43	2.23	1.75	0.39	4.0	8.5	8.5	8.5
	1†	0.00	0.62	2.94	1.21	0.56				
Other	7*	0.53	2.76	6.42	1.89	2.72	8.3	8.0	24.2	78.0
	7†	0.86	4.15	9.48	2.77	3.92				
Unknown	11*	0.03	5.23	18.23	6.73	4.28	8.0	2.0	31.8	212.0
	11†	0.07	7.34	24.15	8.82	6.17				
Vibration	1*	0.00	0.40	2.08	1.49	0.39	-	-	-	-
	1†	0.00	0.56	2.97	1.98	0.56				
All modes	**3263***	**241.71**	**1199.23**	**2758.09**	**808.20**	**1268.49**	**17.7**	**0.1**	**27.1**	**3001.0**
	3263†	**460.22**	**2398.21**	**5585.47**	**1648.61**	**1829.46**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.7. 10-2

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Maintainable **item versus failure mode, to be continued**
Item: Gas Turbines

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.09	0.00	0.00	0.00	0.03	0.32	0.00	0.00	0.00	0.00
Air inlet	0.25	0.00	0.03	0.15	0.03	0.08	0.00	0.03	0.31	0.00
Burners/fuel nozzles	0.00	0.00	0.20	0.03	0.04	0.21	0.00	0.03	0.09	0.00
Cabling & junction boxes	0.54	0.00	0.00	0.03	0.06	0.14	0.00	0.00	0.00	0.00
Casing	0.00	0.03	0.06	0.17	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.03	0.12	0.03	0.03	0.09	0.00	0.00	0.03	0.00
Compressor rotor	0.00	0.03	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Control unit	1.53	0.03	0.00	0.03	0.18	0.87	0.06	0.00	0.12	0.00
Cooler(s)	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.03	0.03	0.03	0.37	0.03	0.00	0.00	0.03	0.00	0.18
Filter(s)	0.11	0.00	0.00	0.35	0.03	0.06	0.00	0.03	0.17	0.00
Fuel control	0.09	0.00	0.17	0.00	0.43	0.78	0.00	0.03	0.12	0.00
Fuel filter	0.03	0.00	0.03	0.00	0.03	0.06	0.00	0.00	0.21	0.00
Fuel pump	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Fuel scrubber/coalescer	0.03	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.03	0.00	0.00	0.03	0.00	0.12	0.00	0.00	0.00	0.03
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00
Instrument, flame	0.40	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Instrument, flow	0.35	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00
Instrument, general	0.95	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.03
Instrument, level	0.43	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	2.63	0.00	0.11	0.08	0.06	0.26	0.00	0.03	0.06	0.00
Instrument, speed	0.87	0.00	0.00	0.03	0.09	0.34	0.12	0.00	0.03	0.00
Instrument, temperature	3.69	0.00	0.03	0.00	0.10	0.03	0.00	0.00	0.00	0.00
Instrument, vibration	1.27	0.00	0.00	0.03	0.03	0.08	0.00	0.00	0.03	0.00
Internal power supply	0.28	0.00	0.00	0.06	0.00	0.06	0.00	0.00	0.03	0.00
Monitoring	1.81	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.06	0.00	0.05	0.00	0.00	0.02	0.00
Other	0.31	0.06	0.15	0.83	0.15	0.43	0.00	0.09	0.09	0.00
Piping	0.00	0.03	0.54	1.47	0.00	0.03	0.00	0.03	0.02	0.03
Pump w/motor	0.06	0.03	0.00	0.72	0.05	0.06	0.03	0.06	0.06	0.09
Purge air	0.06	0.03	0.00	0.00	0.00	0.03	0.00	0.00	0.06	0.03
Radial bearing	0.00	0.06	0.00	0.06	0.00	0.03	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.00	0.00
Rotor	0.00	0.12	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.00
Seals	0.00	0.00	0.41	1.12	0.01	0.02	0.00	0.06	0.00	0.00
Start control	0.03	0.00	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.03	0.06	0.18	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.06	0.34	0.06	1.04	0.00	0.00	0.03	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00
Subunit	0.12	0.06	0.06	0.18	0.09	0.95	0.00	0.03	0.77	0.00
Thrust bearing	0.03	0.03	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Unknown	1.44	0.12	0.37	0.67	0.12	1.26	0.06	0.12	0.15	0.03
Valves	0.35	0.09	1.12	1.30	0.93	1.16	0.00	0.34	0.67	0.03
Total	17.81	0.80	3.86	8.92	2.85	9.26	0.28	0.95	3.31	0.46

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Gas Turbines

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.25	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.87
Air inlet	0.25	0.89	0.90	1.00	0.03	0.00	0.25	0.26	0.03	4.47
Burners/fuel nozzles	2.91	0.15	0.16	0.12	0.08	0.00	0.00	0.08	0.00	4.11
Cabling & junction boxes	0.09	0.34	0.03	0.37	0.00	0.00	0.03	0.29	0.00	1.92
Casing	0.03	0.09	0.03	0.09	0.06	0.00	0.06	0.00	0.03	0.66
Combustion chambers	0.02	0.09	0.00	0.00	0.03	0.00	0.00	0.03	0.03	0.54
Compressor rotor	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.12	0.26
Compressor stator	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.02	0.18
Control unit	0.03	0.60	0.31	0.28	0.03	0.00	0.12	1.30	0.03	5.53
Cooler(s)	0.12	0.11	0.06	0.12	0.09	0.00	0.00	0.12	0.02	1.23
Exhaust	0.06	0.49	0.03	0.31	0.58	0.00	0.03	0.17	0.06	2.44
Filter(s)	0.03	0.25	0.49	0.74	0.00	0.00	0.00	0.21	0.00	2.47
Fuel control	0.01	0.21	0.21	0.21	0.00	0.03	0.00	0.74	0.00	3.04
Fuel filter	0.00	0.12	0.18	1.15	0.03	0.00	0.06	0.12	0.00	2.04
Fuel pump	0.00	0.12	0.00	0.03	0.00	0.00	0.00	0.09	0.00	0.60
Fuel scrubber/coalescer	0.00	0.00	0.03	0.06	0.00	0.00	0.06	0.03	0.00	0.31
Hood	0.15	0.55	0.00	0.52	0.09	0.00	0.00	0.12	0.03	1.69
HP turbine	0.00	0.03	0.03	0.00	0.02	0.00	0.00	0.06	0.00	0.20
Instrument, flame	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.09	0.00	0.58
Instrument, flow	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.51
Instrument, general	0.00	0.41	0.03	0.09	0.00	0.03	0.03	0.28	0.00	1.96
Instrument, level	0.00	0.00	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.70
Instrument, pressure	0.15	0.11	0.17	0.21	0.03	0.03	0.00	0.34	0.00	4.27
Instrument, speed	0.00	0.09	0.09	0.06	0.00	0.06	0.00	0.67	0.00	2.46
Instrument, temperature	0.15	0.40	0.18	0.18	0.00	0.00	0.03	0.60	0.00	5.40
Instrument, vibration	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.58	0.23	2.28
Internal power supply	0.00	0.18	0.00	0.12	0.00	0.00	0.03	0.40	0.00	1.16
Monitoring	0.00	0.09	0.09	0.15	0.00	0.00	0.03	0.06	0.00	2.27
Oil	0.03	0.22	0.12	0.15	0.03	0.00	0.00	0.14	0.00	0.82
Other	0.15	0.70	0.41	1.99	0.34	0.00	0.31	0.26	0.09	6.37
Piping	0.02	0.32	0.01	0.37	0.11	0.00	0.03	0.05	0.08	3.12
Pump w/motor	0.06	0.62	0.14	0.15	0.00	0.00	0.12	0.35	0.02	2.63
Purge air	0.06	0.25	0.03	0.86	0.03	0.00	0.00	0.09	0.00	1.53
Radial bearing	0.00	0.09	0.00	0.00	0.03	0.00	0.06	0.09	0.09	0.52
Reservoir w/heating system	0.00	0.06	0.03	0.12	0.00	0.00	0.00	0.00	0.00	0.34
Rotor	0.00	0.00	0.00	0.06	0.03	0.00	0.00	0.00	0.03	0.31
Seals	0.03	0.06	0.01	0.03	0.00	0.00	0.03	0.02	0.00	1.80
Start control	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.32
Start energy (battery, air)	0.00	0.12	0.09	0.12	0.03	0.00	0.00	0.00	0.00	0.64
Starting unit	0.00	0.25	0.00	0.09	0.00	0.00	0.06	0.03	0.00	1.96
Stator	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.09
Subunit	0.06	0.66	0.18	0.49	0.03	0.00	0.03	0.40	0.15	4.28
Thrust bearing	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.25
Unknown	0.31	1.16	0.34	1.72	0.37	0.00	0.18	1.62	0.18	10.24
Valves	0.27	1.32	0.49	0.55	0.14	0.09	0.37	1.39	0.02	10.64
Total	5.09	11.52	5.03	12.84	2.27	0.25	1.93	11.34	1.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Gas Turbines

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.31	0.00	0.00	0.06	0.06	0.18	0.00	0.00	0.64	0.00
Breakage	0.70	0.09	0.12	0.21	0.06	0.12	0.00	0.00	0.00	0.03
Burst	0.00	0.00	0.12	0.12	0.00	0.00	0.00	0.03	0.00	0.00
Cavitation	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.03
Clearance/ alignment failure	0.00	0.00	0.09	0.06	0.00	0.09	0.00	0.03	0.03	0.00
Combined causes	0.00	0.00	0.03	0.00	0.03	0.12	0.00	0.00	0.03	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Contamination	0.12	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.28	0.00
Control failure	0.31	0.00	0.00	0.09	0.34	0.70	0.06	0.00	0.21	0.00
Corrosion	0.28	0.00	0.12	0.40	0.12	0.09	0.00	0.03	0.00	0.00
Deformation	0.03	0.12	0.21	0.83	0.03	0.09	0.03	0.03	0.00	0.09
Earth/isolation fault	0.06	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Electrical failure - general	0.86	0.00	0.00	0.00	0.34	0.67	0.00	0.00	0.09	0.00
Erosion	0.03	0.00	0.15	0.18	0.00	0.03	0.00	0.00	0.00	0.00
External influence - general	0.12	0.00	0.00	0.03	0.03	0.06	0.00	0.00	0.18	0.00
Fatigue	0.03	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.03	0.03
Faulty power/voltage	0.03	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	5.03	0.00	0.00	0.06	0.18	0.46	0.00	0.00	0.03	0.00
Instrument failure - general	3.86	0.09	0.09	0.03	0.25	1.04	0.12	0.03	0.12	0.00
Leakage	0.09	0.03	0.46	2.15	0.03	0.25	0.00	0.18	0.15	0.00
Looseness	0.21	0.00	0.28	0.58	0.00	0.12	0.00	0.03	0.03	0.03
Material failure - general	0.09	0.00	0.67	1.35	0.06	0.03	0.00	0.03	0.03	0.00
Mechanical Failure - general	0.21	0.37	0.92	1.35	0.61	2.42	0.00	0.25	0.49	0.09
Misc. external influences	0.21	0.00	0.03	0.06	0.12	0.06	0.00	0.03	0.06	0.00
Miscellaneous - general	0.03	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
No cause found	0.15	0.00	0.06	0.06	0.00	0.09	0.03	0.03	0.03	0.03
No power/ voltage	0.12	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.70	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Open circuit	0.28	0.00	0.00	0.00	0.03	0.21	0.00	0.00	0.00	0.00
Other	0.09	0.00	0.03	0.03	0.06	0.31	0.00	0.00	0.06	0.03
Out of adjustment	2.39	0.00	0.00	0.03	0.00	0.49	0.03	0.06	0.15	0.00
Overheating	0.06	0.00	0.00	0.03	0.00	0.09	0.00	0.00	0.00	0.00
Short circuiting	0.09	0.00	0.00	0.00	0.03	0.06	0.00	0.00	0.03	0.00
Software failure	0.18	0.00	0.00	0.00	0.03	0.15	0.00	0.00	0.00	0.00
Sticking	0.12	0.03	0.00	0.00	0.12	0.28	0.00	0.06	0.06	0.00
Unknown	0.18	0.03	0.06	0.12	0.06	0.43	0.00	0.00	0.18	0.00
Vibration	0.25	0.00	0.03	0.03	0.06	0.09	0.00	0.00	0.00	0.00
Wear	0.55	0.03	0.37	0.74	0.12	0.06	0.00	0.09	0.34	0.09
Total	17.81	0.80	3.86	8.92	2.85	9.26	0.28	0.95	3.31	0.46

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Gas Turbines

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.15	0.49	1.04	1.93	0.06	0.00	0.00	0.43	0.00	5.36
Breakage	0.12	0.40	0.06	0.52	0.52	0.00	0.03	0.21	0.03	3.25
Burst	0.00	0.25	0.00	0.03	0.21	0.00	0.00	0.03	0.00	0.80
Cavitation	0.00	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.31
Clearance/ alignment failure	0.03	0.12	0.09	0.06	0.00	0.00	0.00	0.03	0.09	0.74
Combined causes	2.30	0.03	0.00	0.03	0.00	0.00	0.00	0.12	0.03	2.73
Common mode failure	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.06
Contamination	0.70	0.43	0.80	0.86	0.00	0.00	0.28	0.21	0.09	3.86
Control failure	0.03	0.28	0.25	0.09	0.03	0.00	0.18	1.13	0.03	3.74
Corrosion	0.03	0.28	0.00	0.74	0.15	0.00	0.15	0.00	0.00	2.39
Deformation	0.06	0.09	0.00	0.25	0.06	0.06	0.00	0.09	0.00	2.08
Earth/isolation fault	0.03	0.28	0.06	0.09	0.00	0.00	0.00	0.03	0.00	0.61
Electrical failure - general	0.12	0.77	0.12	1.16	0.00	0.00	0.09	0.80	0.06	5.09
Erosion	0.03	0.00	0.00	0.09	0.03	0.00	0.03	0.03	0.03	0.64
External influence - general	0.06	0.40	0.15	0.46	0.00	0.00	0.00	0.12	0.00	1.62
Fatigue	0.03	0.03	0.00	0.15	0.12	0.00	0.00	0.00	0.03	0.58
Faulty power/voltage	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.21	0.00	0.37
Faulty signal/indication/alarm	0.18	0.43	0.18	0.12	0.00	0.00	0.00	1.29	0.09	8.06
Instrument failure - general	0.03	0.83	0.43	0.58	0.00	0.06	0.03	1.26	0.03	8.89
Leakage	0.06	0.49	0.15	0.21	0.18	0.00	0.06	0.18	0.03	4.72
Looseness	0.00	0.18	0.00	0.55	0.03	0.00	0.00	0.21	0.03	2.30
Material failure - general	0.03	0.21	0.03	0.25	0.12	0.00	0.12	0.12	0.03	3.19
Mechanical Failure - general	0.46	1.62	0.52	1.20	0.37	0.09	0.49	1.32	0.18	12.96
Misc. external influences	0.18	0.43	0.09	0.28	0.00	0.00	0.00	0.43	0.09	2.08
Miscellaneous - general	0.00	0.06	0.03	0.34	0.00	0.00	0.03	0.03	0.00	0.67
No cause found	0.03	0.06	0.00	0.00	0.00	0.03	0.00	0.18	0.06	0.86
No power/ voltage	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.34
No signal/indication/alarm	0.00	0.15	0.06	0.09	0.00	0.00	0.00	0.12	0.00	1.20
Open circuit	0.03	0.09	0.00	0.09	0.00	0.00	0.03	0.28	0.00	1.04
Other	0.09	1.07	0.03	0.15	0.03	0.00	0.00	0.25	0.00	2.24
Out of adjustment	0.06	0.34	0.37	0.40	0.03	0.00	0.00	0.64	0.00	5.00
Overheating	0.09	0.06	0.09	0.06	0.00	0.00	0.00	0.21	0.00	0.70
Short circuiting	0.00	0.15	0.03	0.03	0.00	0.00	0.00	0.15	0.00	0.58
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
Sticking	0.00	0.43	0.03	0.52	0.00	0.00	0.00	0.12	0.00	1.78
Unknown	0.06	0.43	0.34	0.15	0.00	0.00	0.28	0.31	0.06	2.70
Vibration	0.00	0.09	0.03	0.28	0.03	0.00	0.00	0.58	0.15	1.62
Wear	0.06	0.46	0.03	0.98	0.25	0.00	0.12	0.09	0.09	4.47
Total	5.09	11.52	5.03	12.84	2.27	0.25	1.93	11.34	1.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.2.1	Machinery Gas Turbines Aeroderivative

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
39	12	1.3917	0.8828	6864

Failure mode	No of failures	Failure rate (per 10⁶ hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**604***	**13.44**	**363.52**	**1097.15**	**373.99**	**434.01**	**21.5**	**0.1**	**28.3**	**604.0**
	604†	**3.54**	**590.62**	**2078.09**	**767.34**	**684.18**				
Abnormal instrument reading	2*	0.00	2.06	10.36	4.44	1.44	4.0	4.0	28.5	53.0
	2†	0.00	3.08	14.70	6.04	2.27				
Breakdown	15*	2.87	9.92	20.43	5.54	10.78	60.9	2.0	74.1	301.0
	15†	1.01	15.11	43.76	14.46	16.99				
Erratic output	8*	0.12	6.01	18.67	6.61	5.75	84.4	3.0	75.1	284.0
	8†	0.23	9.73	29.93	10.50	9.06				
External leakage - Fuel	30*	0.06	21.70	85.03	31.60	21.56	10.9	0.3	17.7	80.0
	30†	0.07	34.45	137.39	51.36	33.98				
External leakage - Utility medium	5*	0.66	3.58	8.43	2.50	3.59	42.7	1.0	33.8	100.0
	5†	1.39	5.50	11.83	3.32	5.66				
Fail to start on demand	181*	13.74	121.47	318.77	100.50	130.06	23.7	1.0	25.7	324.0
	181†	4.84	183.84	562.12	195.78	205.03				
Fail to stop on demand	7*	0.98	4.67	10.63	3.09	5.03	5.6	2.0	6.3	12.0
	7†	0.01	7.62	30.79	11.60	7.93				
High output	5*	0.01	3.17	12.62	4.72	3.59	11.9	5.0	24.0	52.0
	5†	0.00	5.28	26.96	11.66	5.66				
Internal leakage	4*	0.00	2.66	12.24	4.91	2.87	13.3	6.0	13.3	28.0
	4†	1.13	4.53	9.80	2.76	4.53				
Low output	18*	0.00	14.55	73.91	31.87	12.93	38.4	5.0	53.7	604.0
	18†	0.00	20.16	102.35	44.12	20.39				
Other	7*	0.52	5.58	15.27	4.93	5.03	42.8	4.0	45.2	114.0
	7†	0.56	8.96	26.16	8.67	7.93				
Overheating	50*	0.00	23.87	136.31	76.64	35.93	19.0	0.1	33.0	243.0
	50†	0.00	39.52	226.30	121.94	56.64				
Parameter deviation	14*	0.00	6.92	30.16	11.74	10.06	21.8	3.0	23.4	96.0
	14†	0.00	12.21	60.09	25.34	15.86				
Spurious stop	247*	0.40	137.65	537.83	199.65	177.49	17.5	1.0	23.0	565.0
	247†	0.09	236.68	1028.66	399.78	279.79				
Unknown	1*	0.00	1.17	6.30	2.91	0.72	-	-	-	-
	1†	0.00	1.37	6.88	2.95	1.13				
Vibration	10*	1.55	6.94	15.49	4.45	7.19	25.1	3.0	65.4	326.0
	10†	0.63	11.18	33.11	11.02	11.33				
Degraded	**374***	**26.42**	**236.55**	**622.71**	**196.70**	**268.74**	**17.3**	**1.0**	**27.3**	**768.0**
	374†	**22.95**	**364.69**	**1064.56**	**352.71**	**423.65**				
Abnormal instrument reading	21*	0.09	14.57	51.40	18.98	15.09	10.4	2.0	15.5	70.0
	21†	0.13	22.23	78.18	28.87	23.79				
Erratic output	25*	8.81	18.13	30.15	6.59	17.96	19.3	4.0	28.8	150.0
	25†	10.53	27.92	52.09	12.97	28.32				

Comments

(cont.)

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Taxonomy no	Item
1.2.1	Machinery Gas Turbines Aeroderivative

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
39	12	1.3917	0.8828	6864

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Fuel	28*	0.00	15.89	71.48	28.35	20.12	9.9	2.0	16.4	84.0
	28†	0.00	28.66	142.91	60.92	31.72				
External leakage - Utility medium	60*	7.33	37.05	85.62	25.16	43.11	19.2	1.0	32.5	768.0
	60†	3.10	56.70	168.26	56.03	67.97				
Fail to start on demand	1*	0.00	0.65	3.24	1.38	0.72	6.0	10.0	10.0	10.0
	1†	0.00	1.14	6.43	3.42	1.13				
High output	3*	0.59	2.15	4.52	1.24	2.16	2.0	2.0	2.0	2.0
	3†	0.02	3.55	12.28	4.53	3.40				
Internal leakage	10*	0.03	7.11	26.30	9.71	7.19	24.7	2.0	25.3	109.0
	10†	0.07	11.39	39.72	14.66	11.33				
Low output	42*	3.16	37.70	105.45	34.38	30.18	14.4	1.0	31.1	520.0
	42†	3.85	54.86	157.79	52.01	47.58				
Minor in-service problems	10*	0.05	7.69	26.82	9.90	7.19	4.0	1.0	12.5	36.0
	10†	0.06	11.31	40.58	15.00	11.33				
Noise	3*	0.00	2.03	9.45	3.82	2.16	55.0	10.0	114.0	312.0
	3†	0.00	3.27	14.40	5.64	3.40				
Other	59*	7.89	42.37	99.41	29.46	42.40	17.5	2.0	23.2	200.0
	59†	15.82	61.90	132.81	37.17	66.83				
Overheating	63*	0.00	30.60	158.86	115.63	45.27	9.5	1.0	17.4	82.0
	63†	0.00	47.97	248.75	182.59	71.36				
Parameter deviation	29*	2.06	17.89	46.71	14.68	20.84	6.9	1.5	9.2	39.0
	29†	0.32	28.33	91.97	33.44	32.85				
Structural deficiency	13*	0.78	9.04	25.13	8.17	9.34	58.6	2.0	107.9	490.0
	13†	1.03	13.90	39.67	13.04	14.73				
Unknown	1*	0.00	0.65	3.24	1.38	0.72	14.0	14.0	14.0	14.0
	1†	0.00	1.14	6.43	3.42	1.13				
Vibration	6*	0.03	4.18	14.15	5.20	4.31	115.0	3.0	101.8	560.0
	6†	0.03	6.45	23.71	8.76	6.80				
Incipient	**926***	**75.63**	**575.67**	**1466.54**	**455.61**	**665.39**	**9.2**	**0.5**	**14.1**	**358.0**
	926†	**32.84**	**936.50**	**2831.34**	**968.51**	**1048.93**				
Abnormal instrument reading	332*	15.60	200.62	568.15	186.18	238.56	8.3	0.5	10.6	184.0
	332†	3.94	327.32	1055.10	382.49	376.07				
Erratic output	2*	0.00	2.85	13.16	5.30	1.44	1.0	1.0	8.5	16.0
	2†	0.00	3.60	16.83	6.83	2.27				
External leakage - Fuel	14*	0.14	10.27	32.71	11.79	10.06	9.1	2.0	9.9	25.0
	14†	0.08	16.71	61.66	22.77	15.86				
External leakage - Utility medium	109*	0.58	60.40	199.12	72.77	78.32	9.1	1.0	16.1	235.0
	109†	0.27	109.00	431.16	160.78	123.47				
Fail to start on demand	1*	0.00	1.00	5.17	2.29	0.72	1.0	1.0	1.0	1.0
	1†	0.00	1.35	6.69	2.84	1.13				

Comments

(cont.)

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Taxonomy no	Item
1.2.1	Machinery Gas Turbines Aeroderivative

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
39	12	1.3917	0.8828	6864

Failure mode	No of failures	Failure rate (per 106 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Internal leakage	11*	0.03	6.78	24.77	9.15	7.90	11.1	2.0	13.9	48.0
	11†	0.00	12.01	54.69	21.79	12.46				
Low output	5*	0.00	3.66	16.93	6.82	3.59	10.0	8.0	14.5	28.0
	5†	0.00	6.75	32.75	13.57	5.66				
Minor in-service problems	256*	1.31	137.85	455.21	166.43	183.95	7.7	1.0	9.1	187.0
	256†	1.01	228.06	850.54	313.97	289.98				
Noise	8*	0.50	5.08	13.77	4.43	5.75	34.0	6.0	83.7	294.0
	8†	0.16	7.94	24.67	8.74	9.06				
Other	121*	2.33	82.10	250.20	86.74	86.95	13.8	1.0	23.0	358.0
	121†	2.17	130.24	408.87	146.06	137.06				
Overheating	5*	0.52	3.53	8.80	2.70	3.59	5.5	1.0	13.4	30.0
	5†	0.61	5.72	15.23	4.85	5.66				
Parameter deviation	21*	0.00	22.88	102.71	40.70	15.09	5.3	1.5	5.4	22.0
	21†	0.00	30.27	140.12	56.52	23.79				
Structural deficiency	26*	0.22	22.77	75.04	27.42	18.68	23.7	1.0	46.4	175.0
	26†	0.34	36.15	119.61	43.76	29.45				
Unknown	8*	0.00	12.29	65.46	30.03	5.75	28.8	14.0	22.8	35.0
	8†	0.00	13.43	74.34	37.94	9.06				
Vibration	7*	0.00	5.30	25.89	10.84	5.03	10.3	3.0	14.8	38.0
	7†	0.00	8.16	34.77	13.42	7.93				
Unknown	**17***	**2.10**	**14.46**	**36.10**	**11.10**	**12.22**	**7.3**	**1.0**	**29.4**	**212.0**
	17†	**5.14**	**20.66**	**44.71**	**12.59**	**19.26**				
Abnormal instrument reading	1*	0.00	1.00	5.17	2.29	0.72	1.0	1.0	1.0	1.0
	1†	0.00	1.35	6.69	2.84	1.13				
Other	6*	1.31	4.39	8.95	2.41	4.31	9.0	8.0	26.2	78.0
	6†	0.00	8.01	35.98	14.26	6.80				
Unknown	10*	0.51	8.53	25.04	8.31	7.19	7.8	2.0	34.3	212.0
	10†	1.32	12.02	31.80	10.08	11.33				
All modes	**1921***	**133.07**	**1186.51**	**3120.38**	**985.06**	**1380.36**	**14.6**	**0.1**	**21.2**	**768.0**
	1921†	**48.95**	**1909.61**	**5846.09**	**2039.40**	**2176.01**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.6. 10-2

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Maintainable **item versus failure mode, to be continued**
Item: Gas Turbines - Aeroderivative

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.10	0.00	0.00	0.00	0.05	0.39	0.00	0.00	0.00	0.00
Air inlet	0.16	0.00	0.00	0.16	0.05	0.05	0.00	0.05	0.31	0.00
Burners/fuel nozzles	0.00	0.00	0.21	0.05	0.02	0.16	0.00	0.05	0.10	0.00
Cabling & junction boxes	0.60	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.00
Casing	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.05	0.10	0.05	0.05	0.16	0.00	0.00	0.05	0.00
Compressor rotor	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.67	0.05	0.00	0.05	0.00	0.96	0.05	0.00	0.10	0.00
Cooler(s)	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.05	0.00	0.05	0.16	0.00	0.00	0.00	0.05	0.00	0.26
Filter(s)	0.18	0.00	0.00	0.44	0.05	0.10	0.00	0.05	0.29	0.00
Fuel control	0.10	0.00	0.18	0.00	0.31	1.04	0.00	0.00	0.21	0.00
Fuel filter	0.05	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.05	0.00
Fuel pump	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.08	0.00
Fuel scrubber/coalescer	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.05	0.00	0.21	0.00	0.00	0.00	0.00
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
Instrument, flame	0.31	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Instrument, flow	0.49	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.52	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Instrument, level	0.21	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	3.22	0.00	0.18	0.13	0.05	0.39	0.00	0.05	0.10	0.00
Instrument, speed	1.12	0.00	0.00	0.05	0.08	0.57	0.21	0.00	0.05	0.00
Instrument, temperature	4.10	0.00	0.05	0.00	0.10	0.05	0.00	0.00	0.00	0.00
Instrument, vibration	1.76	0.00	0.00	0.05	0.00	0.13	0.00	0.00	0.05	0.00
Internal power supply	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.05	0.00
Monitoring	2.03	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.05	0.00	0.08	0.00	0.00	0.03	0.00
Other	0.16	0.05	0.16	1.09	0.10	0.62	0.00	0.10	0.10	0.00
Piping	0.00	0.05	0.23	1.43	0.00	0.05	0.00	0.05	0.03	0.05
Pump w/motor	0.10	0.05	0.00	0.91	0.03	0.05	0.05	0.10	0.10	0.10
Purge air	0.05	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.05
Radial bearing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Seals	0.00	0.00	0.55	0.75	0.02	0.03	0.00	0.10	0.00	0.00
Start control	0.05	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.05	0.05	0.10	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.10	0.47	0.05	0.88	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00
Subunit	0.16	0.05	0.10	0.21	0.16	0.94	0.00	0.05	0.31	0.00
Thrust bearing	0.05	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Unknown	0.68	0.10	0.26	0.47	0.10	0.42	0.10	0.16	0.05	0.05
Valves	0.29	0.16	0.99	1.48	0.33	1.51	0.00	0.42	0.88	0.05
Total	18.53	0.78	3.75	9.06	1.82	9.53	0.42	1.30	3.38	0.57

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Gas Turbines - Aeroderivative

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.21	0.00	0.16	0.00	0.00	0.00	0.16	0.00	1.07
Air inlet	0.00	0.52	0.36	0.96	0.00	0.00	0.10	0.10	0.00	2.84
Burners/fuel nozzles	4.88	0.21	0.23	0.10	0.03	0.00	0.00	0.08	0.00	6.12
Cabling & junction boxes	0.00	0.26	0.00	0.42	0.00	0.00	0.00	0.44	0.00	1.87
Casing	0.00	0.05	0.00	0.05	0.05	0.00	0.10	0.00	0.00	0.36
Combustion chambers	0.03	0.10	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.65
Compressor rotor	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.16	0.36
Compressor stator	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.03	0.08
Control unit	0.05	0.36	0.05	0.21	0.00	0.00	0.10	1.74	0.05	5.47
Cooler(s)	0.00	0.07	0.00	0.10	0.16	0.00	0.00	0.10	0.00	1.11
Exhaust	0.10	0.57	0.00	0.21	0.36	0.00	0.00	0.05	0.10	1.98
Filter(s)	0.05	0.27	0.42	1.25	0.00	0.00	0.00	0.36	0.00	3.47
Fuel control	0.02	0.26	0.16	0.21	0.00	0.05	0.00	0.73	0.00	3.27
Fuel filter	0.00	0.16	0.00	1.64	0.05	0.00	0.00	0.00	0.00	2.06
Fuel pump	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.86
Fuel scrubber/coalescer	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.21
Hood	0.21	0.31	0.00	0.73	0.10	0.00	0.00	0.10	0.05	1.77
HP turbine	0.00	0.05	0.05	0.00	0.03	0.00	0.00	0.05	0.00	0.29
Instrument, flame	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.42
Instrument, flow	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.70
Instrument, general	0.00	0.00	0.05	0.10	0.00	0.05	0.05	0.16	0.00	1.04
Instrument, level	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.42
Instrument, pressure	0.00	0.13	0.08	0.26	0.00	0.00	0.00	0.34	0.00	4.94
Instrument, speed	0.00	0.16	0.00	0.10	0.00	0.10	0.00	0.94	0.00	3.38
Instrument, temperature	0.10	0.47	0.10	0.26	0.00	0.00	0.05	0.83	0.00	6.13
Instrument, vibration	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.88	0.23	3.17
Internal power supply	0.00	0.16	0.00	0.16	0.00	0.00	0.05	0.62	0.00	1.41
Monitoring	0.00	0.16	0.10	0.00	0.00	0.00	0.05	0.10	0.00	2.50
Oil	0.05	0.17	0.00	0.10	0.00	0.00	0.00	0.23	0.00	0.72
Other	0.05	0.78	0.49	2.39	0.36	0.00	0.10	0.34	0.00	6.92
Piping	0.03	0.23	0.02	0.31	0.08	0.00	0.00	0.00	0.13	2.70
Pump w/motor	0.10	0.61	0.10	0.00	0.00	0.00	0.05	0.49	0.00	2.88
Purge air	0.10	0.36	0.05	0.94	0.05	0.00	0.00	0.16	0.00	1.98
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.21
Reservoir w/heating system	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.31
Rotor	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.16
Seals	0.05	0.10	0.02	0.05	0.00	0.00	0.00	0.03	0.00	1.70
Start control	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.36
Start energy (battery, air)	0.00	0.10	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.47
Starting unit	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.05	0.00	1.82
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Subunit	0.00	0.55	0.10	0.36	0.05	0.00	0.05	0.47	0.10	3.67
Thrust bearing	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.26
Unknown	0.10	0.78	0.26	1.51	0.47	0.00	0.10	0.94	0.16	6.72
Valves	0.20	1.30	0.57	0.42	0.13	0.16	0.16	2.03	0.03	11.10
Total	6.14	10.05	3.33	13.85	2.03	0.36	1.04	12.86	1.20	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Gas Turbines - Aeroderivative

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.31	0.00	0.00	0.00	0.05	0.21	0.00	0.00	0.73	0.00
Breakage	0.78	0.05	0.10	0.31	0.10	0.05	0.00	0.00	0.00	0.05
Burst	0.00	0.00	0.16	0.21	0.00	0.00	0.00	0.05	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Clearance/ alignment failure	0.00	0.00	0.16	0.10	0.00	0.16	0.00	0.05	0.05	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.05	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Contamination	0.16	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.10	0.00
Control failure	0.31	0.00	0.00	0.10	0.21	0.73	0.05	0.00	0.16	0.00
Corrosion	0.16	0.00	0.00	0.57	0.05	0.16	0.00	0.00	0.00	0.00
Deformation	0.05	0.21	0.26	1.04	0.00	0.10	0.05	0.05	0.00	0.10
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.73	0.00	0.00	0.00	0.05	0.52	0.00	0.00	0.05	0.00
Erosion	0.00	0.00	0.16	0.10	0.00	0.05	0.00	0.00	0.00	0.00
External influence - general	0.16	0.00	0.00	0.05	0.05	0.10	0.00	0.00	0.00	0.00
Fatigue	0.05	0.00	0.00	0.10	0.00	0.05	0.00	0.05	0.05	0.05
Faulty power/voltage	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	5.36	0.00	0.00	0.00	0.10	0.36	0.00	0.00	0.05	0.00
Instrument failure - general	3.90	0.10	0.16	0.05	0.21	1.25	0.21	0.00	0.21	0.00
Leakage	0.10	0.05	0.52	1.67	0.00	0.16	0.00	0.21	0.26	0.00
Looseness	0.31	0.00	0.31	0.83	0.00	0.21	0.00	0.05	0.05	0.05
Material failure - general	0.05	0.00	0.57	1.41	0.05	0.00	0.00	0.05	0.05	0.00
Mechanical Failure - general	0.26	0.21	0.68	1.30	0.42	2.50	0.00	0.36	0.47	0.10
Misc. external influences	0.05	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00
Miscellaneous - general	0.05	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
No cause found	0.10	0.00	0.10	0.10	0.00	0.16	0.05	0.05	0.05	0.05
No power/ voltage	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.94	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Open circuit	0.31	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00
Other	0.05	0.00	0.00	0.05	0.10	0.36	0.00	0.00	0.05	0.00
Out of adjustment	2.55	0.00	0.00	0.05	0.00	0.68	0.05	0.10	0.26	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.05	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.31	0.00	0.00	0.00	0.05	0.16	0.00	0.00	0.00	0.00
Sticking	0.16	0.05	0.00	0.00	0.10	0.36	0.00	0.05	0.10	0.00
Unknown	0.10	0.05	0.00	0.16	0.00	0.10	0.00	0.00	0.10	0.00
Vibration	0.42	0.00	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
Wear	0.68	0.05	0.52	0.68	0.16	0.05	0.00	0.16	0.47	0.10
Total	18.53	0.78	3.75	9.06	1.82	9.53	0.42	1.30	3.38	0.57

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Gas Turbines - Aeroderivative

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.16	0.52	0.83	2.81	0.00	0.00	0.00	0.31	0.00	5.93
Breakage	0.10	0.31	0.10	0.47	0.47	0.00	0.00	0.21	0.00	3.12
Burst	0.00	0.42	0.00	0.05	0.21	0.00	0.00	0.05	0.00	1.15
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Clearance/ alignment failure	0.00	0.16	0.16	0.10	0.00	0.00	0.00	0.05	0.05	1.04
Combined causes	3.90	0.05	0.00	0.05	0.00	0.00	0.00	0.05	0.05	4.37
Common mode failure	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10
Contamination	0.94	0.52	0.26	1.30	0.00	0.00	0.16	0.26	0.16	3.96
Control failure	0.00	0.36	0.10	0.05	0.00	0.00	0.05	1.30	0.05	3.49
Corrosion	0.05	0.21	0.00	0.94	0.21	0.00	0.00	0.00	0.00	2.34
Deformation	0.05	0.10	0.00	0.42	0.10	0.10	0.00	0.16	0.00	2.81
Earth/isolation fault	0.00	0.16	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.31
Electrical failure - general	0.10	0.62	0.16	0.83	0.00	0.00	0.05	0.99	0.10	4.22
Erosion	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.05	0.52
External influence - general	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.16	0.00	0.68
Fatigue	0.05	0.05	0.00	0.21	0.10	0.00	0.00	0.00	0.00	0.78
Faulty power/voltage	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.31	0.00	0.47
Faulty signal/indication/alarm	0.00	0.00	0.21	0.16	0.00	0.00	0.00	1.82	0.05	8.12
Instrument failure - general	0.00	0.73	0.26	0.47	0.00	0.10	0.05	1.61	0.05	9.37
Leakage	0.05	0.68	0.16	0.05	0.31	0.00	0.00	0.26	0.05	4.53
Looseness	0.00	0.16	0.00	0.83	0.05	0.00	0.00	0.31	0.00	3.18
Material failure - general	0.00	0.16	0.00	0.26	0.05	0.00	0.10	0.16	0.00	2.92
Mechanical Failure - general	0.21	1.30	0.52	0.57	0.21	0.16	0.21	1.46	0.16	11.09
Misc. external influences	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.26	0.10	0.62
Miscellaneous - general	0.00	0.05	0.05	0.42	0.00	0.00	0.05	0.05	0.00	0.88
No cause found	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.83
No power/ voltage	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.26
No signal/indication/alarm	0.00	0.21	0.00	0.05	0.00	0.00	0.00	0.21	0.00	1.46
Open circuit	0.05	0.05	0.00	0.16	0.00	0.00	0.05	0.36	0.00	1.30
Other	0.10	0.99	0.00	0.10	0.05	0.00	0.00	0.36	0.00	2.24
Out of adjustment	0.05	0.26	0.16	0.52	0.00	0.00	0.00	0.57	0.00	5.26
Overheating	0.05	0.05	0.00	0.10	0.00	0.00	0.00	0.10	0.00	0.31
Short circuiting	0.00	0.10	0.05	0.05	0.00	0.00	0.00	0.26	0.00	0.62
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Sticking	0.00	0.68	0.05	0.73	0.00	0.00	0.00	0.16	0.00	2.45
Unknown	0.10	0.26	0.21	0.10	0.00	0.00	0.21	0.26	0.00	1.67
Vibration	0.00	0.10	0.00	0.36	0.00	0.00	0.00	0.42	0.26	1.77
Wear	0.10	0.57	0.05	1.25	0.21	0.00	0.10	0.05	0.05	5.26
Total	6.14	10.05	3.33	13.85	2.03	0.36	1.04	12.86	1.20	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.2.1.1	Machinery Gas Turbines Aeroderivative (-1000) kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
7	2	0.1556	0.1555	

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**57***	**288.09**	**364.05**	**447.34**	**48.51**	**366.23**	-	**1.0**	**20.0**	**120.0**
	57†	**288.37**	**364.41**	**447.79**	**48.56**	**366.63**				
Breakdown	2*	0.34	11.17	33.96	11.73	12.85	-	2.0	37.0	72.0
	2†	0.34	11.19	34.00	11.74	12.86				
External leakage - Utility medium	1*	0.11	5.84	18.13	6.43	6.43	-	1.0	1.0	1.0
	1†	0.11	5.84	18.15	6.43	6.43				
Fail to start on demand	41*	199.00	262.82	333.95	41.14	263.43	-	4.0	17.6	109.0
	41†	199.19	263.08	334.29	41.19	263.71				
High output	1*	0.11	5.84	18.13	6.43	6.43	-	36.0	36.0	36.0
	1†	0.11	5.84	18.15	6.43	6.43				
Spurious stop	12*	45.23	77.88	117.73	22.26	77.10	-	4.0	25.1	120.0
	12†	45.27	77.96	117.85	22.28	77.18				
Degraded	**25***	**12.06**	**123.31**	**334.69**	**107.57**	**160.63**	-	**2.0**	**28.1**	**156.0**
	25†	**12.04**	**123.44**	**335.22**	**107.77**	**160.80**				
Erratic output	4*	8.99	25.96	50.06	12.85	25.70	-	8.0	10.7	12.0
	4†	9.00	25.99	50.11	12.86	25.73				
External leakage - Fuel	1*	0.11	5.84	18.13	6.43	6.43	-	20.0	20.0	20.0
	1†	0.11	5.84	18.15	6.43	6.43				
External leakage - Utility medium	7*	4.79	36.87	94.10	29.26	44.98	-	2.0	42.0	156.0
	7†	4.78	36.90	94.26	29.32	45.02				
Other	10*	3.18	49.30	143.46	47.48	64.25	-	2.0	28.9	130.0
	10†	3.17	49.35	143.69	47.57	64.32				
Parameter deviation	1*	0.11	5.84	18.13	6.43	6.43	-	6.0	6.0	6.0
	1†	0.11	5.84	18.15	6.43	6.43				
Structural deficiency	1*	0.11	5.84	18.13	6.43	6.43	-	4.0	4.0	4.0
	1†	0.11	5.84	18.15	6.43	6.43				
Vibration	1*	0.11	5.84	18.13	6.43	6.43	-	30.0	30.0	30.0
	1†	0.11	5.84	18.15	6.43	6.43				
Incipient	**21***	**51.30**	**120.91**	**214.40**	**50.62**	**134.93**	-	**1.0**	**8.1**	**78.0**
	21†	**51.17**	**120.99**	**214.85**	**50.80**	**135.07**				
Abnormal instrument reading	10*	16.84	58.26	120.04	32.59	64.25	-	1.0	3.4	6.0
	10†	16.82	58.31	120.24	32.66	64.32				
Minor in-service problems	7*	19.75	43.47	74.66	17.00	44.98	-	1.0	3.5	6.0
	7†	19.77	43.51	74.74	17.02	45.02				
Other	1*	0.11	5.84	18.13	6.43	6.43	-	12.0	12.0	12.0
	1†	0.11	5.84	18.15	6.43	6.43				
Structural deficiency	3*	0.33	16.09	49.81	17.59	19.28	-	4.0	41.0	78.0
	3†	0.33	16.11	49.87	17.61	19.30				
All modes	**103***	**335.61**	**601.10**	**929.17**	**182.47**	**661.78**	-	**1.0**	**19.7**	**156.0**
	103†	**335.02**	**601.54**	**931.15**	**183.26**	**662.50**				

Comments

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Taxonomy no	Item
1.2.1.2	Machinery Gas Turbines Aeroderivative (3000-10000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.0927	0.0717	108

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**20***	**107.87**	**202.53**	**321.28**	**65.71**	**215.72**	**9.3**	**1.0**	**27.8**	**326.0**
	20†	**113.95**	**257.67**	**448.45**	**103.68**	**279.08**				
Abnormal instrument reading	1*	0.08	15.77	56.61	20.92	10.79	-	53.0	53.0	53.0
	1†	0.12	19.22	67.11	24.77	13.95				
External leakage - Fuel	2*	0.27	18.69	59.23	21.29	21.57	4.5	4.0	4.5	5.0
	2†	0.30	24.23	77.93	28.22	27.91				
Fail to start on demand	4*	7.74	38.35	88.16	25.83	43.14	18.0	1.0	18.0	68.0
	4†	7.79	49.16	120.17	36.52	55.82				
Internal leakage	1*	0.20	9.84	30.51	10.79	10.79	10.0	10.0	10.0	10.0
	1†	0.24	12.76	39.74	14.11	13.95				
Other	1*	0.08	15.77	56.61	20.92	10.79	-	4.0	4.0	4.0
	1†	0.12	19.22	67.11	24.77	13.95				
Spurious stop	10*	1.61	83.50	259.57	92.01	107.86	6.7	1.0	8.2	29.0
	10†	1.66	109.02	344.53	123.62	139.54				
Vibration	1*	0.08	15.77	56.61	20.92	10.79	-	326.0	326.0	326.0
	1†	0.12	19.22	67.11	24.77	13.95				
Degraded	**13***	**83.92**	**141.27**	**210.69**	**38.89**	**140.22**	**5.9**	**2.0**	**55.0**	**520.0**
	13†	**107.61**	**181.76**	**271.60**	**50.31**	**181.40**				
Erratic output	2*	0.27	18.69	59.23	21.29	21.57	8.5	8.0	8.5	9.0
	2†	0.30	24.23	77.93	28.22	27.91				
External leakage - Utility medium	1*	0.20	9.84	30.51	10.79	10.79	4.0	12.0	12.0	12.0
	1†	0.24	12.76	39.74	14.11	13.95				
Low output	7*	18.26	90.57	208.29	61.03	75.50	6.3	5.0	103.0	520.0
	7†	28.15	112.46	242.89	68.29	97.68				
Minor in-service problems	1*	0.20	9.84	30.51	10.79	10.79	2.0	2.0	2.0	2.0
	1†	0.24	12.76	39.74	14.11	13.95				
Parameter deviation	2*	0.27	18.69	59.23	21.29	21.57	5.5	5.0	5.5	6.0
	2†	0.30	24.23	77.93	28.22	27.91				
Incipient	**54***	**375.89**	**563.46**	**782.00**	**124.17**	**582.45**	**3.2**	**1.0**	**12.1**	**121.0**
	54†	**546.22**	**732.87**	**942.07**	**120.72**	**753.52**				
Abnormal instrument reading	11*	1.44	91.03	286.89	102.75	118.65	2.0	1.0	2.2	8.0
	11†	1.53	119.00	381.28	137.84	153.49				
Erratic output	2*	4.18	23.15	54.68	16.26	21.57	1.0	1.0	8.5	16.0
	2†	6.03	29.47	67.51	19.73	27.91				
External leakage - Utility medium	7*	3.59	60.93	179.29	59.55	75.50	5.8	1.0	8.5	34.0
	7†	3.18	79.09	238.12	80.72	97.68				
Fail to start on demand	1*	0.20	9.84	30.51	10.79	10.79	1.0	1.0	1.0	1.0
	1†	0.24	12.76	39.74	14.11	13.95				
Internal leakage	1*	0.20	9.84	30.51	10.79	10.79	4.0	4.0	4.0	4.0
	1†	0.24	12.76	39.74	14.11	13.95				

Comments

(cont.)

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Taxonomy no	Item
1.2.1.2	Machinery Gas Turbines Aeroderivative (3000-10000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.0927	0.0717	108

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.08	15.77	56.61	20.92	10.79	-	28.0	28.0	28.0
	1†	0.12	19.22	67.11	24.77	13.95				
Minor in-service problems	6*	26.13	62.39	111.25	26.42	64.72	3.5	1.0	4.4	10.0
	6†	29.67	80.12	150.57	37.74	83.72				
Other	5*	22.91	55.87	100.54	24.12	53.93	2.7	1.0	14.0	47.0
	5†	29.16	71.71	129.54	31.20	69.77				
Overheating	1*	0.08	15.77	56.61	20.92	10.79	-	30.0	30.0	30.0
	1†	0.12	19.22	67.11	24.77	13.95				
Parameter deviation	12*	1.33	98.56	314.53	113.48	129.43	3.3	1.5	3.3	8.0
	12†	1.45	128.98	418.33	152.04	167.45				
Structural deficiency	6*	1.06	98.41	320.67	116.75	64.72	1.0	1.0	55.0	121.0
	6†	1.51	120.76	387.83	140.37	83.72				
Vibration	1*	0.08	15.77	56.61	20.92	10.79	-	14.0	14.0	14.0
	1†	0.12	19.22	67.11	24.77	13.95				
Unknown	**3***	**4.93**	**39.48**	**101.56**	**31.69**	**32.36**	**1.0**	**1.0**	**9.0**	**18.0**
	3†	**8.10**	**48.78**	**117.84**	**35.56**	**41.86**				
Abnormal instrument reading	1*	0.20	9.84	30.51	10.79	10.79	1.0	1.0	1.0	1.0
	1†	0.24	12.76	39.74	14.11	13.95				
Other	1*	0.08	15.77	56.61	20.92	10.79	-	8.0	8.0	8.0
	1†	0.12	19.22	67.11	24.77	13.95				
Unknown	1*	0.08	15.77	56.61	20.92	10.79	-	18.0	18.0	18.0
	1†	0.12	19.22	67.11	24.77	13.95				
All modes	**90***	**793.89**	**955.76**	**1130.07**	**102.33**	**970.75**	**5.1**	**1.0**	**21.4**	**520.0**
	90†	**909.99**	**1216.90**	**1560.49**	**198.36**	**1255.86**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0. 100

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Taxonomy no	Item
1.2.1.3	Machinery Gas Turbines Aeroderivative (10000-20000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
7	2	0.2353	0.1630	2647

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**176***	**110.78**	**591.75**	**1386.60**	**410.62**	**748.07**	**15.9**	**0.1**	**29.4**	**390.0**
	176†	**78.83**	**864.59**	**2380.32**	**770.48**	**1079.79**				
External leakage - Fuel	6*	4.03	21.68	50.87	15.08	25.50	13.7	6.0	27.4	80.0
	6†	2.04	30.38	87.95	29.06	36.81				
External leakage - Utility medium	3*	0.23	10.65	32.92	11.61	12.75	42.7	17.0	52.0	100.0
	3†	3.90	16.85	37.24	10.63	18.41				
Fail to start on demand	33*	102.01	139.60	182.04	24.42	140.26	14.5	1.0	26.5	135.0
	33†	143.27	197.45	258.77	35.24	202.46				
Low output	2*	0.23	7.39	22.46	7.74	8.50	5.0	9.0	9.5	10.0
	2†	0.13	10.65	34.23	12.39	12.27				
Other	1*	0.03	7.99	30.76	11.34	4.25	-	-	-	-
	1†	0.05	8.48	29.63	10.94	6.14				
Overheating	41*	0.73	117.48	411.35	151.85	174.27	14.8	0.1	28.8	213.0
	41†	0.92	183.74	667.72	246.72	251.54				
Spurious stop	86*	40.36	283.64	710.82	219.05	365.53	15.3	1.0	28.9	390.0
	86†	27.85	417.24	1208.57	399.39	527.62				
Unknown	1*	0.03	7.99	30.76	11.34	4.25	-	-	-	-
	1†	0.05	8.48	29.63	10.94	6.14				
Vibration	3*	0.23	10.65	32.92	11.61	12.75	58.8	20.0	96.0	172.0
	3†	3.90	16.85	37.24	10.63	18.41				
Degraded	**117***	**19.08**	**360.59**	**1073.79**	**357.95**	**497.30**	**18.4**	**3.0**	**40.4**	**768.0**
	117†	**9.08**	**546.66**	**1716.37**	**613.19**	**717.81**				
Abnormal instrument reading	9*	2.48	29.89	83.71	27.30	38.25	10.7	8.0	23.4	70.0
	9†	0.84	43.53	135.35	47.99	55.22				
Erratic output	7*	13.08	28.77	49.40	11.25	29.75	18.7	6.0	35.8	75.0
	7†	11.30	40.05	83.16	22.71	42.95				
External leakage - Fuel	5*	5.38	18.94	39.24	10.70	21.25	12.8	16.0	26.2	48.0
	5†	2.56	26.00	70.45	22.62	30.68				
External leakage - Utility medium	8*	2.79	27.15	72.91	23.30	34.00	52.0	3.0	140.3	768.0
	8†	1.02	39.15	119.73	41.72	49.08				
Low output	5*	2.52	30.87	86.68	28.31	21.25	29.8	4.0	48.8	121.0
	5†	7.94	35.36	78.87	22.65	30.68				
Other	12*	1.42	38.10	114.96	39.16	51.00	23.8	4.0	47.5	200.0
	12†	0.64	56.67	183.67	66.73	73.62				
Overheating	60*	0.89	169.49	610.12	225.44	255.02	8.5	5.5	16.6	79.5
	60†	1.23	266.99	986.94	364.48	368.11				
Parameter deviation	4*	5.96	17.19	33.13	8.50	17.00	7.5	8.0	16.0	20.0
	4†	8.10	24.20	47.26	12.27	24.54				
Structural deficiency	5*	5.38	18.94	39.24	10.70	21.25	101.8	130.0	241.8	490.0
	5†	2.56	26.00	70.45	22.62	30.68				

Comments

(cont.)

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Taxonomy no	Item
1.2.1.3	Machinery Gas Turbines Aeroderivative (10000-20000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
7	2	0.2353	0.1630	2647

Failure mode	No of	Failure rate (per 106 hours).					Active	Repair (manhours)		
	failures	Lower	Mean	Upper	SD	n/τ	rep.hrs	Min	Mean	Max
Vibration	2*	0.23	7.39	22.46	7.74	8.50	4.0	4.0	7.0	10.0
	2†	0.13	10.65	34.23	12.39	12.27				
Incipient	**234***	**256.21**	**826.91**	**1662.39**	**442.16**	**994.59**	**7.6**	**1.0**	**13.4**	**192.0**
	234†	**175.77**	**1183.82**	**2938.99**	**901.19**	**1435.63**				
Abnormal instrument reading	87*	39.70	286.34	721.55	222.98	369.78	4.8	1.0	9.2	68.0
	87†	27.35	421.60	1225.85	405.62	533.76				
External leakage - Fuel	3*	0.84	19.09	57.35	19.32	12.75	10.3	3.0	11.0	19.0
	3†	3.53	21.49	52.09	15.75	18.41				
External leakage - Utility medium	26*	56.03	102.33	159.88	31.94	110.51	8.4	1.0	16.6	72.0
	26†	32.41	138.12	304.08	86.57	159.51				
Internal leakage	2*	0.23	7.39	22.46	7.74	8.50	5.0	5.5	9.8	14.0
	2†	0.13	10.65	34.23	12.39	12.27				
Minor in-service problems	48*	2.46	143.95	451.07	160.92	204.02	3.9	1.0	7.5	40.0
	48†	1.96	220.56	733.94	268.88	294.49				
Noise	1*	0.03	7.99	30.76	11.34	4.25	16.0	16.0	16.0	16.0
	1†	0.05	8.48	29.63	10.94	6.14				
Other	50*	2.35	149.40	470.94	168.70	212.52	11.2	2.0	19.6	192.0
	50†	1.96	229.31	766.94	281.31	306.76				
Overheating	1*	0.08	3.86	12.00	4.25	4.25	15.0	30.0	30.0	30.0
	1†	0.11	5.61	17.46	6.20	6.14				
Parameter deviation	4*	0.14	36.50	140.51	51.79	17.00	13.7	9.0	13.7	22.0
	4†	0.16	39.16	148.28	54.68	24.54				
Structural deficiency	3*	0.23	10.65	32.92	11.61	12.75	44.7	8.0	89.0	175.0
	3†	3.90	16.85	37.24	10.63	18.41				
Unknown	8*	0.29	74.52	286.56	105.58	34.00	28.8	14.0	22.8	35.0
	8†	0.32	80.08	305.52	112.59	49.08				
Vibration	1*	0.08	3.86	12.00	4.25	4.25	3.0	3.0	3.0	3.0
	1†	0.11	5.61	17.46	6.20	6.14				
Unknown	**4***	**4.58**	**15.44**	**31.53**	**8.50**	**17.00**	**4.0**	**2.0**	**8.0**	**20.0**
	4†	**3.46**	**21.62**	**52.71**	**15.99**	**24.54**				
Other	1*	0.08	3.86	12.00	4.25	4.25	10.0	20.0	20.0	20.0
	1†	0.11	5.61	17.46	6.20	6.14				
Unknown	3*	0.23	10.65	32.92	11.61	12.75	1.0	2.0	2.0	2.0
	3†	3.90	16.85	37.24	10.63	18.41				
All modes	**531***	**319.05**	**1773.35**	**4194.34**	**1248.17**	**2256.96**	**12.7**	**0.1**	**24.7**	**768.0**
	531†	**233.06**	**2601.35**	**7185.95**	**2329.68**	**3257.77**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.2. 10-2

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Taxonomy no	Item
1.2.1.4	Machinery Gas Turbines Aeroderivative (20000-40000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
15	5	0.6453	0.3408	3512

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**296***	**2.07**	**373.37**	**1331.07**	**491.76**	**458.73**	**23.7**	**0.3**	**27.6**	**604.0**
	296†	**1.49**	**756.82**	**3032.67**	**1136.91**	**868.45**				
Abnormal instrument reading	1*	0.00	1.39	5.66	2.14	1.55	4.0	4.0	4.0	4.0
	1†	0.00	2.73	12.95	5.30	2.93				
Breakdown	7*	1.60	10.24	25.12	7.65	10.85	30.6	2.0	63.4	286.0
	7†	0.85	20.03	60.20	20.32	20.54				
Erratic output	8*	5.34	12.72	22.67	5.38	12.40	84.4	3.0	75.1	284.0
	8†	3.10	23.18	58.84	18.25	23.47				
External leakage - Fuel	22*	0.36	37.02	121.93	44.54	34.09	10.7	0.3	16.2	78.0
	22†	0.80	62.39	200.07	72.35	64.55				
External leakage - Utility medium	1*	0.00	1.64	8.07	3.40	1.55	-	12.0	12.0	12.0
	1†	0.00	2.76	13.20	5.44	2.93				
Fail to start on demand	87*	0.76	104.78	357.87	131.76	134.83	28.9	1.0	29.1	324.0
	87†	0.70	218.94	851.34	315.38	255.25				
Fail to stop on demand	6*	3.61	8.80	15.83	3.80	9.30	4.0	2.0	5.2	10.0
	6†	1.08	16.38	47.56	15.73	17.60				
High output	4*	0.01	4.97	19.86	7.43	6.20	11.9	5.0	21.0	52.0
	4†	0.00	10.30	47.26	18.91	11.74				
Internal leakage	2*	0.44	2.90	7.17	2.19	3.10	18.5	9.0	18.5	28.0
	2†	0.05	5.51	18.42	6.75	5.87				
Low output	12*	0.00	28.47	127.58	50.51	18.60	45.9	5.0	68.6	604.0
	12†	0.00	38.28	179.26	72.91	35.21				
Other	5*	0.65	7.52	20.90	6.79	7.75	42.8	12.0	53.4	114.0
	5†	5.58	14.43	26.63	6.56	14.67				
Overheating	7*	0.08	9.36	31.56	11.60	10.85	42.0	3.0	60.1	243.0
	7†	0.03	18.49	75.34	28.47	20.54				
Parameter deviation	7*	0.00	7.89	37.47	15.36	10.85	10.7	4.0	12.7	26.0
	7†	0.00	17.45	86.10	36.40	20.54				
Spurious stop	122*	0.02	139.73	638.98	254.96	189.07	18.3	1.0	19.4	565.0
	122†	0.01	304.75	1433.65	584.76	357.94				
Vibration	5*	1.02	7.06	17.65	5.43	7.75	10.1	3.0	8.9	28.5
	5†	0.12	13.28	44.09	16.14	14.67				
Degraded	**167***	**41.28**	**272.44**	**673.23**	**205.91**	**258.81**	**17.6**	**1.0**	**17.7**	**560.0**
	167†	**47.50**	**462.24**	**1241.15**	**396.62**	**489.97**				
Abnormal instrument reading	12*	1.79	21.34	59.68	19.45	18.60	10.0	2.0	10.3	20.0
	12†	6.94	34.60	79.67	23.36	35.21				
Erratic output	9*	0.34	13.70	42.00	14.68	13.95	24.7	6.0	25.9	66.0
	9†	0.30	25.04	80.86	29.33	26.41				
External leakage - Fuel	21*	0.06	27.46	109.14	40.76	32.54	9.1	2.0	14.0	84.0
	21†	0.02	55.37	242.10	94.50	61.61				

Comments

(cont.)

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Taxonomy no	Item
1.2.1.4	Machinery Gas Turbines Aeroderivative (20000-40000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
15	5	0.6453	0.3408	3512

Failure mode	No of failures	Failure rate (per 10⁶ hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
External leakage - Utility medium	31*	3.54	42.70	119.66	39.04	48.04	10.4	1.0	12.4	58.0
	31†	1.65	79.46	245.94	86.83	90.95				
Fail to start on demand	1*	0.00	1.39	5.66	2.14	1.55	6.0	10.0	10.0	10.0
	1†	0.00	2.73	12.95	5.30	2.93				
High output	3*	0.02	4.58	16.76	6.19	4.65	2.0	2.0	2.0	2.0
	3†	2.34	8.71	18.39	5.08	8.80				
Internal leakage	8*	0.39	13.76	41.92	14.52	12.40	16.5	2.0	15.8	34.0
	8†	2.69	23.45	61.30	19.28	23.47				
Low output	22*	0.61	39.70	125.33	44.94	34.09	15.6	1.0	15.6	77.0
	22†	1.03	64.53	203.15	72.71	64.55				
Minor in-service problems	7*	0.10	12.71	42.98	15.80	10.85	5.5	1.0	17.0	36.0
	7†	0.22	19.60	63.60	23.12	20.54				
Noise	2*	0.00	3.35	14.33	5.54	3.10	10.0	10.0	15.0	20.0
	2†	0.03	5.84	21.34	7.88	5.87				
Other	28*	10.33	55.31	129.69	38.42	43.39	15.4	2.0	13.8	36.0
	28†	27.38	84.44	166.97	43.83	82.15				
Overheating	2*	0.00	4.60	20.55	8.13	3.10	37.5	1.0	41.5	82.0
	2†	0.00	6.35	27.36	10.60	5.87				
Parameter deviation	11*	0.02	14.35	59.13	22.44	17.05	6.0	2.0	9.1	39.0
	11†	0.01	29.55	131.93	52.14	32.27				
Structural deficiency	6*	0.16	10.17	32.05	11.48	9.30	15.4	2.0	15.8	53.0
	6†	1.05	17.46	51.29	17.03	17.60				
Unknown	1*	0.00	1.39	5.66	2.14	1.55	14.0	14.0	14.0	14.0
	1†	0.00	2.73	12.95	5.30	2.93				
Vibration	3*	0.02	4.58	16.76	6.19	4.65	189.0	3.0	189.0	560.0
	3†	2.34	8.71	18.39	5.08	8.80				
Incipient	**454***	**59.51**	**660.98**	**1824.18**	**591.14**	**703.59**	**8.4**	**1.0**	**13.6**	**358.0**
	454†	**22.75**	**1233.57**	**3845.96**	**1366.69**	**1332.01**				
Abnormal instrument reading	177*	25.57	268.67	733.36	236.39	274.31	7.2	1.0	9.8	172.0
	177†	10.44	484.81	1497.56	527.72	519.31				
External leakage - Fuel	9*	0.14	14.27	47.08	17.21	13.95	10.6	2.0	11.2	25.0
	9†	0.14	26.83	97.21	35.92	26.41				
External leakage - Utility medium	65*	0.36	72.69	265.49	98.09	100.73	10.7	1.0	18.4	235.0
	65†	0.39	162.52	644.05	240.30	190.71				
Internal leakage	8*	0.03	9.50	36.92	13.67	12.40	13.9	2.0	16.2	48.0
	8†	0.01	20.36	88.02	34.15	23.47				
Low output	4*	0.01	4.97	19.86	7.43	6.20	10.0	8.0	10.0	12.0
	4†	0.00	10.30	47.26	18.91	11.74				
Minor in-service problems	112*	0.82	164.77	599.92	221.66	173.57	5.9	1.0	8.1	117.0
	112†	0.78	299.12	1177.78	438.50	328.60				

Comments

(cont.)

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Taxonomy no	Item
1.2.1.4	Machinery Gas Turbines Aeroderivative (20000-40000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
15	5	0.6453	0.3408	3512

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	2*	0.44	2.90	7.17	2.19	3.10	-	16.0	16.0	16.0
	2†	0.05	5.51	18.42	6.75	5.87				
Other	56*	24.86	98.72	212.80	59.75	86.79	17.8	1.0	26.7	358.0
	56†	40.81	172.65	379.31	107.84	164.30				
Overheating	2*	0.44	2.90	7.17	2.19	3.10	1.5	1.0	1.5	2.0
	2†	0.05	5.51	18.42	6.75	5.87				
Parameter deviation	2*	0.16	2.87	8.50	2.83	3.10	3.0	3.0	5.0	7.0
	2†	0.05	5.62	18.73	6.87	5.87				
Structural deficiency	14*	1.34	17.73	50.44	16.56	21.70	15.6	4.0	34.4	94.0
	14†	0.37	37.04	121.70	44.43	41.08				
Vibration	3*	0.08	4.69	14.64	5.21	4.65	14.0	4.0	21.0	38.0
	3†	0.82	8.73	23.92	7.72	8.80				
Unknown	**8***	**2.41**	**16.25**	**40.34**	**12.37**	**12.40**	**9.8**	**6.0**	**47.0**	**212.0**
	8†	**12.23**	**24.07**	**39.15**	**8.30**	**23.47**				
Other	3*	1.35	4.75	9.84	2.68	4.65	8.0	8.0	34.3	78.0
	3†	0.10	9.37	30.71	11.20	8.80				
Unknown	5*	0.30	11.61	35.54	12.40	7.75	10.3	6.0	54.6	212.0
	5†	1.47	16.00	43.96	14.22	14.67				
All modes	**925***	**96.73**	**1326.04**	**3792.70**	**1247.64**	**1433.52**	**15.2**	**0.3**	**19.1**	**604.0**
	925†	**32.85**	**2477.48**	**7916.43**	**2858.08**	**2713.90**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.2. 10-2

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Taxonomy no	Item
1.2.1.5	Machinery Gas Turbines Aeroderivative Unknown

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.2628	0.1518	597

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**55***	**165.14**	**209.30**	**262.01**	**209.30**	**209.30**	**32.6**	**2.0**	**35.8**	**301.0**
	55†	**285.80**	**362.23**	**453.45**	**362.23**	**362.23**				
Breakdown	6*	9.95	22.83	45.06	22.83	22.83	76.0	6.0	99.0	301.0
	6†	17.22	39.52	77.98	39.52	39.52				
Fail to start on demand	16*	38.19	60.89	92.47	60.89	60.89	24.0	2.0	25.2	120.0
	16†	66.09	105.38	160.03	105.38	105.38				
Fail to stop on demand	1*	0.19	3.81	18.06	3.81	3.81	12.0	12.0	12.0	12.0
	1†	0.33	6.59	31.25	6.59	6.59				
Internal leakage	1*	0.19	3.81	18.06	3.81	3.81	6.0	6.0	6.0	6.0
	1†	0.33	6.59	31.25	6.59	6.59				
Low output	4*	5.19	15.22	34.84	15.22	15.22	34.6	8.0	34.6	106.5
	4†	8.99	26.34	60.29	26.34	26.34				
Overheating	2*	1.35	7.61	23.96	7.61	7.61	22.0	12.0	22.0	32.0
	2†	2.34	13.17	41.46	13.17	13.17				
Parameter deviation	7*	12.50	26.64	50.04	26.64	26.64	31.3	3.0	34.1	96.0
	7†	21.63	46.10	86.61	46.10	46.10				
Spurious stop	17*	41.22	64.69	97.03	64.69	64.69	29.5	3.0	29.5	238.0
	17†	71.33	111.96	167.92	111.96	111.96				
Vibration	1*	0.19	3.81	18.06	3.81	3.81	18.0	26.0	26.0	26.0
	1†	0.33	6.59	31.25	6.59	6.59				
Degraded	**52***	**155.01**	**197.89**	**249.32**	**197.89**	**197.89**	**15.8**	**1.0**	**21.5**	**312.0**
	52†	**268.27**	**342.47**	**431.48**	**342.47**	**342.47**				
Erratic output	3*	3.12	11.42	29.51	11.42	11.42	10.0	4.0	56.7	150.0
	3†	5.40	19.76	51.07	19.76	19.76				
External leakage - Fuel	1*	0.19	3.81	18.06	3.81	3.81	8.0	8.0	8.0	8.0
	1†	0.33	6.59	31.25	6.59	6.59				
External leakage - Utility medium	13*	29.26	49.47	78.64	49.47	49.47	16.5	2.0	17.5	122.0
	13†	50.63	85.62	136.10	85.62	85.62				
Internal leakage	2*	1.35	7.61	23.96	7.61	7.61	53.5	17.0	63.0	109.0
	2†	2.34	13.17	41.46	13.17	13.17				
Low output	8*	15.15	30.44	54.93	30.44	30.44	7.0	3.0	7.0	22.0
	8†	26.21	52.69	95.07	52.69	52.69				
Minor in-service problems	2*	1.35	7.61	23.96	7.61	7.61	3.0	1.0	2.0	3.0
	2†	2.34	13.17	41.46	13.17	13.17				
Noise	1*	0.19	3.81	18.06	3.81	3.81	145.0	312.0	312.0	312.0
	1†	0.33	6.59	31.25	6.59	6.59				
Other	9*	17.87	34.25	59.77	34.25	34.25	10.9	3.0	10.9	30.0
	9†	30.92	59.27	103.43	59.27	59.27				
Overheating	1*	0.19	3.81	18.06	3.81	3.81	16.0	16.0	16.0	16.0
	1†	0.33	6.59	31.25	6.59	6.59				

Comments

(cont.)

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Taxonomy no	Item
1.2.1.5	Machinery Gas Turbines Aeroderivative Unknown

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.2628	0.1518	597

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Parameter deviation	11*	23.48	41.86	69.30	41.86	41.86	7.8	1.5	7.9	24.0
	11†	40.64	72.45	119.93	72.45	72.45				
Structural deficiency	1*	0.19	3.81	18.06	3.81	3.81	-	3.0	3.0	3.0
	1†	0.33	6.59	31.25	6.59	6.59				
Incipient	**163***	**542.60**	**620.30**	**706.38**	**620.30**	**620.30**	**15.4**	**0.5**	**17.4**	**294.0**
	163†	**939.04**	**1073.51**	**1222.48**	**1073.51**	**1073.51**				
Abnormal instrument reading	47*	138.21	178.86	228.09	178.86	178.86	19.9	0.5	19.4	184.0
	47†	239.20	309.54	394.73	309.54	309.54				
External leakage - Fuel	2*	1.35	7.61	23.96	7.61	7.61	3.5	3.0	3.5	4.0
	2†	2.34	13.17	41.46	13.17	13.17				
External leakage - Utility medium	11*	23.48	41.86	69.30	41.86	41.86	6.4	3.0	6.7	12.0
	11†	40.64	72.45	119.93	72.45	72.45				
Minor in-service problems	83*	261.07	315.86	379.12	315.86	315.86	12.9	1.0	12.2	187.0
	83†	451.82	546.64	656.11	546.64	546.64				
Noise	5*	7.50	19.03	40.02	19.03	19.03	38.5	6.0	110.8	294.0
	5†	12.97	32.93	69.25	32.93	32.93				
Other	9*	17.87	34.25	59.77	34.25	34.25	23.0	1.0	27.0	52.0
	9†	30.92	59.27	103.43	59.27	59.27				
Overheating	1*	0.19	3.81	18.06	3.81	3.81	4.0	4.0	4.0	4.0
	1†	0.33	6.59	31.25	6.59	6.59				
Parameter deviation	3*	3.12	11.42	29.51	11.42	11.42	5.7	3.0	5.7	8.0
	3†	5.40	19.76	51.07	19.76	19.76				
Vibration	2*	1.35	7.61	23.96	7.61	7.61	-	-	-	-
	2†	2.34	13.17	41.46	13.17	13.17				
Unknown	**2***	**1.35**	**7.61**	**23.96**	**7.61**	**7.61**	**14.0**	**14.0**	**14.0**	**14.0**
	2†	**2.34**	**13.17**	**41.46**	**13.17**	**13.17**				
Other	1*	0.19	3.81	18.06	3.81	3.81	-	-	-	-
	1†	0.33	6.59	31.25	6.59	6.59				
Unknown	1*	0.19	3.81	18.06	3.81	3.81	14.0	14.0	14.0	14.0
	1†	0.33	6.59	31.25	6.59	6.59				
All modes	**272***	**934.07**	**1035.10**	**1144.46**	**1035.10**	**1035.10**	**19.2**	**0.5**	**22.0**	**312.0**
	272†	**1616.53**	**1791.38**	**1980.64**	**1791.38**	**1791.38**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 3.4. 10-3

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Taxonomy no	Item
1.2.2	Machinery Gas Turbines Industrial

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
45	14	1.1807	0.9008	4232

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**337***	**52.29**	**362.73**	**906.50**	**278.95**	**285.43**	**37.6**	**1.0**	**61.5**	**3001.0**
	337†	**116.38**	**535.26**	**1205.37**	**348.51**	**374.12**				
Abnormal instrument reading	2*	0.00	2.70	14.87	7.27	1.69	48.5	31.0	97.0	163.0
	2†	0.00	3.32	17.99	8.36	2.22				
Breakdown	11*	0.12	9.22	29.42	10.62	9.32	77.8	10.0	88.3	229.0
	11†	1.92	11.87	28.87	8.75	12.21				
Erratic output	13*	0.02	12.33	49.52	18.59	11.01	14.7	1.0	28.3	93.0
	13†	0.08	15.09	54.69	20.21	14.43				
External leakage - Fuel	10*	0.03	16.77	67.03	25.09	8.47	48.6	2.0	154.1	1113.0
	10†	0.14	23.65	83.16	30.71	11.10				
External leakage - Utility medium	10*	0.06	11.15	40.28	14.88	8.47	14.1	2.0	26.4	92.0
	10†	0.15	13.51	44.00	16.02	11.10				
Fail to start on demand	118*	24.53	119.73	274.16	80.12	99.94	33.7	1.0	46.1	511.0
	118†	37.75	195.22	453.79	133.80	131.00				
Fail to stop on demand	1*	0.00	0.97	4.50	1.82	0.85	-	-	-	-
	1†	0.00	1.31	7.57	4.11	1.11				
Internal leakage	2*	0.00	1.70	8.78	3.85	1.69	91.8	12.0	177.5	343.0
	2†	0.00	2.64	11.91	4.73	2.22				
Low output	9*	0.59	7.91	22.57	7.42	7.62	11.4	2.0	21.0	64.0
	9†	1.33	10.73	27.63	8.63	9.99				
Other	5*	0.05	4.94	16.35	5.98	4.23	24.2	2.0	38.5	115.0
	5†	0.08	7.02	22.85	8.31	5.55				
Overheating	4*	0.00	4.84	20.17	7.69	3.39	11.3	2.0	16.5	33.0
	4†	0.03	5.68	20.93	7.73	4.44				
Parameter deviation	17*	0.12	21.76	78.05	28.84	14.40	22.7	1.0	44.1	249.0
	17†	0.23	26.28	87.67	32.14	18.87				
Spurious stop	123*	0.70	124.27	442.04	163.30	104.18	28.5	1.0	44.3	1024.0
	123†	3.70	177.45	549.10	193.83	136.55				
Structural deficiency	5*	0.35	4.28	12.02	3.93	4.23	346.5	12.0	693.2	3001.0
	5†	2.24	5.62	10.23	2.49	5.55				
Unknown	2*	0.00	1.55	8.03	3.52	1.69	68.0	68.0	68.0	68.0
	2†	0.00	2.02	9.83	4.10	2.22				
Vibration	5*	0.02	4.05	15.12	5.58	4.23	80.8	22.0	138.3	307.0
	5†	0.01	5.68	23.06	8.70	5.55				
Degraded	**330***	**47.74**	**290.63**	**704.12**	**212.83**	**279.50**	**21.3**	**1.0**	**32.7**	**939.0**
	330†	**100.77**	**379.13**	**803.19**	**222.67**	**366.35**				
Abnormal instrument reading	13*	0.11	8.57	27.37	9.88	11.01	6.3	1.0	10.8	48.0
	13†	1.24	12.11	32.56	10.41	14.43				
Erratic output	33*	5.10	25.66	59.23	17.40	27.95	8.5	1.0	15.1	72.0
	33†	13.62	34.98	64.38	15.81	36.63				

Comments

(cont.)

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Taxonomy no	Item
1.2.2	Machinery Gas Turbines Industrial

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
45	14	1.1807	0.9008	4232

Failure mode	No of failures	Failure rate (per 10⁶ hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Fuel	27*	4.19	22.26	52.10	15.42	22.87	15.2	3.0	16.2	47.0
	27†	1.44	33.01	99.17	33.43	29.97				
External leakage - Utility medium	52*	8.61	48.61	115.42	34.42	44.04	42.3	2.0	59.3	939.0
	52†	18.15	63.58	131.55	35.83	57.73				
High output	1*	0.00	0.74	3.24	1.27	0.85	8.0	8.0	8.0	8.0
	1†	0.00	0.98	3.58	1.32	1.11				
Internal leakage	2*	0.17	1.79	4.90	1.58	1.69	22.0	22.0	22.0	22.0
	2†	0.00	2.60	12.93	5.50	2.22				
Low output	34*	0.03	31.82	132.14	50.27	28.80	26.7	1.0	28.2	224.0
	34†	0.08	38.48	153.93	57.64	37.74				
Minor in-service problems	2*	0.00	6.36	32.15	13.82	1.69	-	8.0	8.0	8.0
	2†	0.00	7.07	36.37	15.77	2.22				
Noise	1*	0.04	0.87	2.62	0.88	0.85	-	23.0	23.0	23.0
	1†	0.00	1.19	6.62	3.39	1.11				
Other	60*	6.25	59.99	160.59	51.23	50.82	33.7	1.0	49.3	354.0
	60†	10.97	81.85	207.69	64.40	66.61				
Overheating	29*	0.29	22.71	72.87	26.36	24.56	18.8	2.0	36.3	110.0
	29†	2.24	29.96	85.36	28.04	32.19				
Parameter deviation	40*	0.00	38.27	202.47	92.25	33.88	7.0	1.0	13.1	76.0
	40†	0.00	46.73	242.84	107.75	44.41				
Structural deficiency	17*	0.00	15.31	76.05	32.33	14.40	11.3	2.0	15.5	46.0
	17†	0.00	18.36	88.95	36.81	18.87				
Unknown	13*	0.00	9.90	53.23	24.62	11.01	44.8	2.0	44.8	116.0
	13†	0.00	12.49	65.76	29.79	14.43				
Vibration	6*	0.09	5.07	15.84	5.63	5.08	26.9	12.0	61.2	224.0
	6†	0.38	6.82	20.19	6.72	6.66				
Incipient	**667***	**178.60**	**566.53**	**1131.95**	**299.63**	**564.93**	**16.3**	**1.0**	**26.9**	**1519.0**
	667†	**534.63**	**1760.86**	**3566.39**	**954.77**	**740.47**				
Abnormal instrument reading	206*	69.55	174.08	316.87	76.94	174.48	7.9	1.0	12.9	75.0
	206†	142.45	691.10	1579.90	461.27	228.69				
Erratic output	12*	0.60	9.09	26.40	8.73	10.16	8.9	2.0	12.9	28.0
	12†	3.35	12.47	26.31	7.27	13.32				
External leakage - Fuel	16*	0.00	12.57	69.22	34.43	13.55	13.0	2.0	13.1	32.0
	16†	0.00	15.76	86.63	42.24	17.76				
External leakage - Utility medium	55*	11.69	45.69	97.99	27.42	46.58	13.8	2.0	20.3	102.0
	55†	12.97	180.04	515.90	169.83	61.06				
Fail to start on demand	1*	0.00	0.77	4.04	1.82	0.85	4.0	8.0	8.0	8.0
	1†	0.00	1.01	4.75	1.93	1.11				
Internal leakage	2*	0.00	2.02	10.94	5.09	1.69	4.0	2.0	4.0	6.0
	2†	0.00	5.61	29.54	13.38	2.22				

Comments

(cont.)

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Taxonomy no	Item
1.2.2	Machinery Gas Turbines Industrial

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
45	14	1.1807	0.9008	4232

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	151*	4.24	164.83	504.51	175.95	127.89	16.9	1.0	29.0	963.0
	151†	43.88	346.31	888.37	276.87	167.63				
Noise	3*	0.00	2.31	11.28	4.71	2.54	39.7	12.0	79.5	208.5
	3†	0.02	3.47	11.90	4.39	3.33				
Other	117*	0.35	86.88	331.07	122.02	99.10	27.4	1.0	52.3	1519.0
	117†	1.35	157.59	526.58	193.11	129.89				
Overheating	15*	2.32	11.61	26.78	7.86	12.70	23.4	4.0	39.7	165.0
	15†	8.67	16.05	25.27	5.11	16.65				
Parameter deviation	43*	0.00	36.05	183.00	78.88	36.42	13.1	1.0	19.0	215.0
	43†	0.00	44.42	224.94	96.83	47.74				
Structural deficiency	13*	3.43	11.03	22.16	5.89	11.01	22.4	1.0	34.9	134.0
	13†	0.06	14.53	55.15	20.33	14.43				
Unknown	27*	0.00	18.50	101.10	47.26	22.87	24.7	5.0	24.7	222.0
	27†	0.00	22.90	123.03	56.85	29.97				
Vibration	6*	0.04	4.99	16.76	6.15	5.08	17.3	4.0	27.0	57.0
	6†	0.00	16.48	77.78	31.78	6.66				
Unknown	**8***	**0.80**	**6.88**	**17.92**	**5.62**	**6.78**	**5.9**	**2.0**	**8.1**	**14.0**
	8†	**1.48**	**9.53**	**23.42**	**7.14**	**8.88**				
Abnormal instrument reading	4*	0.00	3.62	15.04	5.72	3.39	3.5	2.0	4.5	7.0
	4†	0.04	4.74	16.01	5.88	4.44				
External leakage - Fuel	1*	0.00	0.82	4.49	2.24	0.85	4.0	8.5	8.5	8.5
	1†	0.00	1.31	7.56	4.09	1.11				
Other	1*	0.00	0.82	4.49	2.24	0.85	7.0	14.0	14.0	14.0
	1†	0.00	1.31	7.56	4.09	1.11				
Unknown	1*	0.00	0.93	3.92	1.50	0.85	9.0	9.0	9.0	9.0
	1†	0.00	1.30	7.49	4.05	1.11				
Vibration	1*	0.00	0.78	4.15	1.91	0.85	-	-	-	-
	1†	0.00	1.08	5.64	2.54	1.11				
All modes	**1342***	**312.24**	**1224.19**	**2628.48**	**735.99**	**1136.63**	**23.0**	**1.0**	**37.1**	**3001.0**
	1342†	**959.77**	**2687.13**	**5122.24**	**1301.57**	**1489.81**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.8. 10-2

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Maintainable **item versus failure mode, to be continued**
Item: Gas Turbines - Industrial

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.07	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Air inlet	0.37	0.00	0.07	0.15	0.00	0.11	0.00	0.00	0.30	0.00
Burners/fuel nozzles	0.00	0.00	0.19	0.00	0.07	0.30	0.00	0.00	0.07	0.00
Cabling & junction boxes	0.45	0.00	0.00	0.00	0.15	0.19	0.00	0.00	0.00	0.00
Casing	0.00	0.07	0.07	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Combustion chambers	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compressor rotor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Compressor stator	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Control unit	1.34	0.00	0.00	0.00	0.45	0.75	0.07	0.00	0.15	0.00
Cooler(s)	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.00	0.07	0.00	0.67	0.07	0.00	0.00	0.00	0.00	0.07
Filter(s)	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Fuel control	0.07	0.00	0.15	0.00	0.60	0.41	0.00	0.07	0.00	0.00
Fuel filter	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.45	0.00
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel scrubber/coalescer	0.00	0.00	0.15	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flame	0.52	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Instrument, flow	0.15	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Instrument, general	1.56	0.00	0.00	0.00	0.07	0.04	0.00	0.00	0.00	0.07
Instrument, level	0.75	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.79	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00
Instrument, speed	0.52	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.09	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	0.56	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.30	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Monitoring	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.52	0.07	0.15	0.45	0.22	0.15	0.00	0.07	0.07	0.00
Piping	0.00	0.00	0.97	1.53	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.45	0.07	0.07	0.00	0.00	0.00	0.07
Purge air	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.07	0.00	0.15	0.00	0.07	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.30	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.22	1.64	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.00	0.00	0.00	0.00	0.02	0.22	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.07	0.30	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.00	0.15	0.07	1.27	0.00	0.00	0.07	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.07	0.07	0.00	0.15	0.00	0.97	0.00	0.00	1.42	0.00
Thrust bearing	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	2.53	0.15	0.52	0.97	0.15	2.46	0.00	0.07	0.30	0.00
Valves	0.45	0.00	1.30	1.04	1.79	0.67	0.00	0.22	0.37	0.00
Total	16.77	0.82	4.02	8.72	4.32	8.87	0.07	0.45	3.20	0.30

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Gas Turbines - Industrial

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
Air inlet	0.60	1.42	1.68	1.04	0.07	0.00	0.45	0.48	0.07	6.82
Burners/fuel nozzles	0.07	0.07	0.07	0.15	0.15	0.00	0.00	0.07	0.00	1.23
Cabling & junction boxes	0.22	0.45	0.07	0.30	0.00	0.00	0.07	0.07	0.00	1.97
Casing	0.07	0.15	0.07	0.15	0.07	0.00	0.00	0.00	0.07	1.08
Combustion chambers	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.37
Compressor rotor	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.11
Compressor stator	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Control unit	0.00	0.93	0.67	0.37	0.07	0.00	0.15	0.67	0.00	5.63
Cooler(s)	0.30	0.19	0.15	0.15	0.00	0.00	0.00	0.15	0.04	1.42
Exhaust	0.00	0.37	0.07	0.45	0.89	0.00	0.07	0.34	0.00	3.09
Filter(s)	0.00	0.22	0.60	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Fuel control	0.00	0.15	0.30	0.22	0.00	0.00	0.00	0.75	0.00	2.72
Fuel filter	0.00	0.07	0.45	0.45	0.00	0.00	0.15	0.30	0.00	2.01
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.22
Fuel scrubber/coalescer	0.00	0.00	0.07	0.00	0.00	0.00	0.15	0.00	0.00	0.45
Hood	0.07	0.89	0.00	0.22	0.07	0.00	0.00	0.15	0.00	1.56
HP turbine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.07
Instrument, flame	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.15	0.00	0.82
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Instrument, general	0.00	1.01	0.00	0.07	0.00	0.00	0.00	0.45	0.00	3.28
Instrument, level	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Instrument, pressure	0.37	0.07	0.30	0.15	0.07	0.07	0.00	0.34	0.00	3.32
Instrument, speed	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.30	0.00	1.14
Instrument, temperature	0.22	0.30	0.30	0.07	0.00	0.00	0.00	0.26	0.00	4.35
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.22	1.01
Internal power supply	0.00	0.22	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.82
Monitoring	0.00	0.00	0.07	0.37	0.00	0.00	0.00	0.00	0.00	1.94
Oil	0.00	0.30	0.30	0.22	0.07	0.00	0.00	0.00	0.00	0.97
Other	0.30	0.60	0.30	1.42	0.30	0.00	0.60	0.15	0.22	5.59
Piping	0.00	0.45	0.00	0.45	0.15	0.00	0.07	0.11	0.00	3.73
Pump w/motor	0.00	0.63	0.19	0.37	0.00	0.00	0.22	0.15	0.04	2.27
Purge air	0.00	0.07	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.89
Radial bearing	0.00	0.22	0.00	0.00	0.07	0.00	0.07	0.22	0.07	0.97
Reservoir w/heating system	0.00	0.15	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.37
Rotor	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.52
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	1.94
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Start energy (battery, air)	0.00	0.15	0.22	0.07	0.07	0.00	0.00	0.00	0.00	0.89
Starting unit	0.00	0.30	0.00	0.15	0.00	0.00	0.15	0.00	0.00	2.16
Stator	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.07
Subunit	0.15	0.82	0.30	0.67	0.00	0.00	0.00	0.30	0.22	5.14
Thrust bearing	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.22
Unknown	0.60	1.71	0.45	2.01	0.22	0.00	0.30	2.61	0.22	15.28
Valves	0.37	1.34	0.37	0.75	0.15	0.00	0.67	0.48	0.00	9.99
Total	3.58	13.64	7.45	11.40	2.61	0.07	3.20	9.17	1.34	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Gas Turbines - Industrial

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.30	0.00	0.00	0.15	0.07	0.15	0.00	0.00	0.52	0.00
Breakage	0.60	0.15	0.15	0.07	0.00	0.22	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Contamination	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.52	0.00
Control failure	0.30	0.00	0.00	0.07	0.52	0.67	0.07	0.00	0.30	0.00
Corrosion	0.45	0.00	0.30	0.15	0.22	0.00	0.00	0.07	0.00	0.00
Deformation	0.00	0.00	0.15	0.52	0.07	0.07	0.00	0.00	0.00	0.07
Earth/isolation fault	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Electrical failure - general	1.04	0.00	0.00	0.00	0.75	0.89	0.00	0.00	0.15	0.00
Erosion	0.07	0.00	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.55	0.00	0.00	0.15	0.30	0.60	0.00	0.00	0.00	0.00
Instrument failure - general	3.80	0.07	0.00	0.00	0.30	0.75	0.00	0.07	0.00	0.00
Leakage	0.07	0.00	0.37	2.83	0.07	0.37	0.00	0.15	0.00	0.00
Looseness	0.07	0.00	0.22	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.15	0.00	0.82	1.27	0.07	0.07	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.15	0.60	1.27	1.42	0.89	2.31	0.00	0.07	0.52	0.07
Misc. external influences	0.45	0.00	0.07	0.15	0.30	0.07	0.00	0.00	0.15	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
No cause found	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	0.22	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.37	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Open circuit	0.22	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.00	0.00
Other	0.15	0.00	0.07	0.00	0.00	0.22	0.00	0.00	0.07	0.07
Out of adjustment	2.16	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Overheating	0.15	0.00	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.00
Short circuiting	0.15	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Sticking	0.07	0.00	0.00	0.00	0.15	0.15	0.00	0.07	0.00	0.00
Unknown	0.30	0.00	0.15	0.07	0.15	0.89	0.00	0.00	0.30	0.00
Vibration	0.00	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.00
Wear	0.37	0.00	0.15	0.82	0.07	0.07	0.00	0.00	0.15	0.07
Total	16.77	0.82	4.02	8.72	4.32	8.87	0.07	0.45	3.20	0.30

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Gas Turbines - Industrial

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.15	0.45	1.34	0.67	0.15	0.00	0.00	0.60	0.00	4.55
Breakage	0.15	0.52	0.00	0.60	0.60	0.00	0.07	0.22	0.07	3.43
Burst	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.30
Cavitation	0.00	0.07	0.00	0.07	0.07	0.00	0.00	0.00	0.00	0.67
Clearance/ alignment failure	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.30
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.37
Contamination	0.37	0.30	1.56	0.22	0.00	0.00	0.45	0.15	0.00	3.73
Control failure	0.07	0.15	0.45	0.15	0.07	0.00	0.37	0.89	0.00	4.10
Corrosion	0.00	0.37	0.00	0.45	0.07	0.00	0.37	0.00	0.00	2.46
Deformation	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Earth/isolation fault	0.07	0.45	0.15	0.07	0.00	0.00	0.00	0.00	0.00	1.04
Electrical failure - general	0.15	0.97	0.07	1.64	0.00	0.00	0.15	0.52	0.00	6.33
Erosion	0.07	0.00	0.00	0.07	0.00	0.00	0.07	0.07	0.00	0.82
External influence - general	0.15	0.89	0.37	0.97	0.00	0.00	0.00	0.07	0.00	2.98
Fatigue	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	0.07	0.30
Faulty power/voltage	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.22
Faulty signal/indication/alarm	0.45	1.04	0.15	0.07	0.00	0.00	0.00	0.52	0.15	7.97
Instrument failure - general	0.07	0.97	0.67	0.75	0.00	0.00	0.00	0.75	0.00	8.20
Leakage	0.07	0.22	0.15	0.45	0.00	0.00	0.15	0.07	0.00	4.99
Looseness	0.00	0.22	0.00	0.15	0.00	0.00	0.00	0.07	0.07	1.04
Material failure - general	0.07	0.30	0.07	0.22	0.22	0.00	0.15	0.07	0.07	3.58
Mechanical Failure - general	0.82	2.09	0.52	2.09	0.60	0.00	0.89	1.12	0.22	15.65
Misc. external influences	0.37	0.97	0.22	0.67	0.00	0.00	0.00	0.67	0.07	4.17
Miscellaneous - general	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.37
No cause found	0.07	0.07	0.00	0.00	0.00	0.07	0.00	0.30	0.15	0.89
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
No signal/indication/alarm	0.00	0.07	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.82
Open circuit	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.67
Other	0.07	1.19	0.07	0.22	0.00	0.00	0.00	0.07	0.00	2.24
Out of adjustment	0.07	0.45	0.67	0.22	0.07	0.00	0.00	0.75	0.00	4.62
Overheating	0.15	0.07	0.22	0.00	0.00	0.00	0.00	0.37	0.00	1.27
Short circuiting	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Sticking	0.00	0.07	0.00	0.22	0.00	0.00	0.00	0.07	0.00	0.82
Unknown	0.00	0.67	0.52	0.22	0.00	0.00	0.37	0.37	0.15	4.17
Vibration	0.00	0.07	0.07	0.15	0.07	0.00	0.00	0.82	0.00	1.42
Wear	0.00	0.30	0.00	0.60	0.30	0.00	0.15	0.15	0.15	3.35
Total	3.58	13.64	7.45	11.40	2.61	0.07	3.20	9.17	1.34	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.2.2.1	Machinery Gas Turbines Industrial (-1000) kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0650	0.0651	100

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**118.29**	**200.02**	**317.98**	**200.02**	**200.02**	-	-	-	-
	13†	**118.12**	**199.73**	**317.51**	**199.73**	**199.73**				
Fail to start on demand	4*	21.00	61.55	140.86	61.55	61.55	-	-	-	-
	4†	20.97	61.46	140.66	61.46	61.46				
Fail to stop on demand	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
Spurious stop	8*	61.24	123.09	222.10	123.09	123.09	-	-	-	-
	8†	61.15	122.91	221.78	122.91	122.91				
Degraded	**15***	**142.25**	**230.80**	**355.35**	**230.80**	**230.80**	-	-	-	-
	15†	**142.04**	**230.46**	**354.82**	**230.46**	**230.46**				
Erratic output	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
External leakage - Fuel	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
External leakage - Utility medium	6*	40.24	92.32	182.18	92.32	92.32	-	-	-	-
	6†	40.18	92.18	181.91	92.18	92.18				
Internal leakage	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
Other	5*	30.31	76.93	161.79	76.93	76.93	-	-	-	-
	5†	30.27	76.82	161.55	76.82	76.82				
Overheating	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
Incipient	**16***	**154.40**	**246.18**	**373.88**	**246.18**	**246.18**	**1.0**	-	-	-
	16†	**154.17**	**245.82**	**373.33**	**245.82**	**245.82**				
Abnormal instrument reading	4*	21.00	61.55	140.86	61.55	61.55	-	-	-	-
	4†	20.97	61.46	140.66	61.46	61.46				
External leakage - Utility medium	2*	5.46	30.77	96.86	30.77	30.77	-	-	-	-
	2†	5.45	30.73	96.72	30.73	30.73				
Minor in-service problems	9*	72.24	138.48	241.65	138.48	138.48	1.0	-	-	-
	9†	72.13	138.27	241.29	138.27	138.27				
Vibration	1*	0.77	15.39	73.01	15.39	15.39	-	-	-	-
	1†	0.77	15.36	72.90	15.36	15.36				
All modes	**44***	**518.31**	**677.01**	**870.45**	**677.01**	**677.01**	**1.0**	-	-	-
	44†	**517.54**	**676.01**	**869.17**	**676.01**	**676.01**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 4.0. 10-2

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Taxonomy no	Item
1.2.2.2	Machinery Gas Turbines Industrial (1000-3000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.1337	0.0342	740

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**2.00**	**268.89**	**915.73**	**337.01**	**157.06**	**13.0**	**2.0**	**22.6**	**83.0**
	21†	**113.28**	**1396.44**	**3927.00**	**1283.19**	**613.32**				
Fail to start on demand	6*	4.44	62.78	180.36	59.43	44.88	9.2	4.0	15.0	32.0
	6†	6.52	848.34	2876.11	1057.72	175.23				
Parameter deviation	3*	0.16	40.37	154.15	56.80	22.44	13.8	6.0	25.7	42.0
	3†	12.02	83.47	208.63	64.20	87.62				
Spurious stop	12*	0.86	159.21	569.93	210.58	89.75	14.8	2.0	25.9	83.0
	12†	63.83	455.81	1146.19	353.84	350.47				
Degraded	**28***	**1.55**	**396.86**	**1523.38**	**561.06**	**209.42**	**8.8**	**2.0**	**12.4**	**40.0**
	28†	**556.81**	**792.79**	**1062.90**	**154.54**	**817.76**				
External leakage - Fuel	1*	0.05	11.85	43.84	16.19	7.48	4.0	4.0	4.0	4.0
	1†	1.02	28.31	85.53	29.21	29.21				
External leakage - Utility medium	1*	0.05	11.85	43.84	16.19	7.48	-	-	-	-
	1†	1.02	28.31	85.53	29.21	29.21				
Low output	4*	0.22	54.63	208.99	77.00	29.92	14.8	6.0	17.0	30.0
	4†	15.10	109.68	276.80	85.61	116.82				
Other	1*	0.05	11.85	43.84	16.19	7.48	8.0	16.0	16.0	16.0
	1†	1.02	28.31	85.53	29.21	29.21				
Overheating	1*	0.05	11.85	43.84	16.19	7.48	20.0	40.0	40.0	40.0
	1†	1.02	28.31	85.53	29.21	29.21				
Parameter deviation	17*	0.94	240.00	921.03	339.22	127.15	7.3	2.0	10.5	40.0
	17†	35.95	405.17	1121.28	363.83	496.50				
Structural deficiency	2*	0.11	26.11	99.21	36.57	14.96	6.0	4.0	6.0	8.0
	2†	8.51	56.51	139.84	42.80	58.41				
Vibration	1*	0.05	11.85	43.84	16.19	7.48	6.0	12.0	12.0	12.0
	1†	1.02	28.31	85.53	29.21	29.21				
Incipient	**56***	**99.03**	**543.43**	**1281.52**	**380.78**	**418.84**	**9.2**	**1.0**	**15.4**	**75.0**
	56†	**66.89**	**11658.49**	**41328.83**	**15266.15**	**1635.51**				
Abnormal instrument reading	23*	102.61	185.52	288.28	57.08	172.02	11.2	1.0	18.6	75.0
	23†	28.76	5945.86	21759.91	8038.94	671.73				
External leakage - Utility medium	5*	5.18	32.13	78.19	23.70	37.40	4.0	3.0	6.8	10.0
	5†	7.84	2069.26	7964.16	2935.56	146.03				
Minor in-service problems	21*	4.02	249.94	786.60	281.47	157.06	9.4	2.0	16.4	62.0
	21†	35.28	2258.59	7123.18	2552.49	613.32				
Other	5*	6.37	47.65	120.98	37.52	37.40	4.5	1.0	5.8	10.0
	5†	5.25	841.52	2941.39	1085.64	146.03				
Structural deficiency	1*	0.05	11.85	43.84	16.19	7.48	-	-	-	-
	1†	1.02	28.31	85.53	29.21	29.21				
Vibration	1*	0.13	6.81	21.13	7.48	7.48	3.0	6.0	6.0	6.0
	1†	1.32	402.59	1562.74	578.46	29.21				

Comments

(cont.)

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Taxonomy no	Item
1.2.2.2	Machinery Gas Turbines Industrial (1000-3000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.1337	0.0342	740

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	**105***	**33.29**	**1217.61**	**3716.70**	**1291.54**	**785.32**	**9.9**	**1.0**	**16.1**	**83.0**
	105†	**151.48**	**13580.82**	**44092.89**	**16031.31**	**3066.59**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 8.1. 10-3

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Taxonomy no	Item
1.2.2.3	Machinery Gas Turbines Industrial (3000-10000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
22	7	0.6050	0.4910	2604

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**128***	**22.66**	**235.25**	**640.55**	**206.21**	**211.57**	**50.3**	**1.0**	**59.9**	**1024.0**
	128†	**36.13**	**365.72**	**990.49**	**317.99**	**260.67**				
Breakdown	6*	0.05	10.47	39.20	14.47	9.92	119.5	10.0	82.3	229.0
	6†	0.16	12.40	39.62	14.30	12.22				
Erratic output	3*	0.10	4.97	15.43	5.47	4.96	4.0	3.0	6.7	13.0
	3†	0.76	6.15	15.84	4.94	6.11				
External leakage - Fuel	3*	0.07	5.68	18.20	6.58	4.96	9.5	7.0	9.5	12.0
	3†	0.01	12.21	50.22	19.05	6.11				
External leakage - Utility medium	1*	0.00	5.20	24.05	9.69	1.65	-	8.0	8.0	8.0
	1†	0.00	5.67	26.54	10.79	2.04				
Fail to start on demand	58*	4.10	104.43	314.64	106.83	95.87	48.7	1.0	53.7	511.0
	58†	9.03	166.07	493.12	164.25	118.12				
Internal leakage	1*	0.05	1.77	5.37	1.85	1.65	12.0	12.0	12.0	12.0
	1†	0.00	4.54	21.67	8.91	2.04				
Low output	2*	0.72	3.50	8.01	2.34	3.31	4.8	2.0	8.5	15.0
	2†	0.03	6.12	22.63	8.36	4.07				
Other	2*	0.00	3.82	16.35	6.32	3.31	-	9.0	9.0	9.0
	2†	0.03	6.14	22.68	8.38	4.07				
Overheating	2*	0.00	3.85	16.56	6.42	3.31	16.5	2.0	17.5	33.0
	2†	0.01	4.61	18.10	6.73	4.07				
Parameter deviation	1*	0.03	1.79	5.68	2.04	1.65	52.0	104.0	104.0	104.0
	1†	0.17	2.19	6.21	2.04	2.04				
Spurious stop	44*	4.57	81.93	242.60	80.74	72.73	61.9	2.0	77.8	1024.0
	44†	9.58	123.08	348.47	114.19	89.61				
Structural deficiency	1*	0.03	1.79	5.68	2.04	1.65	6.0	12.0	12.0	12.0
	1†	0.17	2.19	6.21	2.04	2.04				
Unknown	2*	0.00	3.02	12.63	4.83	3.31	68.0	68.0	68.0	68.0
	2†	0.01	3.76	15.05	5.64	4.07				
Vibration	2*	0.00	3.85	16.56	6.42	3.31	78.0	48.0	112.0	176.0
	2†	0.01	4.61	18.10	6.73	4.07				
Degraded	**155***	**79.06**	**256.05**	**515.42**	**137.25**	**256.20**	**22.0**	**1.0**	**25.4**	**224.0**
	155†	**103.27**	**359.05**	**741.05**	**201.45**	**315.66**				
Abnormal instrument reading	9*	0.04	10.13	37.79	13.95	14.88	6.3	1.0	10.8	48.0
	9†	0.22	13.44	42.29	15.13	18.33				
Erratic output	24*	4.70	37.10	95.17	29.66	39.67	5.3	1.0	12.3	45.0
	24†	1.72	52.29	158.44	54.42	48.88				
External leakage - Fuel	22*	12.60	37.22	72.37	18.72	36.36	17.5	3.0	17.6	47.0
	22†	6.29	63.16	170.78	54.78	44.80				
External leakage - Utility medium	18*	1.11	31.80	96.15	32.89	29.75	33.5	2.0	32.8	155.0
	18†	3.83	42.02	115.71	37.46	36.66				

Comments

(cont.)

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Taxonomy no	Item
1.2.2.3	Machinery Gas Turbines Industrial (3000-10000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
22	7	0.6050	0.4910	2604

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
High output	1*	0.01	1.43	4.88	1.80	1.65	8.0	8.0	8.0	8.0
	1†	0.02	1.77	5.64	2.04	2.04				
Internal leakage	1*	0.12	1.74	5.01	1.65	1.65	22.0	22.0	22.0	22.0
	1†	0.17	2.19	6.21	2.04	2.04				
Low output	23*	0.17	39.93	150.97	55.68	38.02	30.0	1.0	22.3	99.0
	23†	0.19	45.74	173.18	63.86	46.84				
Minor in-service problems	2*	0.01	12.73	53.35	20.42	3.31	-	8.0	8.0	8.0
	2†	0.00	13.47	58.99	23.05	4.07				
Noise	1*	0.12	1.74	5.01	1.65	1.65	-	23.0	23.0	23.0
	1†	0.00	2.23	11.19	4.79	2.04				
Other	20*	0.34	37.61	124.85	45.71	33.06	31.8	1.0	34.6	106.0
	20†	1.57	53.30	162.19	56.11	40.73				
Overheating	4*	0.00	7.08	30.39	11.76	6.61	-	12.0	27.7	45.0
	4†	0.00	12.22	55.34	22.01	8.15				
Parameter deviation	7*	3.76	11.76	23.38	6.16	11.57	7.8	2.0	19.4	55.0
	7†	3.34	15.71	35.62	10.35	14.26				
Structural deficiency	6*	0.43	8.43	25.19	8.40	9.92	20.0	12.0	12.0	12.0
	6†	0.16	10.52	33.28	11.95	12.22				
Unknown	13*	0.01	19.24	84.10	32.82	21.49	44.8	2.0	44.8	116.0
	13†	0.01	23.18	100.98	39.31	26.47				
Vibration	4*	0.40	6.80	20.04	6.66	6.61	42.0	12.0	80.0	224.0
	4†	0.09	8.97	29.39	10.72	8.15				
Incipient	**291***	**136.73**	**457.78**	**932.62**	**250.91**	**481.00**	**16.5**	**1.0**	**22.6**	**1519.0**
	291†	**156.56**	**709.82**	**1591.76**	**458.91**	**592.62**				
Abnormal instrument reading	91*	60.35	143.74	256.05	60.74	150.42	6.6	1.0	9.5	65.0
	91†	71.46	212.12	413.36	107.11	185.32				
Erratic output	6*	0.51	9.00	26.57	8.84	9.92	12.5	4.0	12.5	28.0
	6†	1.31	11.34	29.58	9.29	12.22				
External leakage - Fuel	16*	0.00	24.51	115.29	47.02	26.45	13.0	2.0	13.1	32.0
	16†	0.00	29.24	139.06	57.05	32.58				
External leakage - Utility medium	33*	11.48	57.95	133.88	39.33	54.55	12.5	2.0	14.6	61.0
	33†	8.75	93.80	257.05	83.02	67.20				
Fail to start on demand	1*	0.03	1.79	5.68	2.04	1.65	4.0	8.0	8.0	8.0
	1†	0.17	2.19	6.21	2.04	2.04				
Internal leakage	2*	0.00	3.89	18.20	7.40	3.31	4.0	2.0	4.0	6.0
	2†	0.00	10.62	48.81	19.57	4.07				
Minor in-service problems	35*	2.12	66.80	202.68	69.79	57.85	7.4	1.0	13.8	66.0
	35†	2.41	145.02	455.32	162.66	71.28				
Other	24*	4.43	40.97	108.72	34.51	39.67	65.9	1.0	110.6	1519.0
	24†	8.59	54.92	134.69	41.02	48.88				

Comments

(cont.)

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Taxonomy no	Item
1.2.2.3	Machinery Gas Turbines Industrial (3000-10000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
22	7	0.6050	0.4910	2604

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Overheating	10*	4.32	14.95	30.81	8.37	16.53	22.6	4.0	34.1	159.0
	10†	7.06	19.09	35.89	9.00	20.36				
Parameter deviation	35*	0.00	55.78	267.56	110.19	57.85	14.0	1.0	17.6	215.0
	35†	0.00	65.28	320.22	134.59	71.28				
Structural deficiency	10*	0.92	15.65	46.05	15.30	16.53	22.3	1.0	36.6	134.0
	10†	0.39	20.03	62.19	22.03	20.36				
Unknown	27*	0.01	36.29	157.55	61.21	44.63	24.7	5.0	24.7	222.0
	27†	0.02	42.85	186.02	72.27	54.99				
Vibration	1*	0.01	1.84	6.39	2.36	1.65	-	4.0	4.0	4.0
	1†	0.00	3.29	15.29	6.19	2.04				
Unknown	**1***	**0.00**	**5.20**	**24.05**	**9.69**	**1.65**	**-**	**2.0**	**2.0**	**2.0**
	1†	**0.00**	**5.67**	**26.54**	**10.79**	**2.04**				
Abnormal instrument reading	1*	0.00	5.20	24.05	9.69	1.65	-	2.0	2.0	2.0
	1†	0.00	5.67	26.54	10.79	2.04				
All modes	**575***	**280.99**	**944.62**	**1927.23**	**519.11**	**950.43**	**25.5**	**1.0**	**32.2**	**1519.0**
	575†	**352.61**	**1445.23**	**3145.80**	**889.13**	**1170.98**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.3. 10-2

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Taxonomy no	Item
1.2.2.4	Machinery Gas Turbines Industrial (10000-20000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
10	5	0.2227	0.2121	488

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**87***	**203.08**	**446.49**	**766.59**	**174.45**	**390.67**	**32.6**	**1.0**	**71.2**	**1113.0**
	87†	**222.61**	**472.58**	**797.92**	**177.90**	**410.14**				
Abnormal instrument reading	2*	0.04	9.47	35.24	13.01	8.98	48.5	31.0	97.0	163.0
	2†	0.04	10.22	39.19	14.44	9.43				
Breakdown	4*	0.05	14.81	57.42	21.24	17.96	70.5	132.0	141.3	150.5
	4†	0.06	15.65	60.19	22.18	18.86				
Erratic output	5*	4.61	22.22	50.72	14.79	22.45	28.9	17.0	57.8	93.0
	5†	4.07	23.61	56.45	16.92	23.57				
External leakage - Fuel	4*	0.19	43.58	163.65	60.39	17.96	110.1	6.2	378.4	1113.0
	4†	0.18	44.16	167.78	61.85	18.86				
External leakage - Utility medium	6*	7.49	26.38	54.69	14.91	26.94	19.3	9.0	38.8	92.0
	6†	7.01	27.93	60.29	16.94	28.29				
Fail to start on demand	26*	55.32	133.23	238.41	56.84	116.75	14.2	1.0	40.0	176.0
	26†	57.02	143.31	261.33	63.57	122.57				
Internal leakage	1*	0.01	4.10	16.28	6.08	4.49	171.5	343.0	343.0	343.0
	1†	0.01	4.33	17.03	6.34	4.71				
Low output	5*	8.49	22.02	40.70	10.04	22.45	14.7	2.0	29.4	64.0
	5†	9.03	23.27	42.87	10.54	23.57				
Other	3*	3.72	13.52	28.31	7.78	13.47	24.2	2.0	48.3	115.0
	3†	4.00	14.31	29.83	8.17	14.14				
Overheating	2*	0.09	13.36	46.05	16.98	8.98	8.8	4.0	15.5	27.0
	2†	0.11	14.01	47.19	17.34	9.43				
Parameter deviation	11*	5.48	62.00	171.71	55.73	49.39	24.7	1.0	48.0	249.0
	11†	6.23	65.03	177.24	57.09	51.86				
Spurious stop	16*	21.74	75.64	156.16	42.46	71.85	14.5	1.0	22.9	116.0
	16†	25.97	79.10	155.67	40.70	75.43				
Structural deficiency	1*	0.01	4.10	16.28	6.08	4.49	204.0	408.0	408.0	408.0
	1†	0.01	4.33	17.03	6.34	4.71				
Vibration	1*	0.01	4.15	16.89	6.38	4.49	-	-	-	-
	1†	0.01	4.34	17.12	6.38	4.71				
Degraded	**66***	**89.32**	**287.13**	**576.44**	**153.15**	**296.37**	**38.6**	**1.0**	**67.0**	**939.0**
	66†	**86.82**	**312.74**	**653.01**	**179.05**	**311.14**				
Abnormal instrument reading	3*	0.12	11.98	39.49	14.43	13.47	-	-	-	-
	3†	0.25	12.58	39.03	13.81	14.14				
External leakage - Fuel	2*	0.71	8.40	23.43	7.63	8.98	3.0	6.0	6.0	6.0
	2†	0.83	8.82	24.13	7.79	9.43				
External leakage - Utility medium	13*	12.49	60.39	137.92	40.24	58.38	93.4	6.0	136.8	939.0
	13†	10.33	66.00	161.84	49.28	61.28				
Other	25*	32.52	120.50	253.96	70.13	112.26	41.3	10.0	65.1	354.0
	25†	27.90	133.26	303.33	88.32	117.86				

Comments

(cont.)

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Taxonomy no	Item
1.2.2.4	Machinery Gas Turbines Industrial (10000-20000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
10	5	0.2227	0.2121	488

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Overheating	17*	0.49	59.78	201.10	73.85	76.34	20.9	2.0	41.7	110.0
	17†	0.55	63.34	211.31	77.46	80.14				
Parameter deviation	5*	1.52	22.12	63.81	21.05	22.45	10.8	1.0	21.2	76.0
	5†	1.24	23.75	70.81	23.61	23.57				
Structural deficiency	1*	0.00	4.73	22.32	9.12	4.49	23.0	46.0	46.0	46.0
	1†	0.00	5.11	24.21	9.92	4.71				
Incipient	**163***	**274.88**	**700.62**	**1285.21**	**314.53**	**731.94**	**24.6**	**1.0**	**43.4**	**963.0**
	163†	**271.05**	**767.27**	**1468.71**	**374.63**	**768.42**				
Abnormal instrument reading	49*	91.38	215.54	382.33	90.29	220.03	7.8	1.0	14.9	43.0
	49†	90.48	230.31	422.23	103.27	231.00				
Erratic output	5*	0.01	17.68	75.26	29.03	22.45	5.6	2.0	11.2	18.0
	5†	0.01	18.68	78.95	30.35	23.57				
External leakage - Utility medium	9*	7.39	35.66	81.42	23.75	40.41	23.5	4.0	47.0	102.0
	9†	8.75	37.70	83.25	23.75	42.43				
Minor in-service problems	46*	31.35	242.52	619.77	192.82	206.56	53.3	2.0	67.6	963.0
	46†	31.10	276.17	725.54	228.89	216.85				
Noise	1*	0.01	4.10	16.28	6.08	4.49	6.0	12.0	12.0	12.0
	1†	0.01	4.33	17.03	6.34	4.71				
Other	38*	2.51	138.53	432.38	153.78	170.64	30.2	1.0	57.7	402.0
	38†	2.97	148.55	460.84	163.06	179.14				
Overheating	4*	0.05	14.81	57.42	21.24	17.96	24.9	9.5	49.5	165.0
	4†	0.06	15.65	60.19	22.18	18.86				
Parameter deviation	8*	3.75	34.33	90.88	28.81	35.92	9.4	2.0	23.9	80.0
	8†	3.85	36.73	98.20	31.30	37.71				
Structural deficiency	2*	0.31	11.34	34.59	12.01	8.98	23.0	10.0	28.0	46.0
	2†	0.15	13.20	42.68	15.49	9.43				
Vibration	1*	0.01	4.10	16.28	6.08	4.49	-	-	-	-
	1†	0.01	4.33	17.03	6.34	4.71				
Unknown	**4***	**0.16**	**15.56**	**50.93**	**18.57**	**17.96**	**3.5**	**7.0**	**7.0**	**7.0**
	4†	**0.23**	**16.29**	**51.71**	**18.60**	**18.86**				
Abnormal instrument reading	3*	0.38	12.13	36.82	12.68	13.47	3.5	7.0	7.0	7.0
	3†	0.63	12.73	38.14	12.75	14.14				
Vibration	1*	0.01	4.15	16.89	6.38	4.49	-	-	-	-
	1†	0.01	4.34	17.12	6.38	4.71				
All modes	**320***	**903.70**	**1454.99**	**2112.76**	**370.41**	**1436.94**	**29.7**	**1.0**	**56.0**	**1113.0**
	320†	**884.49**	**1580.48**	**2439.92**	**478.14**	**1508.55**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.7. 10-2

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Taxonomy no	Item
1.2.2.5	Machinery Gas Turbines Industrial (20000-40000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1543	0.0983	300

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**88***	**23.99**	**969.11**	**2971.80**	**1038.86**	**570.33**	**33.8**	**1.0**	**65.9**	**3001.0**
	88†	**110.89**	**1118.20**	**3026.02**	**971.08**	**895.30**				
Breakdown	1*	0.05	11.97	46.01	16.94	6.48	9.0	18.0	18.0	18.0
	1†	0.13	12.63	41.30	15.05	10.17				
Erratic output	5*	0.26	69.01	265.46	97.82	32.41	4.9	1.0	7.8	23.0
	5†	0.31	73.20	275.13	101.51	50.87				
External leakage - Fuel	3*	1.42	28.69	85.94	28.72	19.44	13.2	2.0	26.3	61.0
	3†	9.77	32.90	67.17	18.10	30.52				
External leakage - Utility medium	3*	0.15	40.49	155.87	57.46	19.44	3.8	2.0	7.7	11.0
	3†	0.20	42.91	158.61	58.58	30.52				
Fail to start on demand	24*	75.61	179.28	318.71	75.45	155.55	20.4	1.0	39.7	232.0
	24†	170.46	246.34	333.63	49.84	244.17				
Low output	2*	1.25	15.48	43.56	14.24	12.96	9.8	11.0	12.5	14.0
	2†	4.14	21.11	48.89	14.39	20.35				
Parameter deviation	2*	0.33	11.27	34.29	11.86	12.96	11.3	22.0	22.5	23.0
	2†	2.75	18.80	46.83	14.39	20.35				
Spurious stop	43*	3.51	549.98	1915.85	706.94	278.69	10.5	1.0	18.5	110.0
	43†	6.17	603.05	1975.34	720.45	437.48				
Structural deficiency	3*	1.42	28.69	85.94	28.72	19.44	507.5	14.0	1015.3	3001.0
	3†	9.77	32.90	67.17	18.10	30.52				
Vibration	2*	0.33	11.27	34.29	11.86	12.96	82.3	22.0	164.5	307.0
	2†	2.75	18.80	46.83	14.39	20.35				
Degraded	**66***	**44.85**	**674.75**	**1955.60**	**646.38**	**427.75**	**15.1**	**1.0**	**29.6**	**255.0**
	66†	**144.22**	**798.68**	**1887.46**	**561.44**	**671.48**				
Abnormal instrument reading	1*	0.11	5.89	18.29	6.48	6.48	-	-	-	-
	1†	0.12	9.33	29.94	10.83	10.17				
Erratic output	8*	4.91	79.43	232.42	77.06	51.85	12.1	2.0	22.4	72.0
	8†	19.95	92.92	210.01	60.87	81.39				
External leakage - Fuel	1*	0.05	11.97	46.01	16.94	6.48	-	-	-	-
	1†	0.13	12.63	41.30	15.05	10.17				
External leakage - Utility medium	14*	19.61	122.69	299.32	90.86	90.73	16.2	3.0	32.4	85.0
	14†	81.01	149.45	234.80	47.31	142.43				
Low output	7*	0.57	86.94	301.90	111.37	45.37	27.6	2.0	55.2	224.0
	7†	1.21	95.31	305.64	110.54	71.22				
Other	9*	3.59	45.52	128.60	42.10	58.33	28.3	8.0	56.6	255.0
	9†	0.91	73.91	237.79	86.13	91.56				
Overheating	6*	9.62	48.88	113.10	33.26	38.89	13.8	5.0	27.5	62.0
	6†	22.22	64.14	123.66	31.74	61.04				
Parameter deviation	11*	0.75	144.20	520.53	192.34	71.29	4.9	1.0	8.7	29.0
	11†	1.12	156.17	534.70	196.94	111.91				

Comments

(cont.)

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Taxonomy no	Item
1.2.2.5	Machinery Gas Turbines Industrial (20000-40000)kW

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1543	0.0983	300

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	8*	0.43	111.79	429.81	158.34	51.85	7.4	2.0	14.4	37.0
	8†	0.49	118.63	449.70	165.81	81.39				
Vibration	1*	0.11	5.89	18.29	6.48	6.48	17.5	35.0	35.0	35.0
	1†	0.12	9.33	29.94	10.83	10.17				
Incipient	**141***	**272.61**	**1207.06**	**2687.59**	**770.93**	**913.83**	**13.0**	**1.0**	**25.1**	**388.0**
	141†	**888.27**	**1527.91**	**2308.09**	**435.82**	**1434.52**				
Abnormal instrument reading	39*	35.49	379.75	1040.39	335.97	252.76	8.2	1.0	15.1	71.0
	39†	119.00	456.04	972.03	270.73	396.78				
Erratic output	1*	0.11	5.89	18.29	6.48	6.48	11.5	23.0	23.0	23.0
	1†	0.12	9.33	29.94	10.83	10.17				
External leakage - Utility medium	6*	17.71	40.67	71.28	16.61	38.89	16.7	14.0	33.4	81.0
	6†	26.57	61.01	106.94	24.92	61.04				
Minor in-service problems	40*	4.98	476.56	1557.41	567.58	259.24	12.6	1.0	23.3	388.0
	40†	17.05	534.55	1621.55	558.10	406.95				
Noise	2*	0.33	11.27	34.29	11.86	12.96	56.5	18.0	113.3	208.5
	2†	2.75	18.80	46.83	14.39	20.35				
Other	50*	125.27	286.55	501.47	116.64	324.05	14.2	2.0	28.6	127.0
	50†	64.98	435.64	1080.42	331.11	508.69				
Overheating	1*	0.05	11.97	46.01	16.94	6.48	-	-	-	-
	1†	0.13	12.63	41.30	15.05	10.17				
Vibration	2*	0.33	11.27	34.29	11.86	12.96	24.5	41.0	49.0	57.0
	2†	2.75	18.80	46.83	14.39	20.35				
Unknown	**3***	**5.96**	**20.28**	**41.54**	**11.23**	**19.44**	**6.7**	**8.5**	**10.5**	**14.0**
	3†	**8.33**	**30.50**	**64.03**	**17.62**	**30.52**				
External leakage - Fuel	1*	0.11	5.89	18.29	6.48	6.48	4.0	8.5	8.5	8.5
	1†	0.12	9.33	29.94	10.83	10.17				
Other	1*	0.11	5.89	18.29	6.48	6.48	7.0	14.0	14.0	14.0
	1†	0.12	9.33	29.94	10.83	10.17				
Unknown	1*	0.05	11.97	46.01	16.94	6.48	9.0	9.0	9.0	9.0
	1†	0.13	12.63	41.30	15.05	10.17				
All modes	**298***	**295.09**	**2884.92**	**7754.12**	**2479.29**	**1931.35**	**19.4**	**1.0**	**37.7**	**3001.0**
	298†	**960.99**	**3494.44**	**7318.44**	**2010.94**	**3031.81**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 7.0. 10-2

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Pumps

Inventory description

The boundary applies both to general service- and fire pumps, as shown in Figure 12. The Pump system is further subdivided in Subunits and Maintainable Items as shown in Table 7.

Pump *driver (e.g. el.motor) is not included.* Inlet and outlet valves and suction strainer is not within boundary.

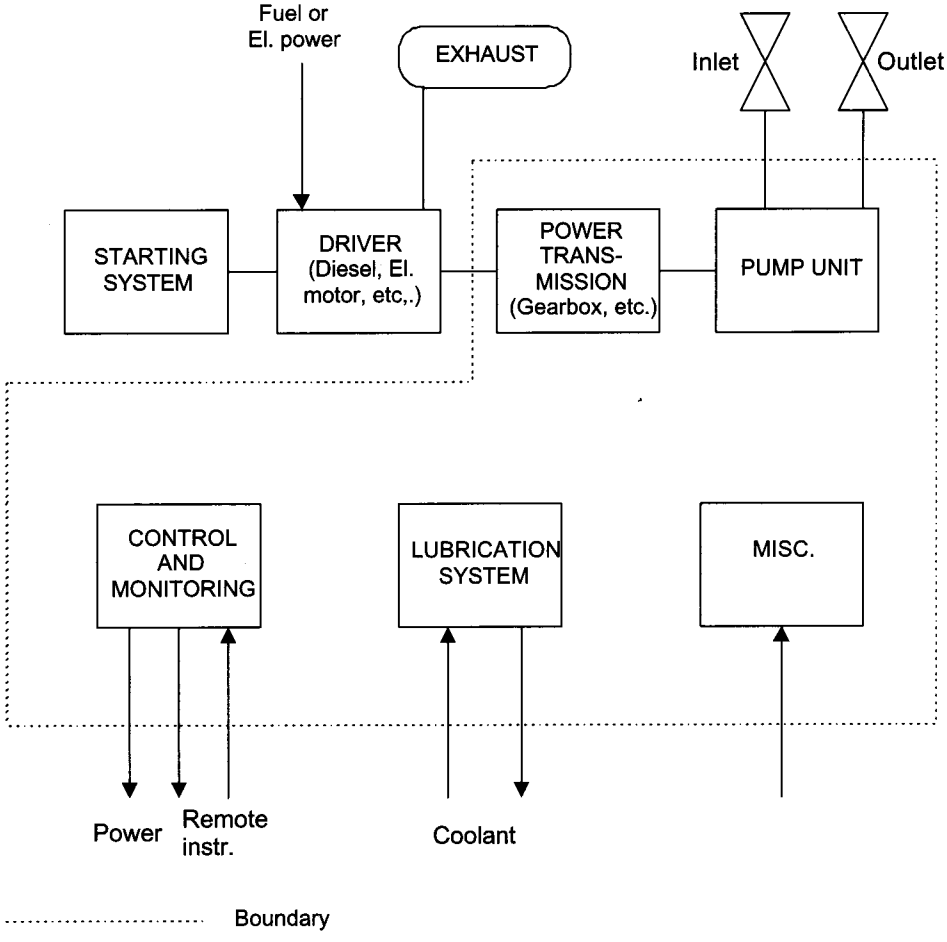

Figure 12 Pumps, Boundary Definition

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Table 7 Pumps, Subdivision in Maintainable Items

PUMP				
Power transmission	Pump	Control and Monitoring	Lubrication system	Miscellaneous
• Gearbox/var. drive • Bearing • Seals • Lubrication • Coupling to driver • Coupling to driven unit • Instruments	• Support • Casing • Impeller • Shaft • Radial bearing • Thrust bearing • Seals • Valves & piping • Cylinder liner[5] • Piston • Diaphragm[6] • Instruments	• Instruments • Cabling & junction boxes • Control unit • Actuating device • Monitoring • Internal power supply • Valves	• Instruments • Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Seals	• Purge air • Cooling/heating system • Filter, cyclone • Pulsation damper

(For all subunits the MIs "Unknown" and "Subunit" are included.)

[5] Reciprocating pumps.

[6] Diaphragm pumps

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List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELP	External leakage - Process medium
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

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Taxonomy no	Item
1.3	Machinery Pumps

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
449	61	19.0224	8.6743	11200

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**524***	**0.00**	**20.52**	**108.44**	**49.34**	**27.55**	**37.3**	**1.0**	**53.1**	**1025.0**
	524†	**1.14**	**65.40**	**204.64**	**72.93**	**60.41**				
Breakdown	45*	0.00	1.27	6.56	5.17	2.37	16.1	3.0	52.5	766.0
	45†	0.01	3.85	15.72	5.95	5.19				
Erratic output	2*	0.00	0.14	0.72	0.58	0.11	19.8	11.0	39.5	68.0
	2†	0.00	0.38	2.00	0.91	0.23				
External leakage - Process medium	86*	0.00	2.38	12.29	9.53	4.52	28.4	2.0	38.3	444.0
	86†	0.00	7.07	33.87	13.94	9.91				
External leakage - Utility medium	46*	0.00	1.20	5.04	5.60	2.42	16.0	2.0	29.8	90.0
	46†	0.00	3.59	16.82	6.84	5.30				
Fail to start on demand	50*	0.01	2.52	9.77	3.62	2.63	52.0	1.0	56.6	551.0
	50†	0.08	13.75	48.28	17.83	5.76				
Fail to stop on demand	2*	0.00	0.10	0.21	0.54	0.11	3.5	3.0	3.5	4.0
	2†	0.00	0.26	1.30	0.56	0.23				
High output	3*	0.00	0.67	3.51	2.44	0.16	-	1.0	3.3	6.0
	3†	0.00	2.31	12.00	5.32	0.35				
Internal leakage	8*	0.00	0.34	1.39	0.52	0.42	95.5	3.0	48.3	188.0
	8†	0.16	0.98	2.37	0.72	0.92				
Low output	46*	0.00	2.50	3.96	15.25	2.42	35.4	3.0	41.2	508.0
	46†	0.00	4.57	13.58	22.90	5.30				
Noise	6*	0.15	0.33	0.56	0.13	0.32	23.3	16.0	60.5	122.0
	6†	0.01	1.03	3.73	1.38	0.69				
Other	8*	0.00	0.57	2.99	2.43	0.42	275.5	2.0	424.5	734.0
	8†	0.00	1.53	7.57	3.21	0.92				
Overheating	5*	0.00	0.27	0.95	0.35	0.26	183.2	3.0	265.0	1025.0
	5†	0.00	6.41	32.56	14.04	0.58				
Parameter deviation	18*	0.00	0.66	3.49	2.31	0.95	11.0	1.0	20.8	88.0
	18†	0.14	1.96	5.66	1.87	2.08				
Spurious stop	133*	0.00	5.69	27.65	11.50	6.99	37.5	1.0	42.1	714.0
	133†	1.57	19.07	53.52	17.47	15.33				
Structural deficiency	33*	0.00	0.41	0.51	4.91	1.73	20.6	5.0	40.5	211.0
	33†	0.00	1.24	3.74	6.18	3.80				
Unknown	1*	0.00	0.05	0.15	0.05	0.05	-	-	-	-
	1†	0.00	0.11	0.33	0.12	0.12				
Vibration	32*	0.00	1.67	7.70	3.10	1.68	81.2	5.0	118.3	896.0
	32†	0.47	5.11	14.03	4.53	3.69				
Degraded	**754***	**0.00**	**44.20**	**210.34**	**86.32**	**39.64**	**20.2**	**0.3**	**26.4**	**798.0**
	754†	**11.39**	**238.41**	**714.72**	**239.40**	**86.92**				
Abnormal instrument reading	9*	0.00	0.80	4.56	2.45	0.47	9.0	2.0	16.0	65.0
	9†	0.00	2.53	11.22	4.42	1.04				
Erratic output	23*	0.00	2.27	12.50	6.03	1.21	14.8	2.0	16.8	65.0
	23†	0.00	7.88	35.25	13.95	2.65				

Comments

(cont

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Taxonomy no	Item
1.3	Machinery Pumps

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
449	61	19.0224	8.6743	11200

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	160*	0.00	11.61	66.33	35.66	8.41	11.2	1.0	18.7	278.0
	160†	0.00	22.20	121.98	58.38	18.45				
External leakage - Utility medium	192*	0.00	7.98	35.67	14.11	10.09	29.5	1.0	34.5	219.0
	192†	0.02	51.23	222.63	86.52	22.13				
Fail to stop on demand	3*	0.00	0.25	1.34	0.91	0.16	3.8	6.0	7.7	10.0
	3†	0.01	8.74	36.88	14.16	0.35				
High output	1*	0.00	0.05	0.19	0.07	0.05	2.0	2.0	2.0	2.0
	1†	0.00	0.11	0.33	0.12	0.12				
Internal leakage	53*	0.00	5.76	33.26	18.05	2.79	27.2	0.3	17.6	304.0
	53†	0.00	16.00	79.64	33.91	6.11				
Low output	37*	0.03	2.21	7.07	2.55	1.95	7.9	0.5	13.3	144.0
	37†	5.47	33.01	79.81	24.09	4.27				
Minor in-service problems	3*	0.00	0.26	1.47	0.79	0.16	13.0	18.0	22.0	26.0
	3†	0.01	8.78	36.90	14.14	0.35				
Noise	15*	0.00	0.60	3.22	1.49	0.79	8.3	1.0	26.0	112.0
	15†	0.00	1.87	9.63	4.18	1.73				
Other	61*	0.00	5.32	25.64	10.58	3.21	18.5	1.0	22.2	165.0
	61†	0.01	26.51	116.49	45.63	7.03				
Overheating	9*	0.00	0.75	4.13	1.94	0.47	45.6	7.0	66.0	112.0
	9†	0.00	5.72	31.01	14.42	1.04				
Parameter deviation	76*	0.00	2.48	7.60	12.33	4.00	4.5	1.0	7.7	67.0
	76†	0.00	5.93	33.65	17.96	8.76				
Structural deficiency	66*	0.00	1.22	1.44	8.86	3.47	25.3	1.0	31.8	798.0
	66†	0.00	3.85	14.51	18.37	7.61				
Vibration	46*	0.00	1.89	10.54	5.51	2.42	33.1	1.0	76.1	737.0
	46†	0.01	6.21	24.60	9.18	5.30				
Incipient	**1124***	**0.08**	**55.97**	**228.31**	**86.32**	**59.09**	**10.3**	**0.5**	**15.1**	**697.0**
	1124†	**127.07**	**760.29**	**1833.66**	**552.65**	**129.58**				
Abnormal instrument reading	550*	0.01	24.76	105.79	40.87	28.91	5.5	0.5	8.5	169.0
	550†	8.45	238.23	719.96	246.09	63.41				
Erratic output	8*	0.00	0.67	3.74	2.20	0.42	4.1	2.0	13.0	26.0
	8†	0.00	2.29	10.78	4.40	0.92				
External leakage - Process medium	56*	0.00	2.68	15.38	8.57	2.94	14.8	0.5	22.6	206.0
	56†	0.00	8.16	38.89	15.97	6.46				
External leakage - Utility medium	125*	0.00	4.83	25.46	11.55	6.57	22.4	1.0	26.6	179.0
	125†	0.42	15.24	46.51	16.15	14.41				
Internal leakage	9*	0.00	0.39	1.94	0.83	0.47	42.6	0.5	41.2	172.0
	9†	0.09	1.04	2.90	0.94	1.04				
Low output	1*	0.00	0.05	0.29	0.14	0.05	2.0	2.0	2.0	2.0
	1†	0.00	0.13	0.51	0.19	0.12				
Minor in-service problems	249*	0.00	15.57	76.10	31.87	13.09	5.8	0.5	9.6	111.0
	249†	53.83	360.26	893.12	273.64	28.71				

Comments

(cont.)

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Taxonomy no	Item
1.3	Machinery Pumps

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
449	61	19.0224	8.6743	11200

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	15*	0.00	0.74	2.77	1.02	0.79	6.6	0.5	17.3	46.0
	15†	0.47	2.04	4.52	1.29	1.73				
Other	52*	0.00	3.24	16.91	7.57	2.73	26.0	1.0	46.1	697.0
	52†	0.00	19.56	90.09	36.18	5.99				
Overheating	4*	0.07	0.21	0.41	0.11	0.21	30.3	3.0	34.3	64.0
	4†	0.00	0.55	2.61	1.07	0.46				
Parameter deviation	24*	0.00	1.12	6.03	3.87	1.26	9.3	2.0	14.4	81.0
	24†	0.00	3.34	14.31	5.53	2.77				
Structural deficiency	15*	0.00	0.79	4.42	2.29	0.79	35.0	1.0	55.7	213.5
	15†	0.04	2.23	6.94	2.46	1.73				
Unknown	4*	0.00	0.39	0.88	2.09	0.21	45.3	8.0	38.5	70.0
	4†	0.00	1.33	7.71	4.23	0.46				
Vibration	12*	0.00	0.69	3.19	1.28	0.63	9.9	1.0	26.7	96.0
	12†	0.00	1.98	8.31	3.18	1.38				
Unknown	**21***	**0.00**	**2.04**	**9.97**	**4.16**	**1.10**	**6.8**	**1.0**	**13.1**	**52.0**
	21†	**0.09**	**6.97**	**22.41**	**8.12**	**2.42**				
External leakage - Utility medium	1*	0.00	0.20	0.90	0.94	0.05	-	29.0	29.0	29.0
	1†	0.00	0.78	4.28	2.03	0.12				
Noise	2*	0.00	0.35	1.71	1.57	0.11	-	6.0	29.0	52.0
	2†	0.00	0.89	4.87	2.43	0.23				
Other	4*	0.00	0.44	2.35	1.59	0.21	-	8.0	11.5	14.0
	4†	0.00	1.64	8.01	3.35	0.46				
Unknown	13*	0.00	0.86	4.78	2.87	0.68	6.8	1.0	9.2	48.0
	13†	0.00	3.22	15.01	6.08	1.50				
Vibration	1*	0.00	0.15	0.48	0.72	0.05	-	15.0	15.0	15.0
	1†	0.00	0.39	2.15	1.01	0.12				
All modes	**2423***	**0.12**	**123.75**	**515.05**	**196.22**	**127.38**	**20.0**	**0.3**	**27.4**	**1025.0**
	2423†	**230.16**	**1184.82**	**2751.06**	**810.62**	**279.33**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.5 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Pumps

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.41	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.04	0.06	0.00	0.04	0.00	0.00	0.00	0.04
Cabling & junction boxes	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.37	0.47	0.25	0.00	0.00	0.00	0.00	0.04	0.00
Check valves	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Control unit	0.95	0.00	0.00	0.00	0.25	0.21	0.00	0.00	0.04	0.00
Cooler(s)	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Cooling/heating system	0.04	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.04	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.25
Coupling to driver	0.04	0.00	0.00	0.04	0.00	0.12	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.04	0.01	0.08	0.00	0.00	0.00	0.01	0.04	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00
Filter(s)	0.04	0.00	0.00	0.25	0.00	0.00	0.04	0.04	0.00	0.00
Filter, cyclone	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.04	0.00
Gearbox/var.drive	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Instrument, flow	6.60	0.00	0.00	0.04	0.00	0.00	0.00	0.06	0.04	0.00
Instrument, general	1.03	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Instrument, level	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.40	0.00	0.02	0.21	0.12	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.65	0.00	0.00	0.08	0.04	0.04	0.00	0.00	0.00	0.00
Instrument, vibration	1.94	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.89	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.21	0.00	0.04	0.00	0.00	0.76	0.00
Other	0.04	0.00	0.04	0.41	0.00	0.04	0.00	0.14	0.21	0.08
Piping	0.00	0.04	1.57	1.63	0.00	0.00	0.00	0.01	0.39	0.00
Piston(s)	0.00	0.04	0.72	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Pulsation damper	0.00	0.00	0.25	0.04	0.12	0.00	0.00	0.19	0.00	0.04
Pump w/motor	0.00	0.00	0.00	0.41	0.00	0.04	0.00	0.00	0.00	0.12
Purge air	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.12	0.04	0.02	0.00	0.04	0.00	0.00	0.00	0.14
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.08	5.85	7.18	0.00	0.00	0.00	0.57	0.04	0.08
Shaft	0.04	0.17	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.12
Subunit	0.12	0.58	0.10	0.21	0.00	0.33	0.00	0.08	0.54	0.04
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.12	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.40	0.21	0.99	1.11	0.21	0.87	0.12	0.21	1.11	0.37
Valves	0.04	0.00	2.31	1.57	0.37	0.04	0.00	1.53	0.17	0.23
Total	23.07	1.86	12.46	15.02	1.36	2.06	0.17	2.89	3.47	1.57

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Pumps

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.08	0.00	1.28
Bearing	0.00	0.04	0.00	0.04	0.12	0.00	0.00	0.10	0.08	0.58
Cabling & junction boxes	0.00	0.04	0.17	0.21	0.00	0.00	0.00	0.08	0.00	1.05
Casing	0.04	0.00	0.00	0.04	0.27	0.00	0.00	0.00	0.08	1.57
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Control unit	0.00	0.12	0.25	0.21	0.12	0.17	0.00	0.29	0.02	2.62
Cooler(s)	0.12	0.04	0.04	0.12	0.12	0.00	0.00	0.00	0.00	0.74
Cooling/heating system	0.08	0.04	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.83
Coupling to driven unit	0.00	0.00	0.00	0.10	0.37	0.00	0.04	0.12	0.04	1.09
Coupling to driver	0.00	0.00	0.00	0.10	0.04	0.00	0.00	0.04	0.12	0.52
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.32
Diaphragm	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.14
Filter(s)	0.00	0.33	0.17	0.54	0.08	0.00	0.00	0.00	0.00	1.49
Filter, cyclone	0.00	0.04	0.00	0.12	0.00	0.00	0.04	0.00	0.00	0.37
Gearbox/var.drive	0.04	0.04	0.00	0.04	0.04	0.00	0.00	0.12	0.00	0.37
Impeller	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.08	0.12	0.34
Instrument, flow	0.00	0.04	0.62	0.17	0.04	0.00	0.00	0.12	0.00	7.74
Instrument, general	0.00	0.21	0.08	0.45	0.00	0.04	0.00	0.17	0.00	2.19
Instrument, level	0.00	0.00	0.04	0.17	0.04	0.00	0.00	0.04	0.00	0.62
Instrument, pressure	0.04	0.08	0.37	0.50	0.12	0.00	0.04	0.50	0.00	6.40
Instrument, speed	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Instrument, temperature	0.04	0.00	0.29	0.56	0.02	0.00	0.00	0.54	0.00	5.26
Instrument, vibration	0.00	0.00	0.45	0.45	0.00	0.00	0.04	0.33	0.39	3.65
Internal power supply	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.08	0.00	0.25
Lubrication	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.12
Monitoring	0.00	0.04	0.08	0.14	0.00	0.00	0.00	0.12	0.00	1.40
Oil	0.04	0.12	0.04	0.45	0.00	0.00	0.00	0.00	0.00	1.67
Other	0.04	0.08	0.50	0.58	0.12	0.00	0.12	0.00	0.04	2.46
Piping	0.00	0.29	0.45	0.33	0.66	0.00	0.00	0.00	0.04	5.42
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
Pulsation damper	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Pump w/motor	0.00	0.04	0.08	0.04	0.00	0.00	0.00	0.00	0.00	0.74
Purge air	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.21
Radial bearing	0.00	0.08	0.12	0.08	0.31	0.00	0.00	0.04	0.61	1.62
Reservoir	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.04
Reservoir w/heating system	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.12
Seals	0.12	0.21	0.08	0.29	0.56	0.00	0.00	0.35	0.01	15.44
Shaft	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.08	0.11	0.69
Subunit	0.00	0.50	0.25	0.37	0.45	0.00	0.00	0.37	0.41	4.35
Support	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.91	1.03
Thrust bearing	0.04	0.00	0.00	0.04	0.19	0.00	0.00	0.00	0.18	0.67
Unknown	0.08	1.20	0.29	1.73	0.62	0.00	0.45	1.53	0.58	13.08
Valves	0.00	1.03	0.50	1.32	0.17	0.00	0.00	0.10	0.00	9.37
Total	0.74	5.16	4.87	10.40	4.70	0.21	0.74	5.49	3.76	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Pumps

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	1.36	0.08	0.25	0.29	0.12	0.04	0.00	0.00	0.91	0.00
Breakage	0.74	0.12	0.37	0.41	0.08	0.08	0.00	0.04	0.00	0.00
Burst	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.12	0.12	0.21	0.00	0.00	0.00	0.00	0.00	0.12
Clearance/ alignment failure	0.21	0.00	0.12	0.12	0.00	0.04	0.00	0.00	0.00	0.21
Combined causes	0.00	0.08	0.08	0.00	0.00	0.00	0.00	0.04	0.04	0.04
Contamination	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.04	0.95	0.00
Control failure	0.33	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.00
Corrosion	0.45	0.04	0.37	0.33	0.00	0.00	0.00	0.00	0.21	0.00
Deformation	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.25	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Electrical failure - general	0.50	0.00	0.00	0.00	0.08	0.25	0.00	0.00	0.00	0.04
Erosion	0.00	0.08	0.00	0.12	0.00	0.00	0.00	0.00	0.04	0.00
External influence - general	0.04	0.00	0.33	0.00	0.00	0.04	0.00	0.08	0.00	0.00
Fatigue	0.04	0.00	0.12	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.85	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Instrument failure - general	6.56	0.00	0.08	0.17	0.08	0.25	0.04	0.00	0.08	0.00
Leakage	0.17	0.00	2.56	5.86	0.08	0.00	0.00	0.58	0.17	0.04
Looseness	0.08	0.00	0.37	0.12	0.00	0.04	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.21	0.58	0.04	0.04	0.08	0.12	0.00	0.00
Mechanical Failure - general	0.54	0.78	4.21	4.54	0.21	0.41	0.00	0.95	0.33	0.45
Misc. external influences	0.41	0.29	0.37	0.37	0.12	0.00	0.00	0.00	0.12	0.00
Miscellaneous - general	0.00	0.00	0.00	0.08	0.04	0.00	0.00	0.00	0.04	0.00
No cause found	0.17	0.00	0.00	0.04	0.08	0.08	0.00	0.04	0.00	0.00
No power/ voltage	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
Open circuit	0.33	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Other	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	5.98	0.00	0.00	0.00	0.12	0.08	0.00	0.00	0.04	0.00
Overheating	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.08	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
Software failure	0.08	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Sticking	0.17	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Unknown	0.25	0.04	0.12	0.08	0.00	0.25	0.04	0.08	0.04	0.21
Vibration	0.29	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Wear	0.33	0.12	2.64	1.53	0.08	0.12	0.00	0.87	0.45	0.21
Total	23.07	1.86	12.46	15.02	1.36	2.06	0.17	2.89	3.47	1.57

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Pumps

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.04	1.53	0.62	0.21	0.00	0.00	0.08	0.04	5.57
Breakage	0.04	0.12	0.04	0.33	0.04	0.00	0.00	0.21	0.25	2.89
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cavitation	0.00	0.08	0.08	0.04	0.12	0.00	0.00	0.00	0.04	0.95
Clearance/ alignment failure	0.04	0.04	0.17	0.08	0.17	0.00	0.00	0.00	0.78	1.98
Combined causes	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.41
Contamination	0.00	0.21	0.00	0.50	0.00	0.00	0.00	0.00	0.00	1.82
Control failure	0.00	0.08	0.00	0.17	0.00	0.08	0.00	0.25	0.04	1.07
Corrosion	0.00	0.29	0.00	0.70	0.41	0.00	0.00	0.17	0.00	2.97
Deformation	0.04	0.00	0.00	0.08	0.04	0.00	0.00	0.08	0.04	0.37
Earth/isolation fault	0.04	0.08	0.00	0.08	0.00	0.00	0.00	0.04	0.00	0.54
Electrical failure - general	0.04	0.21	0.12	0.21	0.08	0.00	0.04	0.45	0.00	2.02
Erosion	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.29
External influence - general	0.00	0.37	0.21	0.50	0.00	0.00	0.00	0.00	0.04	1.61
Fatigue	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04	0.29
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
Faulty signal/indication/alarm	0.08	0.08	0.08	0.12	0.00	0.00	0.00	0.54	0.12	3.96
Instrument failure - general	0.00	0.41	1.07	1.73	0.00	0.08	0.12	1.16	0.08	11.93
Leakage	0.00	0.08	0.08	0.33	0.21	0.00	0.04	0.17	0.04	10.40
Looseness	0.00	0.00	0.00	0.29	0.04	0.00	0.00	0.04	0.04	1.03
Material failure - general	0.00	0.12	0.00	0.33	0.62	0.00	0.00	0.04	0.08	2.27
Mechanical Failure - general	0.12	1.07	0.54	1.44	2.31	0.00	0.21	0.78	0.70	19.60
Misc. external influences	0.00	0.50	0.17	0.95	0.08	0.00	0.00	0.08	0.45	3.92
Miscellaneous - general	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.04	0.00	0.33
No cause found	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.74
No power/ voltage	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.08
No signal/indication/alarm	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.99
Open circuit	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.45
Other	0.04	0.17	0.04	0.12	0.00	0.00	0.04	0.08	0.00	0.58
Out of adjustment	0.00	0.00	0.54	0.29	0.00	0.00	0.00	0.21	0.08	7.35
Overheating	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.17
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Software failure	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.21
Sticking	0.00	0.29	0.00	0.37	0.00	0.00	0.00	0.04	0.00	1.16
Unknown	0.17	0.29	0.08	0.25	0.00	0.04	0.29	0.12	0.12	2.48
Vibration	0.00	0.04	0.12	0.04	0.17	0.00	0.00	0.41	0.37	1.57
Wear	0.00	0.29	0.00	0.62	0.12	0.00	0.00	0.12	0.21	7.72
Total	0.74	5.16	4.87	10.40	4.70	0.21	0.74	5.49	3.76	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.3.1	Machinery Pumps Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
350	59	13.9546	5.7455	10340

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**464***	**0.00**	**21.60**	**124.23**	**67.21**	**33.25**	**39.7**	**1.0**	**57.6**	**1025.0**
	464†	**0.12**	**70.52**	**284.09**	**106.81**	**80.76**				
Breakdown	37*	0.00	1.20	1.67	7.82	2.65	16.4	3.0	57.1	766.0
	37†	0.00	3.70	21.16	11.38	6.44				
Erratic output	2*	0.00	0.15	0.79	0.54	0.14	19.8	11.0	39.5	68.0
	2†	0.00	0.46	2.22	0.92	0.35				
External leakage - Process medium	77*	0.00	2.25	5.52	11.84	5.52	30.2	2.0	42.0	444.0
	77†	0.00	7.04	38.07	17.67	13.40				
External leakage - Utility medium	46*	0.00	1.61	2.94	9.28	3.30	16.0	2.0	29.8	90.0
	46†	0.00	4.81	26.68	13.65	8.01				
Fail to start on demand	42*	0.01	2.28	8.52	3.14	3.01	55.8	1.0	63.0	551.0
	42†	0.02	13.74	55.88	21.10	7.31				
Fail to stop on demand	2*	0.00	0.13	0.65	0.57	0.14	3.5	3.0	3.5	4.0
	2†	0.00	0.38	1.55	0.58	0.35				
High output	3*	0.00	0.69	3.58	2.77	0.21	-	1.0	3.3	6.0
	3†	0.00	2.49	13.73	6.44	0.52				
Internal leakage	3*	0.00	0.16	0.87	0.57	0.21	188.0	36.0	90.7	188.0
	3†	0.00	0.56	2.63	1.08	0.52				
Low output	40*	0.00	2.58	3.33	17.49	2.87	38.2	3.0	45.3	508.0
	40†	0.00	4.68	7.79	27.92	6.96				
Noise	4*	0.00	0.25	1.29	0.57	0.29	25.0	16.0	67.3	122.0
	4†	0.03	0.78	2.34	0.80	0.70				
Other	8*	0.00	0.60	3.20	2.68	0.57	275.5	2.0	424.5	734.0
	8†	0.00	1.85	8.07	3.14	1.39				
Overheating	5*	0.11	0.36	0.72	0.19	0.36	183.2	3.0	265.0	1025.0
	5†	0.00	6.83	37.16	17.32	0.87				
Parameter deviation	16*	0.00	0.65	2.84	3.03	1.15	11.6	1.0	21.7	88.0
	16†	0.15	2.58	7.60	2.53	2.78				
Spurious stop	120*	0.00	6.33	33.92	15.65	8.60	39.7	1.0	45.0	714.0
	120†	0.51	22.56	69.52	24.44	20.89				
Structural deficiency	27*	0.00	0.61	0.72	6.77	1.93	23.9	7.0	47.3	211.0
	27†	0.00	1.77	3.32	10.06	4.70				
Vibration	32*	0.00	2.12	10.93	4.76	2.29	81.2	5.0	118.3	896.0
	32†	0.62	6.76	18.55	6.00	5.57				
Degraded	**537***	**0.00**	**32.39**	**163.45**	**70.23**	**38.48**	**22.3**	**0.5**	**32.1**	**798.0**
	537†	**3.74**	**237.30**	**747.95**	**267.91**	**93.46**				
Abnormal instrument reading	9*	0.00	0.85	4.95	2.70	0.64	9.0	2.0	16.0	65.0
	9†	0.00	2.95	12.59	4.86	1.57				
Erratic output	10*	0.00	1.95	10.27	6.99	0.72	20.3	2.0	17.4	65.0
	10†	0.00	4.87	26.99	13.79	1.74				

Comments

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Taxonomy no	Item
1.3.1	Machinery Pumps Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
350	59	13.9546	5.7455	10340

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	56*	0.00	3.25	18.02	9.21	4.01	14.1	2.0	31.7	278.0
	56†	0.02	10.52	41.84	15.63	9.75				
External leakage - Utility medium	178*	0.00	9.26	45.08	18.79	12.76	30.2	1.0	36.3	219.0
	178†	0.00	57.14	265.19	107.20	30.98				
Fail to stop on demand	3*	0.00	0.30	1.59	1.11	0.21	3.8	6.0	7.7	10.0
	3†	0.00	9.30	43.28	17.53	0.52				
High output	1*	0.00	0.07	0.20	0.07	0.07	2.0	2.0	2.0	2.0
	1†	0.00	0.15	0.48	0.17	0.17				
Internal leakage	11*	0.00	0.87	4.75	2.22	0.79	56.8	2.0	56.0	304.0
	11†	0.00	6.17	34.28	17.67	1.91				
Low output	30*	1.32	2.15	3.15	0.56	2.15	8.4	0.5	14.4	144.0
	30†	4.96	37.34	94.91	29.45	5.22				
Minor in-service problems	3*	0.00	0.29	1.61	0.83	0.21	13.0	18.0	22.0	26.0
	3†	0.00	9.27	43.11	17.46	0.52				
Noise	5*	0.00	0.32	1.72	1.08	0.36	17.7	6.0	35.3	75.0
	5†	0.00	0.95	4.61	1.91	0.87				
Other	46*	0.00	4.29	21.19	8.96	3.30	18.5	1.0	21.8	165.0
	46†	0.00	27.99	132.88	54.47	8.01				
Overheating	9*	0.00	0.83	4.58	2.14	0.64	45.6	7.0	66.0	112.0
	9†	0.00	6.15	34.20	17.71	1.57				
Parameter deviation	70*	0.00	2.60	3.48	17.29	5.02	4.5	1.0	7.3	67.0
	70†	0.00	5.71	19.81	27.67	12.18				
Structural deficiency	61*	0.00	1.73	1.92	13.81	4.37	26.9	1.0	33.9	798.0
	61†	0.00	5.75	20.30	27.74	10.62				
Vibration	45*	0.00	2.89	16.73	9.18	3.22	34.2	1.0	78.1	737.0
	45†	0.00	8.58	37.96	14.93	7.83				
Incipient	**936***	**0.00**	**56.57**	**262.99**	**106.45**	**67.07**	**10.8**	**0.5**	**15.6**	**697.0**
	936†	**95.49**	**834.30**	**2182.80**	**686.83**	**162.91**				
Abnormal instrument reading	445*	0.00	25.76	128.63	54.90	31.89	5.7	0.5	8.1	144.0
	445†	4.46	274.18	862.22	308.37	77.45				
Erratic output	5*	0.00	0.39	2.04	1.41	0.36	4.1	2.0	8.2	16.0
	5†	0.00	1.36	5.38	2.01	0.87				
External leakage - Process medium	46*	0.00	2.73	14.38	9.89	3.30	15.3	0.5	24.4	206.0
	46†	0.00	8.60	44.48	19.52	8.01				
External leakage - Utility medium	108*	0.00	5.29	28.69	13.34	7.74	23.5	1.0	28.0	179.0
	108†	0.57	17.63	53.47	18.40	18.80				
Internal leakage	9*	0.00	0.45	2.09	0.84	0.64	42.6	0.5	41.2	172.0
	9†	0.28	1.42	3.27	0.96	1.57				
Low output	1*	0.00	0.06	0.33	0.15	0.07	2.0	2.0	2.0	2.0
	1†	0.00	0.18	0.55	0.20	0.17				

Comments

(cont.)

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Taxonomy no	Item
1.3.1	Machinery Pumps Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
350	59	13.9546	5.7455	10340

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	213*	0.00	15.38	80.97	36.69	15.26	6.1	0.5	10.4	111.0
	213†	39.27	391.65	1057.33	338.88	37.07				
Noise	8*	0.00	0.64	3.23	1.39	0.57	7.3	0.5	20.1	46.0
	8†	0.04	2.12	6.58	2.32	1.39				
Other	47*	0.00	3.14	17.24	8.40	3.37	27.3	1.0	46.0	697.0
	47†	0.00	20.65	103.50	44.28	8.18				
Overheating	4*	0.00	0.23	0.95	1.08	0.29	30.3	3.0	34.3	64.0
	4†	0.00	0.67	2.83	1.09	0.70				
Parameter deviation	23*	0.00	1.08	5.59	4.15	1.65	9.3	2.0	14.1	81.0
	23†	0.02	3.82	13.98	5.17	4.00				
Structural deficiency	12*	0.00	0.79	4.43	2.30	0.86	42.1	1.0	70.0	213.5
	12†	1.32	2.21	3.28	0.60	2.09				
Unknown	4*	0.00	0.41	0.74	2.34	0.29	45.3	8.0	38.5	70.0
	4†	0.00	1.48	8.16	4.96	0.70				
Vibration	11*	0.00	0.78	3.33	1.28	0.79	9.9	1.0	26.7	96.0
	11†	0.01	2.48	9.16	3.38	1.91				
Unknown	**12***	**0.00**	**1.17**	**6.41**	**3.08**	**0.86**	**6.8**	**2.0**	**13.6**	**48.0**
	12†	**0.01**	**4.50**	**17.83**	**6.65**	**2.09**				
External leakage - Utility medium	1*	0.00	0.21	0.59	1.05	0.07	-	29.0	29.0	29.0
	1†	0.00	0.84	4.67	2.38	0.17				
Other	2*	0.01	0.15	0.43	0.14	0.14	-	12.0	12.0	12.0
	2†	0.00	0.60	3.14	1.42	0.35				
Unknown	9*	0.00	0.82	4.48	2.79	0.64	6.8	2.0	12.1	48.0
	9†	0.00	3.20	15.07	6.15	1.57				
All modes	**1949***	**0.00**	**112.64**	**546.74**	**226.89**	**139.67**	**21.3**	**0.5**	**30.5**	**1025.0**
	1949†	**172.90**	**1277.00**	**3233.73**	**1001.75**	**339.22**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.3 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Pumps - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.51	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.05	0.08	0.00	0.05	0.00	0.00	0.00	0.05
Cabling & junction boxes	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Casing	0.00	0.46	0.59	0.31	0.00	0.00	0.00	0.00	0.05	0.00
Check valves	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Control unit	1.18	0.00	0.00	0.00	0.31	0.21	0.00	0.00	0.05	0.00
Cooler(s)	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Cooling/heating system	0.05	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.05	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.05
Coupling to driver	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.31	0.00	0.00	0.05	0.05	0.00	0.00
Filter, cyclone	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.05	0.00
Gearbox/var.drive	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Instrument, flow	3.95	0.00	0.00	0.05	0.00	0.00	0.00	0.08	0.05	0.00
Instrument, general	1.13	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00
Instrument, level	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.90	0.00	0.03	0.21	0.15	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	4.54	0.00	0.00	0.10	0.05	0.05	0.00	0.00	0.00	0.00
Instrument, vibration	2.41	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	1.10	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.26	0.00	0.05	0.00	0.00	0.95	0.00
Other	0.05	0.00	0.05	0.51	0.00	0.05	0.00	0.05	0.10	0.10
Piping	0.00	0.05	1.80	2.03	0.00	0.00	0.00	0.00	0.49	0.00
Pump w/motor	0.00	0.00	0.00	0.51	0.00	0.05	0.00	0.00	0.00	0.15
Purge air	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.15	0.05	0.03	0.00	0.05	0.00	0.00	0.00	0.13
Reservoir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reservoir w/heating system	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.10	5.11	8.16	0.00	0.00	0.00	0.59	0.00	0.03
Shaft	0.05	0.21	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.10
Subunit	0.15	0.56	0.08	0.26	0.00	0.36	0.00	0.05	0.51	0.05
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.15	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.49	0.15	0.46	1.08	0.05	0.92	0.15	0.15	1.23	0.10
Valves	0.00	0.00	0.92	1.74	0.10	0.05	0.00	0.21	0.10	0.05
Total	23.29	1.90	9.18	17.09	0.87	2.15	0.21	1.18	3.64	0.87

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Pumps - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.26	0.00	0.62	0.00	0.00	0.00	0.05	0.00	1.49
Bearing	0.00	0.00	0.00	0.05	0.15	0.00	0.00	0.13	0.10	0.67
Cabling & junction boxes	0.00	0.05	0.21	0.26	0.00	0.00	0.00	0.10	0.00	1.26
Casing	0.05	0.00	0.00	0.05	0.33	0.00	0.00	0.00	0.10	1.95
Check valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control unit	0.00	0.15	0.21	0.26	0.10	0.21	0.00	0.36	0.03	3.05
Cooler(s)	0.15	0.05	0.05	0.15	0.15	0.00	0.00	0.00	0.00	0.92
Cooling/heating system	0.10	0.05	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.03
Coupling to driven unit	0.00	0.00	0.00	0.08	0.41	0.00	0.05	0.15	0.05	1.00
Coupling to driver	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.15	0.33
Diaphragm	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05
Filter(s)	0.00	0.41	0.21	0.46	0.10	0.00	0.00	0.00	0.00	1.59
Filter, cyclone	0.00	0.05	0.00	0.15	0.00	0.00	0.05	0.00	0.00	0.46
Gearbox/var.drive	0.05	0.00	0.00	0.05	0.05	0.00	0.00	0.15	0.00	0.36
Impeller	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.10	0.15	0.38
Instrument, flow	0.00	0.05	0.77	0.21	0.05	0.00	0.00	0.15	0.00	5.36
Instrument, general	0.00	0.26	0.10	0.51	0.00	0.05	0.00	0.15	0.00	2.46
Instrument, level	0.00	0.00	0.05	0.10	0.05	0.00	0.00	0.05	0.00	0.67
Instrument, pressure	0.05	0.10	0.36	0.56	0.15	0.00	0.05	0.46	0.00	7.03
Instrument, speed	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Instrument, temperature	0.05	0.00	0.36	0.69	0.03	0.00	0.00	0.67	0.00	6.54
Instrument, vibration	0.00	0.00	0.56	0.56	0.00	0.00	0.05	0.41	0.49	4.54
Internal power supply	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.10	0.00	0.31
Lubrication	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.15
Monitoring	0.00	0.05	0.10	0.18	0.00	0.00	0.00	0.15	0.00	1.74
Oil	0.05	0.15	0.05	0.26	0.00	0.00	0.00	0.00	0.00	1.77
Other	0.05	0.10	0.62	0.72	0.15	0.00	0.15	0.00	0.05	2.77
Piping	0.00	0.31	0.56	0.41	0.72	0.00	0.00	0.00	0.05	6.41
Pump w/motor	0.00	0.05	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.92
Purge air	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.26
Radial bearing	0.00	0.10	0.15	0.10	0.38	0.00	0.00	0.05	0.76	1.97
Reservoir	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05
Reservoir w/heating system	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.15
Seals	0.15	0.21	0.10	0.36	0.54	0.00	0.00	0.44	0.02	15.79
Shaft	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.70
Subunit	0.00	0.56	0.31	0.46	0.46	0.00	0.00	0.46	0.51	4.80
Support	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	1.08	1.23
Thrust bearing	0.05	0.00	0.00	0.05	0.23	0.00	0.00	0.00	0.22	0.84
Unknown	0.10	0.97	0.31	1.54	0.56	0.00	0.31	1.85	0.62	12.06
Valves	0.00	1.08	0.41	1.28	0.21	0.00	0.00	0.05	0.00	6.21
Total	0.92	5.28	5.59	11.08	5.13	0.26	0.67	6.16	4.52	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Pumps - Centrifugal

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	1.44	0.05	0.31	0.36	0.15	0.05	0.00	0.00	0.92	0.00
Breakage	0.77	0.05	0.05	0.46	0.00	0.05	0.00	0.00	0.00	0.00
Burst	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.15	0.15	0.26	0.00	0.00	0.00	0.00	0.00	0.15
Clearance/ alignment failure	0.26	0.00	0.15	0.15	0.00	0.05	0.00	0.00	0.00	0.00
Combined causes	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Contamination	0.00	0.00	0.00	0.05	0.10	0.00	0.00	0.05	1.18	0.00
Control failure	0.41	0.00	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00
Corrosion	0.51	0.05	0.41	0.41	0.00	0.00	0.00	0.00	0.26	0.00
Deformation	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.31	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Electrical failure - general	0.62	0.00	0.00	0.00	0.05	0.21	0.00	0.00	0.00	0.05
Erosion	0.00	0.10	0.00	0.15	0.00	0.00	0.00	0.00	0.05	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Fatigue	0.05	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.34	0.00	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00
Instrument failure - general	7.75	0.00	0.10	0.21	0.10	0.26	0.05	0.00	0.10	0.00
Leakage	0.21	0.00	2.72	6.88	0.00	0.00	0.00	0.56	0.05	0.05
Looseness	0.10	0.00	0.36	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.26	0.67	0.00	0.05	0.10	0.00	0.00	0.00
Mechanical Failure - general	0.67	0.82	3.59	5.39	0.00	0.46	0.00	0.26	0.15	0.41
Misc. external influences	0.46	0.31	0.46	0.46	0.15	0.00	0.00	0.00	0.15	0.00
Miscellaneous - general	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.05	0.00
No cause found	0.21	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.00	0.00
No power/ voltage	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Open circuit	0.41	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Other	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.39	0.00	0.00	0.00	0.15	0.10	0.00	0.00	0.00	0.00
Overheating	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.10	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Software failure	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.31	0.05	0.05	0.10	0.00	0.31	0.05	0.10	0.05	0.10
Vibration	0.36	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Wear	0.41	0.15	0.36	1.08	0.00	0.15	0.00	0.21	0.56	0.05
Total	23.29	1.90	9.18	17.09	0.87	2.15	0.21	1.18	3.64	0.87

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Pumps - Centrifugal

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.05	1.90	0.72	0.21	0.00	0.00	0.10	0.05	6.31
Breakage	0.05	0.05	0.05	0.31	0.05	0.00	0.00	0.05	0.31	2.26
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Cavitation	0.00	0.10	0.10	0.05	0.15	0.00	0.00	0.00	0.05	1.18
Clearance/ alignment failure	0.05	0.05	0.21	0.05	0.21	0.00	0.00	0.00	0.97	2.15
Combined causes	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.21
Contamination	0.00	0.21	0.00	0.56	0.00	0.00	0.00	0.00	0.00	2.15
Control failure	0.00	0.10	0.00	0.15	0.00	0.10	0.00	0.21	0.05	1.18
Corrosion	0.00	0.36	0.00	0.77	0.51	0.00	0.00	0.15	0.00	3.44
Deformation	0.05	0.00	0.00	0.10	0.05	0.00	0.00	0.10	0.05	0.46
Earth/isolation fault	0.05	0.10	0.00	0.10	0.00	0.00	0.00	0.05	0.00	0.67
Electrical failure - general	0.05	0.26	0.15	0.26	0.05	0.00	0.00	0.05	0.51	0.00	2.26
Erosion	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.36
External influence - general	0.00	0.46	0.26	0.15	0.00	0.00	0.00	0.00	0.05	0.97
Fatigue	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.31
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05
Faulty signal/indication/alarm	0.10	0.10	0.10	0.15	0.00	0.00	0.00	0.67	0.15	4.72
Instrument failure - general	0.00	0.46	1.23	2.00	0.00	0.10	0.15	1.39	0.10	14.01
Leakage	0.00	0.05	0.00	0.36	0.26	0.00	0.05	0.21	0.05	11.44
Looseness	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.05	0.05	0.97
Material failure - general	0.00	0.15	0.00	0.36	0.51	0.00	0.00	0.05	0.10	2.26
Mechanical Failure - general	0.15	0.87	0.51	1.49	2.67	0.00	0.15	0.97	0.82	19.39
Misc. external influences	0.00	0.56	0.21	1.13	0.10	0.00	0.00	0.10	0.51	4.62
Miscellaneous - general	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.41
No cause found	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.72
No power/ voltage	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10
No signal/indication/alarm	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.05	0.00	1.08
Open circuit	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.56
Other	0.05	0.21	0.05	0.15	0.00	0.00	0.05	0.10	0.00	0.72
Out of adjustment	0.00	0.00	0.56	0.36	0.00	0.00	0.00	0.21	0.10	4.87
Overheating	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Software failure	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21
Sticking	0.00	0.26	0.00	0.41	0.00	0.00	0.00	0.05	0.00	0.87
Unknown	0.21	0.36	0.10	0.31	0.00	0.05	0.21	0.15	0.15	2.67
Vibration	0.00	0.05	0.15	0.05	0.21	0.00	0.00	0.51	0.46	1.90
Wear	0.00	0.15	0.00	0.56	0.05	0.00	0.00	0.05	0.26	4.05
Total	0.92	5.28	5.59	11.08	5.13	0.26	0.67	6.16	4.52	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.3.1.1	Machinery Pumps Centrifugal Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	2	0.0964	0.0961	4

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.24**	**12.04**	**37.31**	**13.19**	**10.38**	-	**26.0**	**26.0**	**26.0**
	1†	**0.23**	**12.12**	**37.67**	**13.35**	**10.41**				
External leakage - Utility medium	1*	0.24	12.04	37.31	13.19	10.38	-	26.0	26.0	26.0
	1†	0.23	12.12	37.67	13.35	10.41				
All modes	**1***	**0.24**	**12.04**	**37.31**	**13.19**	**10.38**	-	**26.0**	**26.0**	**26.0**
	1†	**0.23**	**12.12**	**37.67**	**13.35**	**10.41**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
1.3.1.2	Machinery Pumps Centrifugal Combined function

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	2	0.3503	0.2991	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.14**	**15.63**	**52.07**	**19.08**	**17.13**	**58.2**	**1.0**	**58.8**	**96.0**
	6†	**0.12**	**20.47**	**72.16**	**26.65**	**20.06**				
External leakage - Process medium	5*	0.15	13.09	42.52	15.46	14.27	69.6	34.0	70.4	96.0
	5†	0.11	17.04	59.06	21.78	16.71				
Fail to start on demand	1*	0.01	2.72	9.71	3.59	2.85	1.0	1.0	1.0	1.0
	1†	0.18	3.37	10.03	3.34	3.34				
Degraded	**2***	**0.75**	**5.48**	**13.85**	**4.29**	**5.71**	**3.0**	**2.0**	**3.0**	**4.0**
	2†	**0.24**	**6.77**	**20.47**	**7.01**	**6.69**				
External leakage - Process medium	1*	0.01	2.72	9.71	3.59	2.85	2.0	2.0	2.0	2.0
	1†	0.18	3.37	10.03	3.34	3.34				
External leakage - Utility medium	1*	0.01	2.72	9.71	3.59	2.85	4.0	4.0	4.0	4.0
	1†	0.18	3.37	10.03	3.34	3.34				
Incipient	**5***	**0.15**	**13.09**	**42.52**	**15.46**	**14.27**	**35.1**	**1.0**	**29.1**	**136.0**
	5†	**0.11**	**17.04**	**59.06**	**21.78**	**16.71**				
Abnormal instrument reading	1*	0.01	2.72	9.71	3.59	2.85	1.5	1.5	1.5	1.5
	1†	0.18	3.37	10.03	3.34	3.34				
External leakage - Process medium	3*	0.34	8.02	24.10	8.14	8.56	1.5	1.0	2.7	5.0
	3†	0.12	10.20	33.03	12.00	10.03				
External leakage - Utility medium	1*	0.01	2.72	9.71	3.59	2.85	136.0	136.0	136.0	136.0
	1†	0.18	3.37	10.03	3.34	3.34				
All modes	**13***	**0.18**	**33.39**	**119.82**	**44.27**	**37.11**	**41.3**	**1.0**	**38.8**	**136.0**
	13†	**0.21**	**44.44**	**164.09**	**60.60**	**43.46**				

Comments

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Taxonomy no	Item
1.3.1.3	Machinery Pumps Centrifugal Completion fluid

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.06	14.25	54.72	20.15	0.00	-	-	-	-
	0†	0.06	16.12	61.90	22.80	0.00				

Comments

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Taxonomy no	Item
1.3.1.4	Machinery Pumps Centrifugal Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	4	0.3189	0.2207	834

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**5.37**	**80.59**	**233.46**	**77.15**	**53.31**	**22.5**	**2.0**	**31.0**	**223.0**
	17†	**8.34**	**136.72**	**400.61**	**132.89**	**77.03**				
Breakdown	1*	0.23	3.30	9.51	3.14	3.14	22.5	45.0	45.0	45.0
	1†	0.00	4.36	19.00	7.39	4.53				
External leakage - Utility medium	1*	0.24	3.33	9.53	3.14	3.14	-	9.0	9.0	9.0
	1†	0.00	4.36	18.97	7.38	4.53				
Fail to start on demand	3*	0.08	13.10	46.37	17.13	9.41	-	6.0	8.3	12.0
	3†	0.17	25.41	87.89	32.41	13.59				
High output	2*	0.01	12.10	50.63	19.35	6.27	-	3.0	4.5	6.0
	2†	0.07	23.69	92.76	34.46	9.06				
Internal leakage	1*	0.02	2.76	9.66	3.57	3.14	-	48.0	48.0	48.0
	1†	0.00	4.35	18.92	7.35	4.53				
Overheating	1*	0.24	3.33	9.53	3.14	3.14	-	223.0	223.0	223.0
	1†	0.00	4.36	18.97	7.38	4.53				
Spurious stop	7*	0.81	32.37	99.21	34.66	21.95	-	2.0	20.2	76.0
	7†	1.12	48.99	150.82	52.97	31.72				
Vibration	1*	0.00	5.19	22.07	8.51	3.14	-	5.0	5.0	5.0
	1†	0.01	9.93	41.62	15.93	4.53				
Degraded	**35***	**29.29**	**110.01**	**232.93**	**64.55**	**109.75**	**37.0**	**2.0**	**40.3**	**250.0**
	35†	**42.31**	**166.26**	**357.22**	**100.07**	**158.60**				
Erratic output	1*	0.24	3.33	9.53	3.14	3.14	-	-	-	-
	1†	0.00	4.36	18.97	7.38	4.53				
External leakage - Process medium	1*	0.24	3.33	9.53	3.14	3.14	-	68.0	68.0	68.0
	1†	0.00	4.36	18.97	7.38	4.53				
External leakage - Utility medium	17*	19.08	50.90	95.18	23.75	53.31	37.0	2.0	37.2	178.0
	17†	9.78	87.63	230.73	72.89	77.03				
Minor in-service problems	1*	0.24	3.33	9.53	3.14	3.14	-	-	-	-
	1†	0.00	4.36	18.97	7.38	4.53				
Other	8*	4.96	23.81	54.28	15.82	25.09	-	3.0	16.0	60.0
	8†	8.67	37.20	82.04	23.38	36.25				
Overheating	1*	0.24	3.33	9.53	3.14	3.14	-	-	-	-
	1†	0.00	4.36	18.97	7.38	4.53				
Parameter deviation	1*	0.24	3.33	9.53	3.14	3.14	-	-	-	-
	1†	0.00	4.36	18.97	7.38	4.53				
Structural deficiency	3*	0.01	10.81	46.54	18.03	9.41	-	23.0	23.0	23.0
	3†	0.05	12.74	49.04	18.08	13.59				
Vibration	2*	0.01	7.14	28.70	10.78	6.27	-	250.0	250.0	250.0
	2†	0.23	8.78	26.84	9.35	9.06				
Incipient	**52***	**0.79**	**192.25**	**729.04**	**268.80**	**163.05**	**-**	**2.0**	**18.4**	**108.0**
	52†	**2.24**	**244.56**	**811.02**	**296.87**	**235.63**				

Comments

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Taxonomy no	Item
1.3.1.4	Machinery Pumps Centrifugal Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	4	0.3189	0.2207	834

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Abnormal instrument reading	30*	1.07	118.26	392.84	143.86	94.07	-	2.0	15.1	108.0
	30†	5.64	159.08	480.77	164.34	135.94				
External leakage - Process medium	4*	0.00	14.43	63.98	25.20	12.54	-	-	-	-
	4†	0.02	16.61	69.22	26.39	18.13				
Minor in-service problems	9*	0.00	32.35	150.26	60.77	28.22	-	16.0	32.5	53.0
	9†	0.00	35.47	165.41	67.09	40.78				
Other	3*	1.46	8.33	19.84	5.93	9.41	-	3.0	20.3	48.0
	3†	0.05	12.72	48.86	17.99	13.59				
Parameter deviation	2*	0.01	7.14	28.70	10.78	6.27	-	4.0	5.0	6.0
	2†	0.23	8.78	26.84	9.35	9.06				
Structural deficiency	1*	0.24	3.33	9.53	3.14	3.14	-	-	-	-
	1†	0.00	4.36	18.97	7.38	4.53				
Vibration	3*	0.01	10.81	46.54	18.03	9.41	-	18.0	26.3	40.0
	3†	0.05	12.74	49.04	18.08	13.59				
Unknown	**5***	**3.19**	**17.17**	**40.29**	**11.94**	**15.68**	**-**	**2.0**	**6.4**	**12.0**
	5†	**2.24**	**30.02**	**85.56**	**28.11**	**22.66**				
Other	1*	0.24	3.33	9.53	3.14	3.14	-	12.0	12.0	12.0
	1†	0.00	4.36	18.97	7.38	4.53				
Unknown	4*	0.34	14.60	44.92	15.76	12.54	-	2.0	5.0	6.0
	4†	0.39	28.11	89.57	32.29	18.13				
All modes	**109***	**31.51**	**407.61**	**1155.40**	**378.76**	**341.79**	**29.8**	**2.0**	**27.6**	**250.0**
	109†	**87.99**	**595.24**	**1479.27**	**453.84**	**493.91**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.2 \cdot 10^{-3}$

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Taxonomy no	Item
1.3.1.5	Machinery Pumps Centrifugal Cooling systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
18	2	0.4729	0.4276	150

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.38**	**5.12**	**14.61**	**4.80**	**4.23**	**4.0**	**4.0**	**63.0**	**122.0**
	2†	**0.43**	**7.34**	**21.63**	**7.19**	**4.68**				
Fail to start on demand	1*	0.04	1.92	5.97	2.11	2.11	4.0	4.0	4.0	4.0
	1†	0.05	2.15	6.64	2.34	2.34				
Noise	1*	0.01	4.00	15.41	5.68	2.11	-	122.0	122.0	122.0
	1†	0.02	7.34	28.92	10.77	2.34				
Incipient	**1***	**0.04**	**1.92**	**5.97**	**2.11**	**2.11**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.05**	**2.15**	**6.64**	**2.34**	**2.34**				
Abnormal instrument reading	1*	0.04	1.92	5.97	2.11	2.11	2.0	2.0	2.0	2.0
	1†	0.05	2.15	6.64	2.34	2.34				
All modes	**3***	**1.96**	**6.63**	**13.57**	**3.66**	**6.34**	**3.0**	**2.0**	**42.7**	**122.0**
	3†	**0.84**	**8.95**	**24.53**	**7.92**	**7.02**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.6	Machinery Pumps Centrifugal Crude oil handling

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	3	0.3596	0.2235	750

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**18.63**	**49.27**	**91.81**	**22.83**	**47.28**	**4.3**	**1.0**	**63.1**	**231.0**
	17†	**49.53**	**77.17**	**109.79**	**18.44**	**76.05**				
Breakdown	2*	0.77	5.17	12.83	3.93	5.56	-	22.0	57.0	92.0
	2†	1.37	8.55	20.85	6.33	8.95				
External leakage - Process medium	3*	0.67	7.42	20.49	6.64	8.34	-	56.0	90.7	148.0
	3†	0.22	12.13	37.91	13.49	13.42				
External leakage - Utility medium	1*	0.02	2.53	8.92	3.29	2.78	-	54.0	54.0	54.0
	1†	0.02	4.17	16.06	5.92	4.47				
Spurious stop	8*	11.17	22.36	36.68	7.87	22.25	4.3	1.0	22.1	96.0
	8†	17.63	35.59	58.64	12.65	35.79				
Vibration	3*	0.07	17.18	66.06	24.34	8.34	-	72.0	151.7	231.0
	3†	0.09	25.80	100.05	37.02	13.42				
Degraded	**51***	**47.42**	**176.59**	**372.82**	**103.08**	**141.84**	**26.1**	**2.0**	**44.3**	**210.0**
	51†	**77.24**	**276.56**	**576.35**	**157.81**	**228.15**				
Abnormal instrument reading	5*	4.85	13.15	24.76	6.22	13.91	9.0	6.0	21.4	65.0
	5†	6.40	21.23	43.11	11.56	22.37				
Erratic output	6*	0.15	36.12	136.17	50.23	16.69	-	8.0	12.3	24.0
	6†	0.21	54.25	207.98	76.61	26.84				
External leakage - Process medium	10*	0.02	20.89	86.60	32.93	27.81	-	20.0	53.9	100.0
	10†	0.02	36.35	154.26	59.41	44.73				
External leakage - Utility medium	9*	8.27	26.94	54.34	14.50	25.03	4.0	2.0	29.0	88.0
	9†	12.79	43.68	89.61	24.24	40.26				
Internal leakage	2*	0.03	10.90	42.37	15.69	5.56	-	16.0	20.0	24.0
	2†	0.05	16.38	64.06	23.79	8.95				
Low output	1*	0.01	4.72	18.72	6.99	2.78	-	12.0	12.0	12.0
	1†	0.02	7.09	28.03	10.45	4.47				
Minor in-service problems	1*	0.02	2.53	8.92	3.29	2.78	-	18.0	18.0	18.0
	1†	0.02	4.17	16.06	5.92	4.47				
Other	4*	3.15	11.73	24.76	6.85	11.12	17.0	8.0	56.3	128.0
	4†	6.17	18.34	35.74	9.26	17.89				
Overheating	4*	3.50	11.02	21.95	5.80	11.12	48.0	38.0	69.8	104.0
	4†	5.69	17.37	34.20	8.95	17.89				
Vibration	9*	2.05	38.67	115.11	38.37	25.03	16.3	18.0	79.6	210.0
	9†	3.15	57.47	170.51	56.78	40.26				
Incipient	**91***	**150.29**	**247.90**	**365.30**	**65.92**	**253.08**	**13.3**	**1.0**	**17.6**	**72.0**
	91†	**301.67**	**398.33**	**506.06**	**62.31**	**407.09**				
Abnormal instrument reading	28*	55.97	78.51	104.17	14.72	77.87	6.1	1.0	11.9	30.0
	28†	89.52	125.76	167.06	23.67	125.26				
External leakage - Process medium	13*	0.01	26.62	113.78	43.96	36.15	52.0	20.0	41.8	72.0
	13†	0.02	46.64	202.84	78.85	58.16				

Comments

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Taxonomy no	Item
1.3.1.6	Machinery Pumps Centrifugal Crude oil handling

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	3	0.3596	0.2235	750

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	16*	13.38	43.62	88.03	23.49	44.50	5.0	2.0	12.9	55.0
	16†	32.41	69.26	117.31	26.26	71.58				
Minor in-service problems	22*	1.28	66.41	206.51	73.22	61.18	6.3	1.0	11.7	33.0
	22†	3.05	98.25	298.37	102.88	98.42				
Other	5*	1.29	13.08	35.48	11.40	13.91	4.5	4.0	14.5	36.0
	5†	2.62	20.80	53.39	16.65	22.37				
Parameter deviation	1*	0.00	2.80	11.56	4.39	2.78	2.0	3.0	3.0	3.0
	1†	0.01	4.28	16.99	6.34	4.47				
Unknown	4*	0.14	9.37	29.56	10.60	11.12	45.3	8.0	38.5	70.0
	4†	0.10	15.64	54.83	20.24	17.89				
Vibration	2*	0.12	5.61	17.33	6.11	5.56	4.5	4.0	11.0	18.0
	2†	0.79	8.64	23.75	7.68	8.95				
Unknown	**2***	**0.77**	**5.17**	**12.83**	**3.93**	**5.56**	-	**12.0**	**30.0**	**48.0**
	2†	**1.37**	**8.55**	**20.85**	**6.33**	**8.95**				
Other	1*	0.02	2.53	8.92	3.29	2.78	-	12.0	12.0	12.0
	1†	0.02	4.17	16.06	5.92	4.47				
Unknown	1*	0.02	2.53	8.92	3.29	2.78	-	48.0	48.0	48.0
	1†	0.02	4.17	16.06	5.92	4.47				
All modes	**161***	**382.61**	**456.58**	**535.97**	**46.67**	**447.76**	**14.9**	**1.0**	**31.1**	**231.0**
	161†	**549.77**	**735.77**	**944.04**	**120.23**	**720.23**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
1.3.1.7	Machinery Pumps Centrifugal Emergency power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0613	0.0612	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.03	7.61	29.21	10.76	0.00	-	-	-	-
	0†	0.03	8.11	31.15	11.47	0.00				

Comments

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Taxonomy no	Item
1.3.1.8	Machinery Pumps Centrifugal Flare, vent & blow-down

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1971	0.1460	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.25**	**5.07**	**24.08**	**5.07**	**5.07**	**25.0**	**25.0**	**25.0**	**25.0**
	1†	**0.34**	**6.85**	**32.50**	**6.85**	**6.85**				
External leakage - Process medium	1*	0.25	5.07	24.08	5.07	5.07	25.0	25.0	25.0	25.0
	1†	0.34	6.85	32.50	6.85	6.85				
All modes	**1***	**0.25**	**5.07**	**24.08**	**5.07**	**5.07**	**25.0**	**25.0**	**25.0**	**25.0**
	1†	**0.34**	**6.85**	**32.50**	**6.85**	**6.85**				

Comments

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Taxonomy no	Item
1.3.1.9	Machinery Pumps Centrifugal Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	3	0.7360	0.6181	155

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**28***	**0.02**	**43.80**	**190.94**	**74.37**	**38.04**	**11.4**	**1.0**	**22.1**	**73.0**
	28†	**0.01**	**48.01**	**214.94**	**85.06**	**45.30**				
Breakdown	5*	0.01	8.06	33.93	13.02	6.79	10.1	14.0	20.2	33.0
	5†	0.01	9.25	38.61	14.74	8.09				
External leakage - Process medium	2*	0.01	3.21	11.92	4.40	2.72	12.3	12.0	24.5	37.0
	2†	0.03	3.79	12.99	4.79	3.24				
External leakage - Utility medium	6*	0.01	9.66	41.13	15.87	8.15	15.8	2.0	31.5	73.0
	6†	0.01	11.00	46.76	18.02	9.71				
Fail to start on demand	2*	0.01	3.21	11.92	4.40	2.72	3.0	3.0	4.5	6.0
	2†	0.03	3.79	12.99	4.79	3.24				
Fail to stop on demand	1*	0.12	1.49	4.16	1.36	1.36	3.0	3.0	3.0	3.0
	1†	0.15	1.78	4.97	1.62	1.62				
Parameter deviation	1*	0.12	1.49	4.16	1.36	1.36	4.0	4.0	4.0	4.0
	1†	0.15	1.78	4.97	1.62	1.62				
Spurious stop	4*	0.43	5.82	16.61	5.46	5.43	3.0	1.0	3.3	5.0
	4†	0.91	6.93	17.67	5.49	6.47				
Structural deficiency	5*	0.01	8.06	33.93	13.02	6.79	14.9	10.0	29.8	51.0
	5†	0.01	9.25	38.61	14.74	8.09				
Vibration	2*	0.01	3.21	11.92	4.40	2.72	25.5	50.0	51.0	52.0
	2†	0.03	3.79	12.99	4.79	3.24				
Degraded	**37***	**0.01**	**58.82**	**262.92**	**103.97**	**50.27**	**4.8**	**2.0**	**9.1**	**45.0**
	37†	**0.00**	**64.08**	**296.16**	**119.32**	**59.86**				
External leakage - Process medium	5*	0.01	8.06	33.93	13.02	6.79	5.7	5.0	11.4	24.0
	5†	0.01	9.25	38.61	14.74	8.09				
External leakage - Utility medium	10*	0.01	16.02	69.90	27.25	13.59	4.2	2.0	8.3	39.0
	10†	0.00	17.92	79.17	31.11	16.18				
Noise	1*	0.12	1.49	4.16	1.36	1.36	3.0	6.0	6.0	6.0
	1†	0.15	1.78	4.97	1.62	1.62				
Parameter deviation	4*	0.01	6.46	26.74	10.16	5.43	2.3	2.0	3.0	6.0
	4†	0.01	7.47	30.35	11.45	6.47				
Structural deficiency	8*	0.01	12.84	55.55	21.56	10.87	8.2	3.0	14.2	45.0
	8†	0.01	14.47	63.09	24.57	12.94				
Vibration	9*	0.01	14.43	62.77	24.40	12.23	4.3	4.0	8.5	14.0
	9†	0.00	16.20	71.12	27.84	14.56				
Incipient	**16***	**0.19**	**25.47**	**86.95**	**32.01**	**21.74**	**4.5**	**1.0**	**18.0**	**179.0**
	16†	**0.38**	**30.99**	**99.82**	**36.18**	**25.88**				
Abnormal instrument reading	11*	0.02	16.89	68.72	25.96	14.95	3.7	1.0	4.8	21.0
	11†	0.03	19.06	77.69	29.37	17.80				
External leakage - Utility medium	1*	0.02	1.21	3.83	1.37	1.36	16.0	179.0	179.0	179.0
	1†	0.03	1.46	4.55	1.62	1.62				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.9	Machinery Pumps Centrifugal Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	3	0.7360	0.6181	155

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	2*	0.01	3.21	11.92	4.40	2.72	2.0	2.0	3.0	4.0
	2†	0.03	3.79	12.99	4.79	3.24				
Noise	1*	0.01	2.42	9.62	3.60	1.36	8.0	46.0	46.0	46.0
	1†	0.02	5.00	18.39	6.79	1.62				
Vibration	1*	0.12	1.49	4.16	1.36	1.36	4.0	4.0	4.0	4.0
	1†	0.15	1.78	4.97	1.62	1.62				
All modes	**81***	**0.06**	**127.76**	**549.81**	**212.98**	**110.06**	**7.3**	**1.0**	**16.0**	**179.0**
	81†	**0.04**	**141.62**	**622.44**	**243.83**	**131.04**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.10	Machinery Pumps Centrifugal Gas production

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.06	14.25	54.72	20.15	0.00	-	-	-	-
	0†	0.06	16.12	61.90	22.80	0.00				

Comments

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Taxonomy no	Item
1.3.1.11	Machinery Pumps Centrifugal Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
22	4	0.1927	0.0723	2574

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.00**	**4.75**	**20.83**	**8.15**	**5.19**	-	**40.0**	**40.0**	**40.0**
	1†	**0.08**	**12.75**	**44.21**	**16.31**	**13.83**				
Noise	1*	0.00	4.75	20.83	8.15	5.19	-	40.0	40.0	40.0
	1†	0.08	12.75	44.21	16.31	13.83				
Unknown	**1***	**0.00**	**5.03**	**23.46**	**9.51**	**5.19**	-	**29.0**	**29.0**	**29.0**
	1†	**0.05**	**13.33**	**51.51**	**19.03**	**13.83**				
External leakage - Utility medium	1*	0.00	5.03	23.46	9.51	5.19	-	29.0	29.0	29.0
	1†	0.05	13.33	51.51	19.03	13.83				
All modes	**2***	**0.34**	**9.89**	**29.94**	**10.26**	**10.38**	-	**29.0**	**34.5**	**40.0**
	2†	**3.72**	**26.46**	**66.49**	**20.52**	**27.67**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.12	Machinery Pumps Centrifugal Heating medium

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
13	5	0.3522	0.2933	12

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**3.19**	**19.73**	**48.01**	**14.55**	**19.87**	**11.8**	**2.0**	**23.3**	**54.0**
	7†	**3.62**	**24.45**	**60.76**	**18.64**	**23.87**				
External leakage - Process medium	3*	0.11	9.00	28.96	10.49	8.52	15.5	25.0	31.0	34.0
	3†	0.78	10.68	30.53	10.04	10.23				
External leakage - Utility medium	2*	0.00	5.51	23.16	8.87	5.68	15.3	7.0	30.5	54.0
	2†	0.38	7.29	21.73	7.25	6.82				
Fail to start on demand	1*	0.21	3.00	8.61	2.84	2.84	2.0	2.0	2.0	2.0
	1†	0.00	3.72	17.76	7.30	3.41				
Spurious stop	1*	0.01	2.45	8.64	3.19	2.84	3.5	7.0	7.0	7.0
	1†	0.04	2.98	9.47	3.41	3.41				
Degraded	**7***	**0.00**	**12.73**	**56.47**	**22.25**	**19.87**	**6.6**	**4.0**	**12.4**	**31.0**
	7†	**0.06**	**15.53**	**59.58**	**21.94**	**23.87**				
Structural deficiency	4*	0.24	8.83	26.96	9.38	11.36	9.8	5.0	18.3	31.0
	4†	3.32	11.92	24.88	6.82	13.64				
Vibration	3*	1.64	7.55	17.00	4.92	8.52	2.3	4.0	4.7	5.0
	3†	0.05	7.68	26.84	9.91	10.23				
Incipient	**20***	**0.43**	**42.08**	**137.73**	**50.22**	**56.78**	**7.6**	**1.0**	**12.8**	**70.0**
	20†	**1.81**	**54.95**	**166.49**	**57.18**	**68.20**				
Abnormal instrument reading	15*	0.00	26.79	120.88	48.00	42.59	4.9	1.0	7.1	39.0
	15†	0.06	33.15	133.55	50.21	51.15				
External leakage - Utility medium	2*	0.84	6.37	16.22	5.04	5.68	30.5	52.0	61.0	70.0
	2†	0.16	9.74	30.61	10.94	6.82				
Minor in-service problems	2*	0.02	4.47	17.26	6.38	5.68	1.0	1.0	1.0	1.0
	2†	0.05	5.48	18.07	6.60	6.82				
Noise	1*	0.01	3.35	13.06	4.84	2.84	-	-	-	-
	1†	0.00	6.53	29.14	11.51	3.41				
All modes	**34***	**1.38**	**72.21**	**224.64**	**79.68**	**96.53**	**8.3**	**1.0**	**15.0**	**70.0**
	34†	**7.20**	**92.14**	**260.69**	**85.40**	**115.94**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.13	Machinery Pumps Centrifugal Materials handling

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0919	0.0919	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	5.19	19.92	7.34	0.00	-	-	-	-
	0†	0.02	5.42	20.81	7.66	0.00				

Comments

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Taxonomy no	Item
1.3.1.14	Machinery Pumps Centrifugal Oil export

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	6	0.6575	0.5886	1430

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**84***	**4.19**	**183.60**	**565.36**	**198.57**	**127.75**	**53.3**	**1.0**	**65.2**	**734.0**
	84†	**6.06**	**204.98**	**623.64**	**215.67**	**142.72**				
Breakdown	3*	0.00	5.08	24.27	9.97	4.56	34.7	3.0	68.3	132.0
	3†	0.00	6.17	29.68	12.23	5.10				
External leakage - Process medium	8*	0.06	23.59	93.53	34.90	12.17	21.7	2.0	37.4	155.0
	8†	0.09	30.54	118.96	44.10	13.59				
External leakage - Utility medium	10*	0.00	16.28	85.19	38.27	15.21	17.8	3.0	35.6	90.0
	10†	0.00	19.98	103.81	46.06	16.99				
Fail to start on demand	5*	0.37	5.70	16.57	5.48	7.60	38.4	4.0	38.4	96.0
	5†	0.96	6.72	16.81	5.17	8.50				
Fail to stop on demand	1*	0.00	2.41	11.13	4.48	1.52	4.0	4.0	4.0	4.0
	1†	0.00	2.60	11.70	4.65	1.70				
Internal leakage	1*	0.02	1.32	4.22	1.52	1.52	188.0	188.0	188.0	188.0
	1†	0.02	1.47	4.70	1.70	1.70				
Low output	32*	0.01	100.62	467.76	189.31	48.67	44.0	3.0	49.2	508.0
	32†	0.00	103.56	495.72	203.97	54.37				
Noise	1*	0.00	2.53	11.75	4.76	1.52	-	-	-	-
	1†	0.00	3.33	15.55	6.31	1.70				
Other	1*	0.00	2.41	11.13	4.48	1.52	397.0	734.0	734.0	734.0
	1†	0.00	2.60	11.70	4.65	1.70				
Parameter deviation	1*	0.12	1.62	4.62	1.52	1.52	4.5	9.0	9.0	9.0
	1†	0.09	1.87	5.61	1.88	1.70				
Spurious stop	16*	2.67	19.03	47.81	14.75	24.33	103.3	1.0	105.5	714.0
	16†	3.65	21.89	52.85	15.94	27.19				
Structural deficiency	1*	0.12	1.62	4.62	1.52	1.52	14.0	28.0	28.0	28.0
	1†	0.09	1.87	5.61	1.88	1.70				
Vibration	4*	1.90	6.34	12.90	3.47	6.08	14.4	8.0	21.8	31.0
	4†	1.69	7.28	16.09	4.59	6.80				
Degraded	**82***	**6.37**	**113.74**	**336.65**	**112.02**	**124.71**	**45.2**	**1.0**	**51.3**	**304.0**
	82†	**5.77**	**135.44**	**407.14**	**137.47**	**139.32**				
Abnormal instrument reading	2*	0.05	4.23	13.61	4.93	3.04	3.0	2.0	3.5	5.0
	2†	0.06	5.03	16.32	5.93	3.40				
External leakage - Process medium	3*	0.00	6.84	33.03	13.64	4.56	31.7	42.0	63.8	106.0
	3†	0.00	9.12	43.11	17.63	5.10				
External leakage - Utility medium	37*	0.65	38.27	120.02	42.84	56.27	75.3	1.0	81.4	210.0
	37†	1.61	44.59	134.69	45.98	62.87				
High output	1*	0.02	1.32	4.22	1.52	1.52	2.0	2.0	2.0	2.0
	1†	0.02	1.47	4.70	1.70	1.70				
Internal leakage	3*	0.00	4.18	19.25	7.74	4.56	130.0	20.0	135.3	304.0
	3†	0.00	4.59	20.28	7.96	5.10				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.14	Machinery Pumps Centrifugal Oil export

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	6	0.6575	0.5886	1430

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.00	1.98	8.38	3.22	1.52	5.5	11.0	11.0	11.0
	1†	0.00	2.59	11.66	4.63	1.70				
Other	1*	0.02	1.32	4.22	1.52	1.52	2.0	2.0	2.0	2.0
	1†	0.02	1.47	4.70	1.70	1.70				
Overheating	1*	0.02	1.32	4.22	1.52	1.52	64.0	64.0	64.0	64.0
	1†	0.02	1.47	4.70	1.70	1.70				
Parameter deviation	14*	0.00	22.63	119.54	54.38	21.29	2.8	1.0	3.0	6.0
	14†	0.00	27.81	145.50	65.34	23.79				
Structural deficiency	9*	0.00	14.69	76.62	34.24	13.69	12.9	5.0	25.3	70.0
	9†	0.00	18.02	93.41	41.24	15.29				
Vibration	10*	0.13	19.09	65.67	24.20	15.21	16.1	1.0	19.0	96.0
	10†	0.14	22.00	76.74	28.32	16.99				
Incipient	**170***	**50.54**	**254.48**	**587.55**	**172.56**	**258.54**	**15.9**	**1.0**	**17.6**	**172.0**
	170†	**52.56**	**307.91**	**738.48**	**221.75**	**288.84**				
Abnormal instrument reading	81*	20.53	129.64	316.99	96.36	123.19	5.4	1.0	6.7	73.0
	81†	21.16	156.40	396.12	122.72	137.62				
Erratic output	1*	0.00	1.98	8.38	3.22	1.52	2.0	4.0	4.0	4.0
	1†	0.00	2.59	11.66	4.63	1.70				
External leakage - Utility medium	34*	0.00	28.33	135.12	55.51	51.71	42.0	1.0	43.5	172.0
	34†	0.00	32.19	147.83	59.23	57.77				
Internal leakage	3*	0.02	3.36	12.05	4.45	4.56	106.7	70.0	112.7	172.0
	3†	0.03	3.79	12.86	4.73	5.10				
Minor in-service problems	40*	2.18	74.63	227.15	78.61	60.83	7.5	1.0	9.6	50.0
	40†	2.31	92.65	284.03	99.25	67.96				
Other	6*	0.72	9.69	27.65	9.08	9.13	6.9	1.0	7.0	18.0
	6†	0.44	11.70	35.31	12.03	10.19				
Overheating	1*	0.02	1.32	4.22	1.52	1.52	52.0	64.0	64.0	64.0
	1†	0.02	1.47	4.70	1.70	1.70				
Structural deficiency	2*	0.00	3.42	14.94	5.82	3.04	5.3	4.0	8.5	13.0
	2†	0.00	4.12	18.47	7.31	3.40				
Vibration	2*	0.14	3.73	11.25	3.83	3.04	3.5	2.0	6.0	10.0
	2†	0.24	4.23	12.49	4.15	3.40				
Unknown	**1***	**0.12**	**1.62**	**4.62**	**1.52**	**1.52**	-	-	-	-
	1†	**0.09**	**1.87**	**5.61**	**1.88**	**1.70**				
Unknown	1*	0.12	1.62	4.62	1.52	1.52	-	-	-	-
	1†	0.09	1.87	5.61	1.88	1.70				
All modes	**337***	**103.86**	**551.43**	**1290.20**	**381.77**	**512.53**	**32.7**	**1.0**	**38.1**	**734.0**
	337†	**113.97**	**649.67**	**1546.45**	**461.99**	**572.59**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.15	Machinery Pumps Centrifugal Oil processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.2037	0.1302	85

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**15***	**0.34**	**75.95**	**282.27**	**104.22**	**73.62**	**14.6**	**2.0**	**14.9**	**80.0**
	15†	**0.55**	**98.46**	**351.20**	**129.75**	**115.23**				
Breakdown	1*	0.27	4.96	14.74	4.91	4.91	-	-	-	-
	1†	0.05	7.18	24.72	9.11	7.68				
External leakage - Process medium	10*	0.25	50.58	184.90	68.31	49.08	11.2	2.0	11.2	20.0
	10†	0.45	66.25	228.19	84.11	76.82				
Fail to start on demand	1*	0.27	4.96	14.74	4.91	4.91	6.0	6.0	6.0	6.0
	1†	0.05	7.18	24.72	9.11	7.68				
Spurious stop	2*	0.31	9.99	30.35	10.46	9.82	3.5	3.0	3.5	4.0
	2†	2.28	14.56	35.69	10.86	15.36				
Vibration	1*	0.27	4.96	14.74	4.91	4.91	76.5	80.0	80.0	80.0
	1†	0.05	7.18	24.72	9.11	7.68				
Degraded	**14***	**13.79**	**67.80**	**155.57**	**45.52**	**68.72**	**6.2**	**3.0**	**48.6**	**167.0**
	14†	**9.46**	**122.03**	**345.75**	**113.32**	**107.55**				
External leakage - Utility medium	11*	22.62	53.63	95.34	22.57	53.99	6.2	3.0	55.8	167.0
	11†	13.55	93.14	232.30	71.41	84.50				
Internal leakage	1*	0.02	4.83	18.22	6.72	4.91	-	56.0	56.0	56.0
	1†	0.64	8.28	23.44	7.68	7.68				
Other	1*	0.02	4.83	18.22	6.72	4.91	-	4.0	4.0	4.0
	1†	0.64	8.28	23.44	7.68	7.68				
Parameter deviation	1*	0.02	4.83	18.22	6.72	4.91	-	6.0	6.0	6.0
	1†	0.64	8.28	23.44	7.68	7.68				
Incipient	**18***	**24.22**	**89.39**	**188.13**	**51.89**	**88.35**	**7.9**	**1.0**	**8.6**	**36.0**
	18†	**87.19**	**136.01**	**193.66**	**32.59**	**138.27**				
Abnormal instrument reading	5*	5.81	24.80	54.62	15.55	24.54	1.8	1.0	2.2	4.0
	5†	8.82	36.96	80.99	22.99	38.41				
External leakage - Process medium	2*	0.31	9.99	30.35	10.46	9.82	21.0	6.0	21.0	36.0
	2†	2.28	14.56	35.69	10.86	15.36				
External leakage - Utility medium	3*	4.07	14.78	30.95	8.50	14.72	23.5	12.0	19.7	24.0
	3†	6.15	22.83	48.16	13.31	23.05				
Minor in-service problems	8*	17.58	39.41	68.29	15.71	39.27	1.4	1.0	5.4	30.0
	8†	30.37	61.23	100.80	21.73	61.46				
All modes	**47***	**91.36**	**232.89**	**427.22**	**104.56**	**230.69**	**10.7**	**1.0**	**22.9**	**167.0**
	47†	**254.18**	**357.03**	**474.20**	**67.17**	**361.05**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.1.16	Machinery Pumps Centrifugal Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	1	0.1987	0.1467	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**90***	**377.42**	**453.01**	**539.78**	**453.01**	**453.01**	**12.1**	**2.0**	**23.9**	**66.0**
	90†	**511.23**	**613.61**	**731.14**	**613.61**	**613.61**				
Breakdown	22*	74.96	110.74	158.12	110.74	110.74	15.4	18.0	30.9	60.0
	22†	101.54	149.99	214.17	149.99	149.99				
External leakage - Process medium	22*	74.96	110.74	158.12	110.74	110.74	9.1	3.0	17.8	38.0
	22†	101.54	149.99	214.17	149.99	149.99				
External leakage - Utility medium	19*	62.62	95.64	140.32	95.64	95.64	11.4	3.0	22.8	49.0
	19†	84.82	129.54	190.07	129.54	129.54				
Fail to start on demand	1*	0.25	5.03	23.88	5.03	5.03	7.5	15.0	15.0	15.0
	1†	0.34	6.82	32.35	6.82	6.82				
Low output	4*	6.87	20.13	46.08	20.13	20.13	14.0	15.0	28.0	45.0
	4†	9.31	27.27	62.42	27.27	27.27				
Overheating	1*	0.25	5.03	23.88	5.03	5.03	22.5	45.0	45.0	45.0
	1†	0.34	6.82	32.35	6.82	6.82				
Parameter deviation	1*	0.25	5.03	23.88	5.03	5.03	7.5	15.0	15.0	15.0
	1†	0.34	6.82	32.35	6.82	6.82				
Spurious stop	7*	16.53	35.23	66.19	35.23	35.23	12.5	2.0	23.1	66.0
	7†	22.40	47.73	89.66	47.73	47.73				
Structural deficiency	11*	31.06	55.37	91.66	55.37	55.37	11.6	8.0	23.3	36.0
	11†	42.07	75.00	124.15	75.00	75.00				
Vibration	2*	1.79	10.07	31.69	10.07	10.07	-	-	-	-
	2†	2.42	13.64	42.92	13.64	13.64				
Degraded	**84***	**349.89**	**422.81**	**506.93**	**422.81**	**422.81**	**5.8**	**1.0**	**10.6**	**75.0**
	84†	**473.93**	**572.70**	**686.64**	**572.70**	**572.70**				
External leakage - Process medium	15*	46.53	75.50	116.25	75.50	75.50	7.0	2.0	12.4	40.0
	15†	63.03	102.27	157.46	102.27	102.27				
External leakage - Utility medium	27*	95.92	135.90	187.41	135.90	135.90	4.1	1.0	7.7	24.0
	27†	129.93	184.08	253.85	184.08	184.08				
Low output	5*	9.92	25.17	52.93	25.17	25.17	2.5	3.0	4.0	5.0
	5†	13.43	34.09	71.69	34.09	34.09				
Noise	2*	1.79	10.07	31.69	10.07	10.07	25.0	25.0	50.0	75.0
	2†	2.42	13.64	42.92	13.64	13.64				
Parameter deviation	7*	16.53	35.23	66.19	35.23	35.23	3.3	2.0	3.8	7.0
	7†	22.40	47.73	89.66	47.73	47.73				
Structural deficiency	21*	70.82	105.70	152.21	105.70	105.70	5.8	1.0	10.7	29.0
	21†	95.93	143.18	206.17	143.18	143.18				
Vibration	7*	16.53	35.23	66.19	35.23	35.23	10.2	18.0	20.3	22.0
	7†	22.40	47.73	89.66	47.73	47.73				
Incipient	**53***	**209.49**	**266.77**	**335.37**	**266.77**	**266.77**	**2.3**	**1.0**	**2.8**	**10.0**
	53†	**283.76**	**361.35**	**454.27**	**361.35**	**361.35**				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.16	Machinery Pumps Centrifugal Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	1	0.1987	0.1467	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Abnormal instrument reading	39*	147.61	196.30	256.40	196.30	196.30	2.2	1.0	2.3	6.0
	39†	199.94	265.90	347.30	265.90	265.90				
Minor in-service problems	14*	42.59	70.47	110.15	70.47	70.47	2.7	1.0	4.2	10.0
	14†	57.70	95.45	149.20	95.45	95.45				
Unknown	**1***	**0.25**	**5.03**	**23.88**	**5.03**	**5.03**	**1.5**	**3.0**	**3.0**	**3.0**
	1†	**0.34**	**6.82**	**32.35**	**6.82**	**6.82**				
Unknown	1*	0.25	5.03	23.88	5.03	5.03	1.5	3.0	3.0	3.0
	1†	0.34	6.82	32.35	6.82	6.82				
All modes	**228***	**1025.52**	**1147.62**	**1280.75**	**1147.62**	**1147.62**	**7.7**	**1.0**	**14.6**	**75.0**
	228†	**1389.10**	**1554.48**	**1734.80**	**1554.48**	**1554.48**				

Comments

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Taxonomy no	Item
1.3.1.17	Machinery Pumps Centrifugal Sea water lift

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	7	0.9527	0.8433	976

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**39***	**16.33**	**47.12**	**90.83**	**23.31**	**40.94**	**159.8**	**1.0**	**199.7**	**766.0**
	39†	**17.05**	**56.17**	**113.76**	**30.45**	**46.25**				
Breakdown	2*	0.27	2.35	6.17	1.94	2.10	-	766.0	766.0	766.0
	2†	0.23	2.78	7.81	2.55	2.37				
External leakage - Process medium	8*	0.22	10.01	30.84	10.84	8.40	88.9	7.0	105.5	444.0
	8†	0.13	12.01	39.23	14.29	9.49				
External leakage - Utility medium	2*	0.06	2.60	8.02	2.82	2.10	52.8	34.0	57.0	80.0
	2†	0.05	3.08	9.66	3.45	2.37				
Fail to start on demand	8*	0.60	7.91	22.49	7.38	8.40	230.3	2.0	196.7	510.0
	8†	0.35	9.25	27.90	9.49	9.49				
High output	1*	0.00	1.08	5.53	2.40	1.05	-	1.0	1.0	1.0
	1†	0.00	1.45	5.90	2.23	1.19				
Internal leakage	1*	0.00	1.08	5.53	2.40	1.05	-	36.0	36.0	36.0
	1†	0.00	1.45	5.90	2.23	1.19				
Low output	1*	0.00	1.14	5.97	2.69	1.05	57.5	115.0	115.0	115.0
	1†	0.00	1.28	6.63	2.91	1.19				
Other	4*	0.00	6.97	34.44	14.58	4.20	313.8	370.0	452.8	630.0
	4†	0.00	7.28	36.63	15.71	4.74				
Overheating	1*	0.00	1.08	5.53	2.40	1.05	-	3.0	3.0	3.0
	1†	0.00	1.45	5.90	2.23	1.19				
Spurious stop	8*	1.10	9.80	25.79	8.14	8.40	172.0	2.0	209.0	446.0
	8†	1.80	10.66	25.61	7.70	9.49				
Structural deficiency	1*	0.00	1.14	5.97	2.69	1.05	15.0	15.0	15.0	15.0
	1†	0.00	1.28	6.63	2.91	1.19				
Vibration	2*	0.00	2.16	8.87	3.37	2.10	-	250.0	285.0	320.0
	2†	0.00	3.22	15.61	6.46	2.37				
Degraded	**45***	**5.97**	**64.47**	**176.93**	**57.19**	**47.23**	**19.9**	**2.0**	**19.4**	**157.0**
	45†	**7.08**	**69.03**	**185.39**	**59.25**	**53.36**				
External leakage - Process medium	8*	1.26	11.11	29.14	9.19	8.40	7.8	2.0	8.3	20.0
	8†	1.75	12.01	29.95	9.20	9.49				
External leakage - Utility medium	13*	0.01	14.44	60.29	23.02	13.65	14.0	3.0	12.3	28.0
	13†	0.03	16.14	64.98	24.42	15.42				
Internal leakage	1*	0.00	1.25	5.09	1.92	1.05	2.0	2.0	2.0	2.0
	1†	0.00	1.62	7.26	2.88	1.19				
Low output	1*	0.01	0.91	3.06	1.12	1.05	144.0	144.0	144.0	144.0
	1†	0.01	1.03	3.28	1.19	1.19				
Other	9*	0.01	13.71	57.13	21.78	9.45	-	4.0	8.0	12.0
	9†	0.02	14.70	60.68	23.04	10.67				
Overheating	1*	0.00	1.21	4.58	1.69	1.05	-	-	-	-
	1†	0.04	1.30	3.94	1.36	1.19				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.17	Machinery Pumps Centrifugal Sea water lift

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	7	0.9527	0.8433	976

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Parameter deviation	9*	0.07	15.88	60.08	22.16	9.45	3.8	2.0	8.2	27.0
	9†	0.06	16.76	64.83	23.96	10.67				
Structural deficiency	3*	0.06	3.67	11.54	4.12	3.15	28.3	3.0	55.0	157.0
	3†	0.14	4.10	12.42	4.26	3.56				
Incipient	**55***	**5.40**	**71.30**	**202.78**	**66.56**	**57.73**	**14.6**	**1.0**	**12.9**	**144.0**
	55†	**6.97**	**78.20**	**216.24**	**70.14**	**65.22**				
Abnormal instrument reading	18*	3.89	21.84	51.77	15.42	18.89	22.5	1.0	21.3	144.0
	18†	4.52	24.60	57.91	17.19	21.35				
External leakage - Process medium	2*	0.00	2.69	12.87	5.30	2.10	-	-	-	-
	2†	0.00	2.85	13.32	5.41	2.37				
External leakage - Utility medium	11*	0.53	10.58	31.69	10.58	11.55	17.4	1.0	14.7	67.0
	11†	0.85	12.39	35.78	11.81	13.04				
Internal leakage	2*	0.00	2.81	13.57	5.61	2.10	2.0	2.0	5.0	8.0
	2†	0.00	3.64	17.75	7.41	2.37				
Minor in-service problems	18*	0.04	25.15	102.05	38.50	18.89	3.8	2.0	5.8	12.0
	18†	0.03	25.96	107.13	40.68	21.35				
Noise	1*	0.00	1.44	6.63	2.66	1.05	4.0	4.0	4.0	4.0
	1†	0.00	1.56	6.87	2.69	1.19				
Other	2*	0.27	2.35	6.17	1.94	2.10	-	-	-	-
	2†	0.23	2.78	7.81	2.55	2.37				
Structural deficiency	1*	0.00	2.69	12.86	5.29	1.05	-	10.0	10.0	10.0
	1†	0.00	2.79	13.48	5.57	1.19				
Unknown	**1***	**0.00**	**1.08**	**5.53**	**2.40**	**1.05**	**-**	**2.0**	**2.0**	**2.0**
	1†	**0.00**	**1.45**	**5.90**	**2.23**	**1.19**				
Unknown	1*	0.00	1.08	5.53	2.40	1.05	-	2.0	2.0	2.0
	1†	0.00	1.45	5.90	2.23	1.19				
All modes	**140***	**32.93**	**185.36**	**439.69**	**131.04**	**146.95**	**75.0**	**1.0**	**81.7**	**766.0**
	140†	**42.35**	**206.31**	**472.19**	**137.96**	**166.02**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $4.1 \cdot 10^{-3}$

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Taxonomy no	Item
1.3.1.18	Machinery Pumps Centrifugal Water fire fighting

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
108	37	7.2284	0.1834	1060

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**0.00**	**1.70**	**6.67**	**2.48**	**1.52**	**50.0**	**1.0**	**104.6**	**1025.0**
	11†	**0.00**	**96.22**	**466.82**	**193.58**	**59.98**				
Fail to start on demand	5*	0.00	0.74	3.49	1.42	0.69	3.6	1.0	12.8	29.0
	5†	0.00	31.38	172.43	83.57	27.27				
Low output	1*	0.00	0.25	1.17	1.14	0.14	1.5	3.0	3.0	3.0
	1†	0.00	25.80	137.19	90.97	5.45				
Overheating	1*	0.00	0.24	1.13	1.09	0.14	512.5	1025.0	1025.0	1025.0
	1†	0.00	23.67	124.17	86.13	5.45				
Spurious stop	4*	0.00	0.54	2.98	1.41	0.55	4.5	12.0	14.8	21.0
	4†	7.62	22.02	42.47	10.91	21.81				
Degraded	**35***	**0.00**	**8.77**	**45.70**	**20.38**	**4.84**	**18.8**	**2.0**	**40.7**	**798.0**
	35†	**0.35**	**833.68**	**3611.50**	**1402.13**	**190.86**				
External leakage - Process medium	1*	0.00	0.25	1.17	1.14	0.14	1.0	2.0	2.0	2.0
	1†	0.00	25.80	137.19	90.97	5.45				
External leakage - Utility medium	10*	0.00	3.38	18.76	9.62	1.38	7.1	2.0	14.2	30.0
	10†	0.06	372.70	1679.89	666.78	54.53				
Fail to stop on demand	2*	0.00	0.49	2.77	1.57	0.28	3.3	6.0	6.5	7.0
	2†	0.00	49.37	268.34	125.03	10.91				
Internal leakage	1*	0.00	0.24	1.13	1.09	0.14	2.5	5.0	5.0	5.0
	1†	0.00	23.67	124.17	86.13	5.45				
Low output	15*	1.28	2.07	3.03	0.54	2.08	4.2	5.0	14.9	26.0
	15†	20.95	82.44	177.21	49.66	81.80				
Minor in-service problems	1*	0.00	0.24	1.13	1.09	0.14	13.0	26.0	26.0	26.0
	1†	0.00	23.67	124.17	86.13	5.45				
Other	3*	0.00	0.93	4.85	3.87	0.42	8.8	5.0	17.5	30.0
	3†	0.00	98.94	544.74	270.97	16.36				
Overheating	1*	0.00	0.24	1.13	1.09	0.14	56.0	112.0	112.0	112.0
	1†	0.00	23.67	124.17	86.13	5.45				
Structural deficiency	1*	0.00	0.24	1.13	1.09	0.14	399.0	798.0	798.0	798.0
	1†	0.00	23.67	124.17	86.13	5.45				
Incipient	**87***	**0.00**	**32.35**	**177.30**	**83.00**	**12.04**	**8.3**	**1.0**	**16.5**	**697.0**
	87†	**8.16**	**3796.79**	**15150.67**	**5665.90**	**474.42**				
Abnormal instrument reading	40*	0.00	14.67	80.64	38.51	5.53	3.8	1.0	7.6	57.0
	40†	2.22	1700.03	6962.93	2636.94	218.13				
Erratic output	1*	0.00	0.25	1.17	1.14	0.14	1.0	2.0	2.0	2.0
	1†	0.00	25.80	137.19	90.97	5.45				
External leakage - Utility medium	6*	0.00	2.13	11.01	8.27	0.83	2.8	1.0	5.5	12.0
	6†	0.00	240.50	1268.10	575.48	32.72				
Minor in-service problems	37*	0.00	13.47	74.05	35.07	5.12	5.0	1.0	9.8	42.0
	37†	2.21	1555.54	6340.65	2396.72	201.77				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.18	Machinery Pumps Centrifugal Water fire fighting

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
108	37	7.2284	0.1834	1060

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Other	3*	0.00	0.86	4.97	2.75	0.42	120.0	4.0	239.0	697.0
	3†	0.00	104.14	514.53	217.76	16.36				
All modes	**133***	**0.00**	**43.63**	**230.15**	**104.49**	**18.40**	**14.6**	**1.0**	**30.2**	**1025.0**
	133†	**12.76**	**4869.01**	**19166.04**	**7134.91**	**725.27**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $9.4 \cdot 10^{-4}$

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Taxonomy no
1.3.1.19

Item
Machinery
Pumps
Centrifugal
Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
44	8	1.3310	1.1506	2310

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**147***	**0.80**	**122.12**	**423.59**	**156.24**	**110.44**	**36.6**	**1.0**	**50.6**	**896.0**
	147†	**0.87**	**140.33**	**491.00**	**181.24**	**127.76**				
Breakdown	1*	0.01	0.80	2.71	1.00	0.75	4.0	8.0	8.0	8.0
	1†	0.01	0.93	3.22	1.19	0.87				
Erratic output	2*	0.22	1.44	3.53	1.07	1.50	19.8	11.0	39.5	68.0
	2†	0.27	1.66	4.05	1.23	1.74				
External leakage - Process medium	15*	0.00	9.22	40.63	15.94	11.27	39.0	2.0	52.0	286.0
	15†	0.00	11.47	52.42	20.91	13.04				
External leakage - Utility medium	5*	0.00	2.86	14.80	6.50	3.76	15.1	6.0	30.4	49.0
	5†	0.00	3.27	16.94	7.45	4.35				
Fail to start on demand	14*	0.15	11.74	37.60	13.59	10.52	57.2	2.0	63.4	551.0
	14†	0.18	13.76	44.09	15.94	12.17				
Low output	2*	0.00	1.78	8.69	3.65	1.50	1.5	3.0	3.0	3.0
	2†	0.00	2.05	10.10	4.26	1.74				
Noise	2*	0.01	1.37	4.87	1.80	1.50	25.0	16.0	40.0	64.0
	2†	0.01	1.61	6.18	2.28	1.74				
Other	3*	0.00	1.91	8.06	3.10	2.25	1.0	2.0	2.0	2.0
	3†	0.00	2.19	9.22	3.54	2.61				
Overheating	1*	0.01	0.80	2.71	1.00	0.75	14.5	29.0	29.0	29.0
	1†	0.01	0.93	3.22	1.19	0.87				
Parameter deviation	13*	0.00	9.86	44.57	17.71	9.77	13.0	1.0	24.5	88.0
	13†	0.00	11.38	51.70	20.58	11.30				
Spurious stop	63*	0.27	61.24	228.86	84.47	47.33	23.6	1.0	29.9	622.0
	63†	0.27	68.60	263.13	96.92	54.76				
Structural deficiency	9*	0.00	8.16	44.00	20.40	6.76	46.1	7.0	92.2	211.0
	9†	0.00	9.47	51.15	23.73	7.82				
Vibration	17*	1.99	13.94	34.90	10.75	12.77	108.6	6.0	133.3	896.0
	17†	2.37	16.07	39.97	12.27	14.78				
Degraded	**144***	**4.86**	**120.63**	**363.17**	**123.09**	**108.19**	**23.8**	**0.5**	**31.2**	**737.0**
	144†	**4.97**	**140.30**	**424.03**	**144.95**	**125.16**				
Abnormal instrument reading	2*	0.00	2.17	10.88	4.66	1.50	15.0	10.0	15.0	20.0
	2†	0.00	2.28	11.45	4.90	1.74				
Erratic output	3*	0.00	2.04	8.10	3.02	2.25	20.3	2.0	27.7	65.0
	3†	0.00	2.40	9.81	3.71	2.61				
External leakage - Process medium	12*	3.65	9.48	17.53	4.33	9.02	32.5	4.0	53.4	278.0
	12†	3.77	11.22	21.90	5.68	10.43				
External leakage - Utility medium	42*	4.44	32.31	81.56	25.23	31.56	17.2	1.0	25.7	219.0
	42†	4.68	37.36	96.04	29.96	36.50				
Fail to stop on demand	1*	0.00	0.94	4.35	1.76	0.75	5.0	10.0	10.0	10.0
	1†	0.00	1.04	4.69	1.86	0.87				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.19	Machinery Pumps Centrifugal Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
44	8	1.3310	1.1506	2310

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Internal leakage	3*	0.68	2.33	4.80	1.30	2.25	20.0	4.0	35.7	93.0
	3†	0.00	3.03	12.28	4.63	2.61				
Low output	7*	0.04	4.80	16.39	6.03	5.26	1.8	0.5	1.9	4.0
	7†	0.02	5.76	22.24	8.22	6.08				
Noise	2*	0.00	5.49	24.12	9.45	1.50	-	-	-	-
	2†	0.00	5.53	25.22	10.05	1.74				
Other	20*	0.07	14.59	53.03	19.59	15.03	23.3	1.0	22.3	165.0
	20†	0.06	17.86	69.33	25.66	17.38				
Overheating	1*	0.00	0.94	4.36	1.76	0.75	7.0	7.0	7.0	7.0
	1†	0.00	1.01	4.37	1.70	0.87				
Parameter deviation	34*	0.00	30.30	165.32	77.21	25.54	5.8	1.0	10.2	67.0
	34†	0.00	35.44	192.70	89.80	29.55				
Structural deficiency	12*	0.00	9.70	47.28	19.74	9.02	52.9	3.0	22.3	115.0
	12†	0.00	11.21	54.83	22.97	10.43				
Vibration	5*	0.01	5.09	20.70	7.82	3.76	164.8	26.0	332.8	737.0
	5†	0.01	5.69	23.10	8.72	4.35				
Incipient	**367***	**84.43**	**298.43**	**619.31**	**169.05**	**275.73**	**9.6**	**0.5**	**15.7**	**213.5**
	367†	**94.78**	**339.42**	**707.38**	**193.69**	**318.98**				
Abnormal instrument reading	176*	14.21	151.20	413.80	133.55	132.23	6.4	0.5	8.3	87.0
	176†	16.17	170.57	465.98	150.26	152.97				
Erratic output	3*	0.61	2.24	4.72	1.30	2.25	5.8	3.0	11.7	16.0
	3†	0.69	2.58	5.45	1.51	2.61				
External leakage - Process medium	22*	0.03	16.30	65.65	24.68	16.53	5.5	0.5	17.3	206.0
	22†	0.02	19.48	79.92	30.29	19.12				
External leakage - Utility medium	34*	0.73	23.43	71.14	24.53	25.54	10.1	1.0	17.0	136.0
	34†	1.46	25.74	76.09	25.31	29.55				
Internal leakage	4*	0.04	2.92	9.36	3.39	3.01	4.6	0.5	5.6	8.0
	4†	0.08	3.34	10.27	3.60	3.48				
Low output	1*	0.00	0.69	3.39	1.44	0.75	2.0	2.0	2.0	2.0
	1†	0.00	0.83	4.34	1.94	0.87				
Minor in-service problems	61*	0.74	60.53	194.85	70.59	45.83	7.7	0.5	12.5	111.0
	61†	0.75	68.79	223.97	81.52	53.02				
Noise	4*	0.23	2.77	7.75	2.52	3.01	8.2	0.5	10.2	18.0
	4†	0.03	3.23	10.81	3.96	3.48				
Other	28*	0.10	18.48	65.75	24.29	21.04	21.8	1.0	39.0	192.0
	28†	0.13	21.54	75.93	28.04	24.34				
Overheating	3*	0.02	3.09	11.28	4.17	2.25	19.5	3.0	19.5	36.0
	3†	0.02	3.21	11.09	4.09	2.61				
Parameter deviation	20*	0.00	11.06	50.65	20.24	15.03	9.7	2.0	15.9	81.0
	20†	0.00	13.70	64.18	26.11	17.38				

Comments

(cont.)

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Taxonomy no	Item
1.3.1.19	Machinery Pumps Centrifugal Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
44	8	1.3310	1.1506	2310

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	8*	0.20	5.79	17.51	5.99	6.01	52.6	1.0	92.8	213.5
	8†	0.24	6.63	20.03	6.84	6.95				
Vibration	3*	0.04	2.13	6.60	2.33	2.25	24.5	1.0	59.0	96.0
	3†	0.02	2.44	8.00	2.92	2.61				
Unknown	**1***	**0.00**	**0.94**	**4.35**	**1.76**	**0.75**	**12.0**	**24.0**	**24.0**	**24.0**
	1†	**0.00**	**1.04**	**4.69**	**1.86**	**0.87**				
Unknown	1*	0.00	0.94	4.35	1.76	0.75	12.0	24.0	24.0	24.0
	1†	0.00	1.04	4.69	1.86	0.87				
All modes	**659***	**62.60**	**541.32**	**1412.51**	**443.69**	**495.12**	**19.0**	**0.5**	**27.0**	**896.0**
	659†	**69.21**	**619.88**	**1632.05**	**515.57**	**572.77**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.0 \cdot 10^{-3}$

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Taxonomy no	Item
1.3.1.20	Machinery Pumps Centrifugal Well servicing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0919	0.0919	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	5.19	19.92	7.34	0.00	-	-	-	-
	0†	0.02	5.42	20.81	7.66	0.00				

Comments

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Taxonomy no	Item
1.3.2	Machinery Pumps Reciprocating

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
98	9	5.0327	2.8960	860

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**46***	**4.67**	**40.61**	**106.11**	**33.36**	**9.14**	**8.3**	**2.0**	**13.9**	**50.0**
	46†	**11.38**	**67.24**	**161.62**	**48.60**	**15.88**				
Breakdown	5*	0.05	5.00	16.33	5.95	0.99	12.0	4.0	26.0	50.0
	5†	0.15	7.49	23.23	8.22	1.73				
External leakage - Process medium	9*	0.39	6.24	18.24	6.04	1.79	4.2	2.0	6.1	16.0
	9†	1.10	10.50	28.08	8.95	3.11				
Fail to start on demand	7*	0.39	10.22	30.79	10.47	1.39	16.5	2.0	17.4	48.0
	7†	0.88	15.05	44.35	14.74	2.42				
Internal leakage	5*	0.00	2.78	11.47	4.35	0.99	3.0	3.0	6.0	10.0
	5†	0.05	7.60	26.17	9.65	1.73				
Low output	4*	0.04	1.85	5.74	2.04	0.79	6.3	3.0	10.8	19.0
	4†	0.03	3.54	12.11	4.46	1.38				
Noise	2*	0.00	2.10	9.40	3.71	0.40	20.0	40.0	40.0	40.0
	2†	0.00	3.46	14.38	5.47	0.69				
Parameter deviation	1*	0.01	1.99	7.79	2.89	0.20	-	26.0	26.0	26.0
	1†	0.01	2.86	10.80	3.98	0.35				
Spurious stop	10*	0.22	5.73	17.29	5.88	1.99	9.5	2.0	16.6	40.0
	10†	0.69	8.47	23.81	7.78	3.45				
Structural deficiency	2*	0.06	0.56	1.52	0.49	0.40	4.5	6.0	6.0	6.0
	2†	0.02	0.75	2.27	0.78	0.69				
Unknown	1*	0.00	0.17	0.55	0.20	0.20	-	-	-	-
	1†	0.00	0.30	0.96	0.35	0.35				
Degraded	**211***	**16.33**	**257.64**	**751.38**	**248.87**	**41.93**	**4.0**	**0.3**	**10.6**	**112.0**
	211†	**43.53**	**410.27**	**1093.53**	**348.00**	**72.86**				
Erratic output	13*	1.25	13.18	36.01	11.62	2.58	4.0	4.0	16.3	32.0
	13†	4.52	27.15	65.57	19.78	4.49				
External leakage - Process medium	103*	2.55	112.66	347.06	121.96	20.47	4.5	1.0	8.5	31.0
	103†	3.37	155.68	480.69	169.33	35.57				
External leakage - Utility medium	11*	0.90	15.72	46.41	15.43	2.19	-	4.0	11.0	18.0
	11†	3.84	36.64	97.94	31.22	3.80				
Internal leakage	42*	1.91	60.81	184.58	63.59	8.35	3.5	0.3	7.3	40.0
	42†	10.92	107.68	289.98	92.81	14.50				
Low output	6*	0.10	7.74	24.76	8.95	1.19	3.0	3.0	8.5	16.0
	6†	1.00	14.02	40.24	13.25	2.07				
Noise	10*	0.02	3.99	14.63	5.40	1.99	4.3	1.0	22.5	112.0
	10†	0.06	6.10	20.22	7.40	3.45				
Other	15*	0.53	20.99	64.28	22.43	2.98	-	3.0	23.5	61.0
	15†	0.94	29.48	89.43	30.78	5.18				
Parameter deviation	6*	0.11	14.32	48.64	17.89	1.19	-	3.0	11.8	24.0
	6†	0.14	19.74	67.58	24.89	2.07				

Comments

(cont.)

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Taxonomy no		Item
1.3.2		Machinery Pumps Reciprocating

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
98	9	5.0327	2.8960	860

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	5*	0.01	1.58	5.32	1.95	0.99	4.0	3.0	4.0	5.0
	5†	0.82	1.93	3.42	0.81	1.73				
Incipient	**172***	**8.36**	**113.08**	**322.79**	**106.11**	**34.18**	**3.2**	**1.0**	**11.6**	**169.0**
	172†	**13.34**	**160.65**	**449.98**	**146.79**	**59.39**				
Abnormal instrument reading	97*	0.82	45.19	141.03	50.15	19.27	3.6	2.0	13.7	169.0
	97†	1.27	64.86	201.48	71.37	33.49				
Erratic output	3*	0.01	3.67	14.33	5.32	0.60	-	24.0	25.0	26.0
	3†	0.06	7.28	24.69	9.08	1.04				
External leakage - Process medium	10*	0.06	3.30	10.35	3.69	1.99	1.0	1.0	4.8	9.0
	10†	0.44	4.90	13.55	4.39	3.45				
External leakage - Utility medium	17*	0.85	3.39	7.31	2.05	3.38	3.0	2.0	8.4	32.0
	17†	1.96	5.79	11.25	2.91	5.87				
Minor in-service problems	30*	1.53	44.70	135.27	46.34	5.96	2.2	2.0	5.5	14.0
	30†	1.96	61.42	186.29	64.11	10.36				
Noise	7*	0.26	1.46	3.46	1.03	1.39	3.0	6.0	9.0	12.0
	7†	0.02	2.49	8.69	3.21	2.42				
Other	5*	0.21	3.72	11.00	3.66	0.99	4.0	3.0	47.7	130.0
	5†	0.46	5.85	16.55	5.42	1.73				
Parameter deviation	1*	0.01	1.99	7.79	2.89	0.20	-	20.0	20.0	20.0
	1†	0.01	2.86	10.80	3.98	0.35				
Structural deficiency	1*	0.01	1.99	7.79	2.89	0.20	-	4.0	4.0	4.0
	1†	0.01	2.86	10.80	3.98	0.35				
Vibration	1*	0.00	0.57	2.48	0.96	0.20	-	-	-	-
	1†	0.00	0.73	2.65	0.98	0.35				
Unknown	**9***	**1.45**	**13.97**	**37.41**	**11.94**	**1.79**	**-**	**1.0**	**12.4**	**52.0**
	9†	**4.65**	**28.08**	**67.88**	**20.49**	**3.11**				
Noise	2*	0.02	4.42	15.95	5.89	0.40	-	6.0	29.0	52.0
	2†	0.04	6.24	22.11	8.17	0.69				
Other	2*	0.00	2.68	11.32	4.35	0.40	-	8.0	11.0	14.0
	2†	0.02	5.37	20.13	7.43	0.69				
Unknown	4*	0.01	4.62	18.57	6.98	0.79	-	1.0	1.3	2.0
	4†	0.21	13.26	41.71	14.92	1.38				
Vibration	1*	0.01	1.99	7.79	2.89	0.20	-	15.0	15.0	15.0
	1†	0.01	2.86	10.80	3.98	0.35				
All modes	**438***	**36.27**	**430.87**	**1203.92**	**392.32**	**87.03**	**4.6**	**0.3**	**11.3**	**169.0**
	438†	**80.35**	**672.63**	**1743.97**	**546.05**	**151.24**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $4.7 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Pumps - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00
Cylinder liner	0.00	0.23	0.08	0.46	0.00	0.00	0.00	0.08	0.23	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.00
Filter(s)	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gearbox/var.drive	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Instrument, flow	18.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.60	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.68	0.00
Piping	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Piston(s)	0.00	0.23	3.96	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Pulsation damper	0.00	0.00	1.37	0.23	0.68	0.00	0.00	1.03	0.00	0.23
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.00	9.67	3.20	0.00	0.00	0.00	0.53	0.23	0.34
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Subunit	0.00	0.23	0.23	0.00	0.00	0.23	0.00	0.23	0.23	0.00
Unknown	1.14	0.46	3.42	1.37	0.91	0.68	0.00	0.46	0.46	1.60
Valves	0.23	0.00	8.68	0.46	1.60	0.00	0.00	7.53	0.46	1.03
Total	22.15	1.14	27.85	6.39	3.65	1.60	0.00	10.73	2.28	4.79

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Pumps - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.46
Bearing	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Control unit	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Coupling to driven unit	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Coupling to driver	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	1.37
Cylinder liner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	1.75
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.57
Filter(s)	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.14
Gearbox/var.drive	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.26
Instrument, general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.23	0.00	1.14
Instrument, level	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.46
Instrument, pressure	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Oil	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	1.37
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26
Piping	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.64
Pulsation damper	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.23	0.00	0.00	0.68	0.00	0.00	0.00	0.00	14.88
Shaft	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	0.68
Subunit	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Unknown	0.00	2.28	0.23	2.74	0.91	0.00	1.14	0.23	0.46	18.49
Valves	0.00	0.91	0.91	0.46	0.00	0.00	0.00	0.34	0.00	22.60
Total	0.00	5.02	1.83	6.85	1.83	0.00	1.14	2.28	0.46	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Pumps - Reciprocating

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00
Breakage	0.68	0.46	1.83	0.23	0.46	0.23	0.00	0.23	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Combined causes	0.00	0.23	0.46	0.00	0.00	0.00	0.00	0.23	0.00	0.23
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
External influence - general	0.23	0.00	1.83	0.00	0.00	0.00	0.00	0.46	0.00	0.00
Fatigue	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.14	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	2.05	1.83	0.46	0.00	0.00	0.68	0.68	0.00
Looseness	0.00	0.00	0.46	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.23	0.23	0.00	0.00	0.68	0.00	0.00
Mechanical Failure - general	0.00	0.46	7.31	0.46	1.14	0.00	0.00	4.11	0.68	0.68
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00	0.00
No signal/indication/alarm	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	17.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Sticking	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.23	0.00	1.14
Unknown	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.68
Vibration	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	13.01	3.65	0.46	0.00	0.00	3.88	0.00	0.91
Total	22.15	1.14	27.85	6.39	3.65	1.60	0.00	10.73	2.28	4.79

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Pumps - Reciprocating

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Breakage	0.00	0.46	0.00	0.46	0.00	0.00	0.00	0.91	0.00	5.94
Clearance/ alignment failure	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	1.37
Combined causes	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Contamination	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23
Corrosion	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.68
Electrical failure - general	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.23	0.00	1.14
External influence - general	0.00	0.00	0.00	2.05	0.00	0.00	0.00	0.00	0.00	4.57
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Instrument failure - general	0.00	0.23	0.46	0.46	0.00	0.00	0.00	0.00	0.00	2.51
Leakage	0.00	0.23	0.23	0.23	0.00	0.00	0.00	0.00	0.00	6.39
Looseness	0.00	0.00	0.00	0.46	0.23	0.00	0.00	0.00	0.00	1.37
Material failure - general	0.00	0.00	0.00	0.23	0.68	0.00	0.00	0.00	0.00	2.05
Mechanical Failure - general	0.00	2.05	0.68	0.68	0.68	0.00	0.46	0.00	0.23	19.63
Misc. external influences	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.91
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.68
Out of adjustment	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.23	0.00	18.72
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Sticking	0.00	0.46	0.00	0.23	0.00	0.00	0.00	0.00	0.00	2.51
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	1.83
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Wear	0.00	0.91	0.00	0.91	0.00	0.00	0.00	0.46	0.00	24.20
Total	0.00	5.02	1.83	6.85	1.83	0.00	1.14	2.28	0.46	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.3.2.1	Machinery Pumps Reciprocating Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
35	3	1.1667	1.0942	759

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**20***	**8.74**	**78.88**	**208.08**	**65.81**	**17.14**	**4.6**	**2.0**	**11.8**	**50.0**
	20†	**13.58**	**105.34**	**269.32**	**83.81**	**18.28**				
Breakdown	2*	0.58	13.32	40.01	13.49	1.71	-	4.0	27.0	50.0
	2†	1.33	18.16	51.90	17.07	1.83				
External leakage - Process medium	4*	0.60	12.66	37.97	12.72	3.43	3.5	2.0	3.3	4.0
	4†	1.19	17.16	49.44	16.31	3.66				
Fail to start on demand	4*	1.63	21.61	61.47	20.18	3.43	-	2.0	7.0	16.0
	4†	2.82	29.18	79.43	25.56	3.66				
Low output	2*	0.06	2.00	6.08	2.10	1.71	9.5	15.0	17.0	19.0
	2†	0.05	2.26	7.01	2.48	1.83				
Parameter deviation	1*	0.11	5.99	18.62	6.60	0.86	-	26.0	26.0	26.0
	1†	0.33	8.23	24.77	8.40	0.91				
Spurious stop	5*	1.39	14.74	40.33	13.02	4.29	2.0	2.0	12.8	31.0
	5†	2.04	19.60	52.45	16.73	4.57				
Structural deficiency	2*	0.15	1.51	4.09	1.32	1.71	4.5	6.0	6.0	6.0
	2†	0.18	1.62	4.29	1.36	1.83				
Degraded	**121***	**69.24**	**663.94**	**1776.74**	**566.71**	**103.71**	**4.0**	**1.0**	**10.6**	**112.0**
	121†	**109.93**	**889.47**	**2292.20**	**715.83**	**110.58**				
Erratic output	8*	0.64	14.75	44.33	14.95	6.86	4.0	4.0	9.6	17.0
	8†	0.91	18.21	54.53	18.21	7.31				
External leakage - Process medium	53*	30.94	320.18	871.22	280.38	45.43	-	1.0	8.3	31.0
	53†	49.39	430.32	1125.08	353.85	48.44				
External leakage - Utility medium	4*	1.26	15.03	42.03	13.70	3.43	-	4.0	8.0	12.0
	4†	1.99	20.03	54.21	17.39	3.66				
Internal leakage	25*	14.32	160.15	442.60	143.52	21.43	-	1.0	6.8	29.0
	25†	23.57	215.84	571.35	181.09	22.85				
Low output	3*	1.18	20.73	61.26	20.37	2.57	-	6.0	12.0	16.0
	3†	2.35	28.20	78.93	25.74	2.74				
Noise	3*	0.98	14.04	40.43	13.33	2.57	-	15.0	63.5	112.0
	3†	1.71	18.95	52.29	16.94	2.74				
Other	14*	6.44	58.83	155.62	49.30	12.00	-	3.0	22.7	61.0
	14†	10.01	78.07	199.81	62.21	12.79				
Parameter deviation	6*	2.96	43.08	124.31	41.03	5.14	-	3.0	11.8	24.0
	6†	5.45	58.44	160.20	51.75	5.48				
Structural deficiency	5*	1.02	4.10	8.89	2.51	4.29	4.0	3.0	4.0	5.0
	5†	1.09	4.45	9.67	2.73	4.57				
Incipient	**65***	**34.45**	**297.12**	**774.78**	**243.26**	**55.71**	**2.5**	**2.0**	**12.0**	**169.0**
	65†	**55.01**	**394.91**	**994.19**	**307.09**	**59.40**				
Abnormal instrument reading	25*	13.81	135.30	363.83	116.36	21.43	-	2.0	20.0	169.0
	25†	21.76	181.26	469.54	146.96	22.85				

Comments

(cont.)

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Taxonomy no	Item
1.3.2.1	Machinery Pumps Reciprocating Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
35	3	1.1667	1.0942	759

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	4*	0.60	9.51	27.77	9.20	3.43	-	4.0	6.0	9.0
	4†	0.87	12.12	34.75	11.44	3.66				
External leakage - Utility medium	3*	0.00	4.51	18.91	7.24	2.57	-	2.0	13.3	32.0
	3†	0.00	5.32	22.46	8.63	2.74				
Minor in-service problems	25*	13.15	121.83	323.39	102.67	21.43	2.0	2.0	5.7	14.0
	25†	20.76	162.68	416.74	129.80	22.85				
Noise	2*	0.01	3.03	12.15	4.56	1.71	-	12.0	12.0	12.0
	2†	0.01	3.58	14.52	5.47	1.83				
Other	3*	0.28	3.45	9.71	3.17	2.57	3.0	3.0	3.0	3.0
	3†	0.18	4.04	12.11	4.07	2.74				
Parameter deviation	1*	0.11	5.99	18.62	6.60	0.86	-	20.0	20.0	20.0
	1†	0.33	8.23	24.77	8.40	0.91				
Structural deficiency	1*	0.11	5.99	18.62	6.60	0.86	-	4.0	4.0	4.0
	1†	0.33	8.23	24.77	8.40	0.91				
Vibration	1*	0.01	1.41	4.93	1.82	0.86	-	-	-	-
	1†	0.01	1.69	6.14	2.27	0.91				
Unknown	**4***	**1.25**	**20.58**	**60.33**	**20.02**	**3.43**	**-**	**6.0**	**24.3**	**52.0**
	4†	**2.36**	**27.92**	**77.93**	**25.38**	**3.66**				
Noise	2*	0.58	13.32	40.01	13.49	1.71	-	6.0	29.0	52.0
	2†	1.33	18.16	51.90	17.07	1.83				
Unknown	1*	0.01	0.77	2.40	0.86	0.86	-	-	-	-
	1†	0.01	0.82	2.56	0.91	0.91				
Vibration	1*	0.11	5.99	18.62	6.60	0.86	-	15.0	15.0	15.0
	1†	0.33	8.23	24.77	8.40	0.91				
All modes	**210***	**117.60**	**1069.01**	**2824.79**	**894.36**	**180.00**	**4.0**	**1.0**	**11.3**	**169.0**
	210†	**187.62**	**1428.28**	**3638.66**	**1130.43**	**191.91**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $5.3 \cdot 10^{-3}$

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Taxonomy no	Item
1.3.2.2	Machinery Pumps Reciprocating Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
51	3	3.6030	1.6922	90

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**14***	**0.63**	**3.36**	**7.86**	**2.33**	**3.89**	**6.9**	**2.0**	**12.1**	**40.0**
	14†	**1.29**	**7.09**	**16.72**	**4.97**	**8.27**				
Breakdown	2*	0.09	0.54	1.30	0.39	0.56	-	-	-	-
	2†	0.19	1.14	2.76	0.84	1.18				
External leakage - Process medium	3*	0.19	0.80	1.76	0.50	0.83	3.0	2.0	5.0	8.0
	3†	0.40	1.71	3.75	1.06	1.77				
Internal leakage	3*	0.19	0.80	1.76	0.50	0.83	3.0	3.0	3.0	3.0
	3†	0.40	1.71	3.75	1.06	1.77				
Low output	1*	0.01	0.27	0.81	0.28	0.28	3.0	3.0	3.0	3.0
	1†	0.02	0.57	1.73	0.59	0.59				
Spurious stop	4*	0.25	1.06	2.33	0.67	1.11	12.0	3.0	23.0	40.0
	4†	0.52	2.25	4.97	1.42	2.36				
Unknown	1*	0.01	0.27	0.81	0.28	0.28	-	-	-	-
	1†	0.02	0.57	1.73	0.59	0.59				
Degraded	**71***	**5.51**	**31.89**	**76.24**	**22.84**	**19.71**	**3.8**	**0.3**	**9.7**	**40.0**
	71†	**12.25**	**64.20**	**149.73**	**44.23**	**41.96**				
Erratic output	3*	0.09	18.83	69.22	25.57	0.83	-	24.0	26.7	32.0
	3†	0.18	37.63	138.47	51.15	1.77				
External leakage - Process medium	47*	1.11	11.23	30.40	9.75	13.04	3.9	4.0	8.1	21.0
	47†	2.58	23.58	62.38	19.76	27.77				
Internal leakage	11*	0.54	2.71	6.24	1.83	3.05	3.5	0.3	5.7	40.0
	11†	1.12	5.73	13.27	3.90	6.50				
Low output	2*	0.09	0.54	1.30	0.39	0.56	3.0	6.0	6.0	6.0
	2†	0.19	1.14	2.76	0.84	1.18				
Noise	7*	0.39	1.79	4.03	1.16	1.94	4.3	1.0	8.8	21.0
	7†	0.82	3.80	8.58	2.48	4.14				
Other	1*	0.00	4.17	17.69	6.81	0.28	-	32.0	32.0	32.0
	1†	0.01	8.34	35.34	13.60	0.59				
Incipient	**101***	**8.57**	**26.79**	**53.26**	**14.04**	**28.03**	**3.2**	**1.0**	**11.9**	**130.0**
	101†	**19.11**	**55.93**	**108.38**	**27.94**	**59.68**				
Abnormal instrument reading	72*	5.45	15.43	29.53	7.53	19.98	3.6	2.0	6.7	8.0
	72†	9.22	31.41	64.38	17.41	42.55				
Erratic output	3*	0.06	12.48	45.51	16.81	0.83	-	24.0	25.0	26.0
	3†	0.12	24.94	90.94	33.60	1.77				
External leakage - Process medium	6*	0.35	1.55	3.47	1.00	1.67	1.0	1.0	1.0	1.0
	6†	0.73	3.30	7.39	2.13	3.55				
External leakage - Utility medium	13*	0.60	3.14	7.32	2.16	3.61	2.3	3.0	3.8	4.0
	13†	1.24	6.64	15.58	4.61	7.68				
Minor in-service problems	1*	0.01	0.27	0.81	0.28	0.28	-	-	-	-
	1†	0.02	0.57	1.73	0.59	0.59				

Comments

(cont.)

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Taxonomy no	Item
1.3.2.2	Machinery Pumps Reciprocating Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
51	3	3.6030	1.6922	90

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Noise	5*	0.30	1.31	2.91	0.83	1.39	3.0	6.0	6.0	6.0
	5†	0.63	2.78	6.19	1.77	2.95				
Other	1*	0.03	6.14	22.86	8.44	0.28	-	130.0	130.0	130.0
	1†	0.05	12.26	45.69	16.87	0.59				
Unknown	**2***	**0.01**	**8.40**	**35.74**	**13.78**	**0.56**	**-**	**8.0**	**11.0**	**14.0**
	2†	**0.01**	**16.80**	**71.45**	**27.54**	**1.18**				
Other	2*	0.01	8.40	35.74	13.78	0.56	-	8.0	11.0	14.0
	2†	0.01	16.80	71.45	27.54	1.18				
All modes	**188***	**24.71**	**67.20**	**126.67**	**31.84**	**52.18**	**3.9**	**0.3**	**10.8**	**130.0**
	188†	**54.31**	**136.24**	**248.22**	**60.33**	**111.10**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
1.3.2.3	Machinery Pumps Reciprocating Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	3	0.2104	0.1089	11

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**12***	**29.50**	**54.36**	**85.35**	**17.18**	**57.03**	**14.6**	**5.0**	**19.7**	**48.0**
	12†	**50.47**	**107.19**	**181.01**	**40.37**	**110.20**				
Breakdown	1*	0.03	4.27	14.87	5.48	4.75	12.0	24.0	24.0	24.0
	1†	0.12	8.07	25.56	9.18	9.18				
External leakage - Process medium	2*	1.24	9.24	23.43	7.26	9.50	8.0	10.0	13.0	16.0
	2†	0.25	19.41	62.18	22.48	18.37				
Fail to start on demand	3*	1.40	12.61	33.26	10.52	14.26	16.5	18.0	33.0	48.0
	3†	0.25	21.52	69.49	25.21	27.55				
Internal leakage	2*	0.09	9.95	33.21	12.18	9.50	-	5.0	7.5	10.0
	2†	0.05	27.73	111.95	42.13	18.37				
Low output	1*	0.31	4.91	14.34	4.75	4.75	-	6.0	6.0	6.0
	1†	0.06	12.60	45.73	16.90	9.18				
Noise	2*	0.04	8.05	29.70	10.97	9.50	20.0	40.0	40.0	40.0
	2†	0.28	15.19	47.33	16.81	18.37				
Spurious stop	1*	0.03	4.27	14.87	5.48	4.75	-	-	-	-
	1†	0.12	8.07	25.56	9.18	9.18				
Degraded	**19***	**17.75**	**120.10**	**298.45**	**91.56**	**90.29**	**6.7**	**3.0**	**12.3**	**40.0**
	19†	**31.52**	**268.51**	**698.29**	**218.91**	**174.49**				
Erratic output	2*	0.04	16.52	65.22	24.31	9.50	-	14.0	17.5	21.0
	2†	0.06	34.24	137.59	51.67	18.37				
External leakage - Process medium	3*	1.40	12.61	33.26	10.52	14.26	6.7	6.0	13.3	24.0
	3†	0.25	21.52	69.49	25.21	27.55				
External leakage - Utility medium	7*	0.23	33.04	113.26	41.72	33.26	-	6.0	12.0	18.0
	7†	0.27	91.64	357.96	132.86	64.29				
Internal leakage	6*	0.16	54.37	212.27	78.77	28.51	-	4.0	12.0	40.0
	6†	0.20	110.28	443.88	166.80	55.10				
Low output	1*	0.02	7.20	28.29	10.52	4.75	-	3.0	3.0	3.0
	1†	0.04	15.27	60.48	22.56	9.18				
Incipient	**6***	**0.11**	**22.13**	**80.55**	**29.76**	**28.51**	**3.3**	**2.0**	**6.7**	**12.0**
	6†	**3.77**	**42.25**	**116.79**	**37.87**	**55.10**				
External leakage - Utility medium	1*	0.03	4.27	14.87	5.48	4.75	6.0	12.0	12.0	12.0
	1†	0.12	8.07	25.56	9.18	9.18				
Minor in-service problems	4*	0.34	15.78	48.74	17.18	19.01	2.3	2.0	4.5	6.0
	4†	9.06	32.28	67.16	18.37	36.73				
Other	1*	0.03	4.27	14.87	5.48	4.75	5.0	10.0	10.0	10.0
	1†	0.12	8.07	25.56	9.18	9.18				
Unknown	**3***	**0.06**	**14.87**	**57.21**	**21.08**	**14.26**	**-**	**1.0**	**1.3**	**2.0**
	3†	**0.05**	**42.58**	**175.97**	**66.85**	**27.55**				
Unknown	3*	0.06	14.87	57.21	21.08	14.26	-	1.0	1.3	2.0
	3†	0.05	42.58	175.97	66.85	27.55				

Comments

(cont.)

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Taxonomy no		Item
1.3.2.3		Machinery Pumps Reciprocating Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	3	0.2104	0.1089	11

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	**40***	**126.40**	**195.09**	**275.92**	**45.75**	**190.09**	**8.1**	**1.0**	**12.3**	**48.0**
	40†	**208.70**	**426.04**	**705.84**	**153.45**	**367.34**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
1.3.2.4	Machinery Pumps Reciprocating Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0526	0.0007	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.04	9.29	35.69	13.15	0.00	-	-	-	-
	0†	1.36	348.59	1338.59	492.98	0.00				

Comments

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Taxonomy no	Item
1.3.3	Machinery Pumps Rotary

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0327	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**14***	**241.34**	**399.27**	**624.12**	**399.27**	**399.27**	**7.7**	**2.0**	**14.1**	**52.0**
	14†	**258.50**	**427.66**	**668.50**	**427.66**	**427.66**				
Breakdown	3*	23.39	85.56	221.17	85.56	85.56	15.0	19.0	30.0	52.0
	3†	25.05	91.64	236.90	91.64	91.64				
Fail to start on demand	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Low output	2*	10.12	57.04	179.53	57.04	57.04	10.0	9.0	20.0	31.0
	2†	10.84	61.09	192.30	61.09	61.09				
Parameter deviation	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Spurious stop	3*	23.39	85.56	221.17	85.56	85.56	5.0	5.0	5.0	5.0
	3†	25.05	91.64	236.90	91.64	91.64				
Structural deficiency	4*	38.93	114.08	261.09	114.08	114.08	6.0	5.0	12.0	20.0
	4†	41.70	122.19	279.66	122.19	122.19				
Degraded	**6***	**74.58**	**171.12**	**337.67**	**171.12**	**171.12**	**3.5**	**3.0**	**5.3**	**10.0**
	6†	**79.88**	**183.28**	**361.68**	**183.28**	**183.28**				
External leakage - Process medium	1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
	1†	1.53	30.55	144.95	30.55	30.55				
External leakage - Utility medium	3*	23.39	85.56	221.17	85.56	85.56	3.0	3.0	3.7	4.0
	3†	25.05	91.64	236.90	91.64	91.64				
Low output	1*	1.43	28.52	135.32	28.52	28.52	4.0	8.0	8.0	8.0
	1†	1.53	30.55	144.95	30.55	30.55				
Vibration	1*	1.43	28.52	135.32	28.52	28.52	5.0	10.0	10.0	10.0
	1†	1.53	30.55	144.95	30.55	30.55				
Incipient	**16***	**286.18**	**456.31**	**692.99**	**456.31**	**456.31**	**3.0**	**1.0**	**3.0**	**5.0**
	16†	**306.53**	**488.76**	**742.27**	**488.76**	**488.76**				
Abnormal instrument reading	8*	113.51	228.15	411.68	228.15	228.15	2.7	1.0	2.7	5.0
	8†	121.58	244.38	440.95	244.38	244.38				
Minor in-service problems	6*	74.58	171.12	337.67	171.12	171.12	3.3	2.0	3.3	4.0
	6†	79.88	183.28	361.68	183.28	183.28				
Structural deficiency	2*	10.12	57.04	179.53	57.04	57.04	3.0	2.0	3.0	4.0
	2†	10.84	61.09	192.30	61.09	61.09				
All modes	**36***	**762.33**	**1026.69**	**1355.81**	**1026.69**	**1026.69**	**5.0**	**1.0**	**7.8**	**52.0**
	36†	**816.54**	**1099.71**	**1452.23**	**1099.71**	**1099.71**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Pumps - Rotary

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Cabling & junction boxes	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Impeller	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	5.56	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00
Valves	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00
Total	22.22	8.33	2.78	8.33	0.00	2.78	0.00	0.00	8.33	0.00

Maintainable item versus failure mode, continued
Item: Pumps - Rotary

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Control unit	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	5.56
Coupling to driven unit	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.78
Impeller	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33
Instrument, pressure	0.00	0.00	2.78	2.78	0.00	0.00	0.00	8.33	0.00	25.00
Piping	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	8.33
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Subunit	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	16.67
Support	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	2.78
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Valves	0.00	0.00	0.00	13.89	0.00	0.00	0.00	0.00	0.00	19.44
Total	0.00	0.00	2.78	16.67	16.67	0.00	0.00	8.33	2.78	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Pumps - Rotary

	AIR	BRD	ELP	ELU	ERO	FTS	HIO	INL	LOO	NOI
Blockage/plugged	8.33	2.78	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	2.78	0.00	8.33	0.00	2.78	0.00	0.00	5.56	0.00
Misc. external influences	2.78	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	22.22	8.33	2.78	8.33	0.00	2.78	0.00	0.00	8.33	0.00

Failure descriptior versus failure mode, continued
Item: Pumps - Rotary

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	16.67
Control failure	0.00	0.00	0.00	2.78	0.00	0.00	0.00	2.78	0.00	5.56
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78	0.00	5.56
Instrument failure - general	0.00	0.00	0.00	2.78	0.00	0.00	0.00	2.78	0.00	13.89
Leakage	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Material failure - general	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	5.56
Mechanical Failure - general	0.00	0.00	0.00	8.33	2.78	0.00	0.00	0.00	0.00	30.56
Misc. external influences	0.00	0.00	0.00	2.78	0.00	0.00	0.00	0.00	2.78	11.11
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Wear	0.00	0.00	0.00	0.00	5.56	0.00	0.00	0.00	0.00	5.56
Total	0.00	0.00	2.78	16.67	16.67	0.00	0.00	8.33	2.78	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.3.3.1	Machinery Pumps Rotary Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0327	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**14***	**241.34**	**399.27**	**624.12**	**399.27**	**399.27**	**7.7**	**2.0**	**14.1**	**52.0**
	14†	**258.50**	**427.66**	**668.50**	**427.66**	**427.66**				
Breakdown	3*	23.39	85.56	221.17	85.56	85.56	15.0	19.0	30.0	52.0
	3†	25.05	91.64	236.90	91.64	91.64				
Fail to start on demand	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Low output	2*	10.12	57.04	179.53	57.04	57.04	10.0	9.0	20.0	31.0
	2†	10.84	61.09	192.30	61.09	61.09				
Parameter deviation	1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
	1†	1.53	30.55	144.95	30.55	30.55				
Spurious stop	3*	23.39	85.56	221.17	85.56	85.56	5.0	5.0	5.0	5.0
	3†	25.05	91.64	236.90	91.64	91.64				
Structural deficiency	4*	38.93	114.08	261.09	114.08	114.08	6.0	5.0	12.0	20.0
	4†	41.70	122.19	279.66	122.19	122.19				
Degraded	**6***	**74.58**	**171.12**	**337.67**	**171.12**	**171.12**	**3.5**	**3.0**	**5.3**	**10.0**
	6†	**79.88**	**183.28**	**361.68**	**183.28**	**183.28**				
External leakage - Process medium	1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
	1†	1.53	30.55	144.95	30.55	30.55				
External leakage - Utility medium	3*	23.39	85.56	221.17	85.56	85.56	3.0	3.0	3.7	4.0
	3†	25.05	91.64	236.90	91.64	91.64				
Low output	1*	1.43	28.52	135.32	28.52	28.52	4.0	8.0	8.0	8.0
	1†	1.53	30.55	144.95	30.55	30.55				
Vibration	1*	1.43	28.52	135.32	28.52	28.52	5.0	10.0	10.0	10.0
	1†	1.53	30.55	144.95	30.55	30.55				
Incipient	**16***	**286.18**	**456.31**	**692.99**	**456.31**	**456.31**	**3.0**	**1.0**	**3.0**	**5.0**
	16†	**306.53**	**488.76**	**742.27**	**488.76**	**488.76**				
Abnormal instrument reading	8*	113.51	228.15	411.68	228.15	228.15	2.7	1.0	2.7	5.0
	8†	121.58	244.38	440.95	244.38	244.38				
Minor in-service problems	6*	74.58	171.12	337.67	171.12	171.12	3.3	2.0	3.3	4.0
	6†	79.88	183.28	361.68	183.28	183.28				
Structural deficiency	2*	10.12	57.04	179.53	57.04	57.04	3.0	2.0	3.0	4.0
	2†	10.84	61.09	192.30	61.09	61.09				
All modes	**36***	**762.33**	**1026.69**	**1355.81**	**1026.69**	**1026.69**	**5.0**	**1.0**	**7.8**	**52.0**
	36†	**816.54**	**1099.71**	**1452.23**	**1099.71**	**1099.71**				

Comments

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Combustion Engines

Inventory description

The boundary definition is shown in Figure 13 and corresponding subdivision in Maintainable Items in Table 8.

The boundary definition applies to combustion engines (diesel/gas) driving equipment such as compressors, generators and pumps. The combustion engines are further subdivided in Subunits and Maintainable Items as shown in Table 8. Included within the boundary is the starting system and auxiliaries related to the engine.

Subunits that are common to the *driver* (i.e. the combustion engine) and the *driven unit* (e.g. generator) are a part of the *driven unit.* Power transmission systems are also regarded as part of the driven unit.

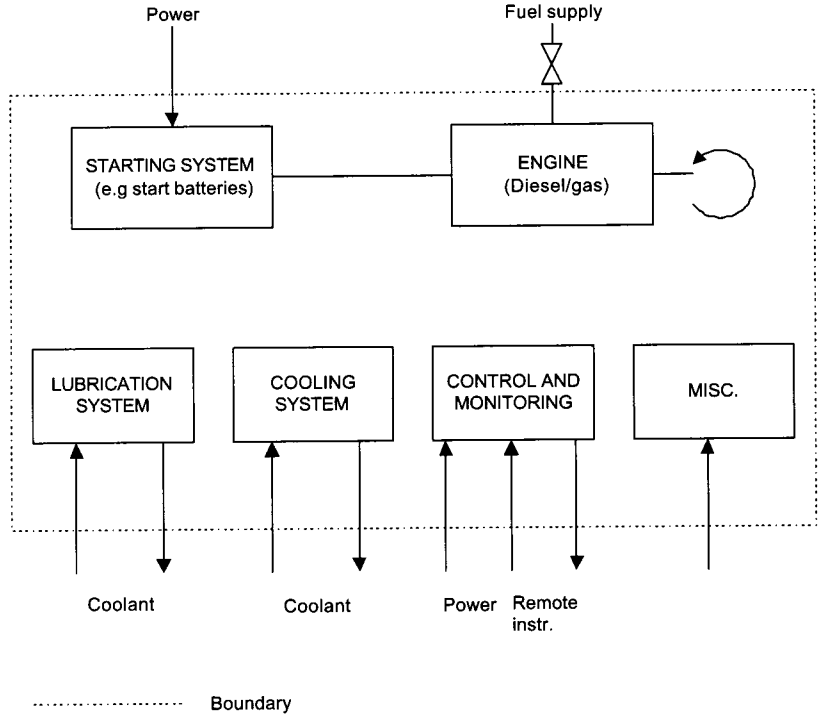

Figure 13-Combustion engines, Boundary Definition

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Table 8 Combustion Engine, Subdivision in Maintainable Items

COMBUSTION ENGINE					
Starting system	Engine	Control & Monitoring	Lubrication system	Cooling system	Miscellaneous
• Instruments • Start control • Start energy (battery, air) • Starting unit	• Air inlet • Cam shaft • Cylinders • Exhaust • Filter • Pump • Injections • Instruments • Piping • Piston • Radial bearing • Seals • Shaft • Super charger • Thrust bearing • Timing chain/V-belt • Valves	• Actuating device • Cabling & junction boxes • Control unit • Instruments • Internal power supply • Monitoring • Valves	• Reservoir • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Instrument • Seals	• Heat exchanger • Fan w/motor • Filter • Valves & piping • Pump • Instruments	• Hood • Heater

(For all subunits the MIs "Unknown" and "Subunit" are included.)

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List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ERO	Erratic output
ELF	External leakage - Fuel
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
HIO	High output
INL	Internal leakage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

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Taxonomy no		Item									
1.4		Machinery Combustion Enigens									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
103	63	**Calendar time** * 3.3923			**Operational time** † 0.3523			20010			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	***n*/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Critical		**83***	**0.07**	**28.05**	**111.22**	**41.51**	**24.47**	**45.4**	**0.5**	**66.7**	**2730.0**
		83†	**920.74**	**3291.31**	**6855.40**	**1876.34**	**235.56**				
Breakdown		6*	0.00	1.82	7.26	2.71	1.77	37.3	4.0	37.7	108.0
		6†	0.00	87.81	434.84	184.39	17.03				
External leakage - Utility medium		3*	0.00	1.91	10.62	6.34	0.88	-	1.0	3.5	6.0
		3†	1.40	290.21	1062.72	392.60	8.51				
Fail to start on demand		34*	0.00	11.51	60.10	26.92	10.02	17.2	1.0	21.7	121.0
		34†	708.84	2838.32	6134.52	1725.63	96.50				
Fail to stop on demand		1*	0.00	0.47	1.20	2.43	0.29	-	6.0	6.0	6.0
		1†	0.00	3.68	21.19	11.48	2.84				
Low output		2*	0.00	0.96	4.99	3.52	0.59	50.0	0.5	50.3	100.0
		2†	0.00	16.42	90.99	46.56	5.68				
Minor in-service problems		1*	0.00	0.47	1.20	2.43	0.29	-	1.0	1.0	1.0
		1†	0.00	3.68	21.19	11.48	2.84				
Other		4*	0.00	1.25	6.26	2.67	1.18	16.0	4.0	39.8	111.0
		4†	0.16	10.12	31.86	11.41	11.35				
Overheating		6*	0.00	1.69	9.34	4.69	1.77	29.5	1.0	36.0	120.0
		6†	0.00	35.06	195.49	101.58	17.03				
Parameter deviation		2*	0.00	1.12	5.78	4.26	0.59	6.0	1.0	6.5	12.0
		2†	0.00	17.74	97.49	47.57	5.68				
Spurious stop		19*	0.08	5.10	16.07	5.76	5.60	7.8	2.0	11.4	40.0
		19†	3.99	305.04	975.87	352.53	53.92				
Structural deficiency		1*	0.00	0.47	1.20	2.43	0.29	-	6.0	6.0	6.0
		1†	0.00	3.15	16.74	7.67	2.84				
Vibration		4*	0.38	1.15	2.26	0.59	1.18	516.7	140.0	1116.7	2730.0
		4†	0.04	10.34	39.44	14.53	11.35				
Degraded		**173***	**0.02**	**54.08**	**236.00**	**91.99**	**51.00**	**15.1**	**0.1**	**22.9**	**221.0**
		173†	**624.54**	**3644.98**	**8732.86**	**2620.50**	**490.99**				
Abnormal instrument reading		1*	0.00	0.26	1.31	0.56	0.29	1.5	3.0	3.0	3.0
		1†	0.05	2.73	8.53	3.03	2.84				
Erratic output		7*	0.95	2.05	3.48	0.78	2.06	11.3	1.0	21.8	60.0
		7†	16.97	314.07	933.17	310.88	19.87				
External leakage - Fuel		6*	0.00	1.46	8.08	4.09	1.77	8.9	3.0	11.2	32.0
		6†	0.00	19.21	105.57	51.42	17.03				
External leakage - Utility medium		52*	0.00	13.14	70.63	32.66	15.33	12.7	1.0	18.4	78.0
		52†	21.44	983.71	3036.60	1069.34	147.58				
Fail to start on demand		4*	0.00	2.01	11.02	5.31	1.18	-	1.0	10.3	18.0
		4†	0.03	14.03	55.77	20.83	11.35				
High output		3*	0.00	0.90	4.08	1.63	0.88	7.3	4.0	7.3	12.0
		3†	0.00	29.20	165.00	87.63	8.51				
Internal leakage		10*	0.00	2.71	14.01	6.17	2.95	21.0	2.0	31.4	80.0
		10†	10.86	446.64	1370.83	479.70	28.38				
Comments											
(cont.)											

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Taxonomy no		Item									
1.4		Machinery Combustion Enigens									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
103	63	**Calendar time** * 3.3923			**Operational time** † 0.3523			20010			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Low output		16*	0.02	4.81	17.61	6.51	4.72	9.4	1.0	20.5	74.0
		16†	0.07	134.68	578.06	223.69	45.41				
Minor in-service problems		1*	0.00	0.47	1.20	2.43	0.29	-	2.0	2.0	2.0
		1†	0.00	3.68	21.19	11.48	2.84				
Noise		4*	0.00	1.34	7.79	4.24	1.18	35.0	10.0	26.5	56.0
		4†	9.67	327.31	995.83	344.39	11.35				
Other		41*	0.00	13.71	66.30	27.39	12.09	17.6	0.1	21.7	82.0
		41†	1.72	368.58	1359.12	501.99	116.36				
Overheating		15*	0.00	3.96	19.53	8.26	4.42	17.3	4.0	32.5	207.0
		15†	0.01	159.79	741.30	299.55	42.57				
Parameter deviation		2*	0.00	0.67	3.77	1.98	0.59	116.0	4.0	60.0	116.0
		2†	0.00	5.05	26.18	11.58	5.68				
Spurious stop		1*	0.00	0.47	1.20	2.43	0.29	-	25.0	25.0	25.0
		1†	0.00	3.68	21.19	11.48	2.84				
Structural deficiency		8*	0.00	2.58	14.60	7.78	2.36	5.8	3.0	47.9	221.0
		8†	0.42	158.95	625.26	232.71	22.70				
Unknown		1*	0.00	0.47	1.20	2.43	0.29	-	4.0	4.0	4.0
		1†	0.00	3.15	16.74	7.67	2.84				
Vibration		1*	0.00	0.29	0.61	1.60	0.29	42.0	42.0	42.0	42.0
		1†	0.00	3.19	17.23	8.00	2.84				
Incipient		**347***	**0.00**	**103.04**	**490.55**	**201.35**	**102.29**	**7.4**	**0.5**	**13.6**	**170.0**
		347†	**1418.30**	**6832.28**	**15588.95**	**4545.85**	**984.82**				
Abnormal instrument reading		111*	0.00	19.30	91.17	88.13	32.72	4.6	1.0	9.3	84.0
		111†	26.26	1620.90	5098.32	1823.67	315.03				
Erratic output		6*	0.00	2.72	14.60	6.74	1.77	-	6.0	32.7	65.0
		6†	0.45	266.35	1075.06	404.56	17.03				
External leakage - Fuel		5*	0.56	1.47	2.74	0.68	1.47	2.5	2.5	3.7	6.0
		5†	44.20	450.40	1221.59	392.48	14.19				
External leakage - Utility medium		39*	0.00	12.69	55.69	21.80	11.50	9.6	2.0	15.6	100.0
		39†	89.74	922.89	2507.93	806.57	110.69				
Fail to start on demand		15*	0.00	10.10	51.31	22.13	4.42	-	1.0	19.0	148.0
		15†	4.01	57.96	167.08	55.12	42.57				
Fail to stop on demand		1*	0.00	0.47	1.20	2.43	0.29	-	8.0	8.0	8.0
		1†	0.00	3.68	21.19	11.48	2.84				
Internal leakage		6*	0.00	1.34	7.09	3.24	1.77	26.7	6.0	48.3	110.0
		6†	0.00	16.01	88.72	53.08	17.03				
Minor in-service problems		86*	0.00	16.85	87.35	68.86	25.35	5.0	1.0	11.5	132.0
		86†	42.40	1812.54	5573.97	1954.95	244.08				
Noise		6*	0.00	1.62	8.29	3.59	1.77	3.8	1.0	9.3	44.0
		6†	71.47	474.93	1175.46	359.83	17.03				
Other		51*	0.00	22.55	102.03	40.56	15.03	18.9	0.5	15.4	170.0
		51†	9.44	155.59	456.22	151.38	144.74				

Comments

(cont.)

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Taxonomy no		Item								
1.4		Machinery Combustion Enigens								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
103	63	**Calendar time** * 3.3923		**Operational time** † 0.3523			20010			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	***n*/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Overheating		7*	0.00	2.16	12.02	6.19	2.06	18.8	3.0	17.9	35.0
		7†	0.00	22.81	123.97	77.56	19.87				
Parameter deviation		1*	0.00	0.47	1.20	2.43	0.29	-	18.0	18.0	18.0
		1†	0.00	3.68	21.19	11.48	2.84				
Spurious stop		9*	0.00	5.26	26.01	11.02	2.65	-	4.0	15.8	66.0
		9†	0.25	34.35	117.53	43.28	25.54				
Structural deficiency		3*	0.00	0.99	5.76	3.14	0.88	10.0	10.0	62.0	128.0
		3†	3.66	237.62	750.15	268.98	8.51				
Vibration		1*	0.00	0.63	1.42	3.41	0.29	-	16.0	16.0	16.0
		1†	0.00	3.68	21.22	11.51	2.84				
Unknown		**21***	**0.00**	**16.30**	**77.55**	**31.82**	**6.19**	**-**	**1.0**	**17.9**	**142.0**
		21†	**0.10**	**451.81**	**2004.63**	**789.72**	**59.60**				
Fail to start on demand		2*	0.00	1.09	5.64	4.17	0.59	-	2.0	2.0	2.0
		2†	0.00	6.75	32.89	13.72	5.68				
Minor in-service problems		1*	0.00	0.63	1.42	3.41	0.29	-	1.0	1.0	1.0
		1†	0.00	3.68	21.22	11.51	2.84				
Other		10*	0.00	7.06	40.86	22.22	2.95	-	1.0	28.8	142.0
		10†	0.05	35.73	145.37	54.90	28.38				
Parameter deviation		1*	0.00	0.63	1.42	3.41	0.29	-	1.0	1.0	1.0
		1†	0.00	3.68	21.22	11.51	2.84				
Unknown		7*	0.00	6.09	33.73	17.21	2.06	-	2.0	6.0	12.0
		7†	30.84	771.70	2323.76	788.01	19.87				
All modes		**624***	**0.20**	**206.03**	**857.85**	**326.91**	**183.95**	**14.7**	**0.1**	**23.1**	**2730.0**
		624†	**5840.31**	**16184.89**	**30730.22**	**7779.92**	**1770.98**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5. 10-3

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Maintainable **item versus failure mode, to be continued**
Item: Combustion Enigens

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.48	0.00	0.00	0.16	0.32	0.16	0.00	0.00	0.16	0.00
Air inlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
Cabling & junction boxes	0.16	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Cam shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Cooler(s)	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Cylinders	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.32	0.00	0.00
Exhaust	0.00	0.00	0.16	0.48	0.00	0.00	0.00	0.00	0.00	0.96
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.16
Filter(s)	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Fuel filter	0.00	0.00	0.16	0.00	0.32	0.32	0.00	0.08	0.00	0.00
Fuel pump	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.32	0.16	0.00
Heat exchanger	0.00	0.00	0.00	0.64	0.00	0.16	0.00	0.16	0.00	0.00
Heater	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	1.28	0.08	0.00	0.00	0.08	0.48	0.00
Instrument, flow	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.76	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Instrument, pressure	2.24	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
Instrument, speed	0.48	0.00	0.00	0.16	0.32	0.48	0.16	0.00	0.00	0.00
Instrument, temperature	6.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.64	0.00
Monitoring	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.32	0.96	0.16	0.64	0.00	0.00	0.32	0.00
Piping	0.00	0.00	0.48	5.13	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Seals	0.00	0.00	0.32	0.96	0.00	0.16	0.00	0.72	0.16	0.00
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.32	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.16	0.00	0.00	0.80	0.00	1.44	0.00	0.16	0.00	0.00
Starting unit	0.32	0.00	0.00	0.32	0.00	1.12	0.00	0.00	0.00	0.00
Subunit	0.16	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Super charger	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.16	0.00
Timing chain/V-belt	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.88	0.64	0.16	1.12	0.48	1.92	0.32	0.48	0.48	0.16
Valves	0.48	0.16	0.00	0.16	0.08	0.32	0.00	0.24	0.00	0.00
Total	17.95	0.96	1.76	15.06	2.08	8.81	0.48	2.56	2.88	1.60

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Combustion Enigens

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.16	0.00	0.32	0.00	0.16	0.00	0.16	0.00	2.08
Air inlet	0.00	0.00	0.00	1.12	0.16	0.00	0.00	0.00	0.00	1.44
Cabling & junction boxes	0.00	0.00	0.00	0.16	0.00	0.00	0.16	0.00	0.00	0.64
Cam shaft	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Control unit	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16	0.00	2.96
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.48
Cylinders	0.00	0.24	0.00	0.00	0.16	0.00	0.00	0.00	0.00	1.04
Exhaust	0.00	0.80	0.00	0.16	0.32	0.00	0.00	0.00	0.00	2.88
Fan w/motor	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.96
Filter(s)	0.00	0.16	0.00	2.08	0.00	0.00	0.00	0.00	0.00	2.40
Fuel filter	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.16	0.00	1.36
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
Heat exchanger	0.48	0.32	0.00	0.16	0.16	0.00	0.00	0.00	0.00	2.08
Heater	0.00	0.32	0.00	0.48	0.00	0.00	0.00	0.00	0.00	1.28
Hood	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.80
Injections	1.04	0.16	0.00	0.08	0.00	0.00	0.00	0.00	0.00	3.21
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Instrument, general	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.64
Instrument, level	0.00	0.16	0.00	0.80	0.00	0.00	0.00	0.48	0.00	3.53
Instrument, pressure	0.00	0.16	0.00	0.48	0.00	0.00	0.00	0.48	0.00	3.69
Instrument, speed	0.00	0.16	0.00	0.32	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	0.48	0.64	0.00	0.48	0.00	0.00	0.00	0.16	0.00	8.49
Internal power supply	0.16	0.64	0.00	0.16	0.00	0.00	0.16	0.00	0.00	1.92
Monitoring	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
Oil	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.48
Other	0.16	3.85	0.32	0.48	0.00	0.00	0.16	0.96	0.16	8.49
Piping	0.00	0.00	0.00	0.72	0.32	0.00	0.00	0.16	0.00	6.81
Piston(s)	0.00	0.16	0.16	0.00	0.16	0.00	0.00	0.00	0.08	0.72
Pump	0.64	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
Pump w/motor	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Seals	0.08	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	2.56
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.96
Start energy (battery, air)	0.00	2.08	0.00	0.48	0.00	0.00	0.00	0.00	0.00	5.13
Starting unit	0.00	0.16	0.00	0.32	0.00	0.16	0.00	0.00	0.00	2.40
Subunit	0.00	0.96	0.00	0.80	0.16	0.00	0.00	0.00	0.00	2.40
Super charger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.80
Timing chain/V-belt	0.16	0.24	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.72
Unknown	0.96	4.49	0.32	1.12	0.48	0.00	0.80	1.28	0.16	16.27
Valves	0.16	0.16	0.00	1.76	0.00	0.00	0.00	0.16	0.00	3.69
Total	4.49	16.99	0.96	14.26	1.92	0.32	1.28	4.65	0.96	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Combustion Enigens

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
ERROR	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blockage/plugged	0.00	0.00	0.00	0.00	0.16	0.32	0.00	0.00	0.00	0.00
Breakage	0.32	0.32	0.32	1.28	0.16	0.48	0.16	0.00	0.00	0.80
Burst	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.16	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.16	0.00	0.00	0.32	0.32	0.00	0.00	0.00	0.16	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
Control failure	1.12	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.32	0.00
Corrosion	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.44	0.00	0.00	0.00	0.16	1.92	0.00	0.00	0.16	0.00
Erosion	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Faulty signal/indication/alarm	2.88	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00
Instrument failure - general	1.92	0.00	0.00	0.00	0.32	0.32	0.16	0.00	0.00	0.00
Leakage	0.00	0.00	1.12	6.57	0.16	0.16	0.00	0.00	0.32	0.00
Looseness	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.16	0.00	0.00
Material failure - general	0.32	0.16	0.16	2.40	0.00	0.16	0.00	0.64	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.96	0.32	1.12	0.00	0.48	0.64	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00
No cause found	0.48	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.76	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Open circuit	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.16	0.16	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.16
Out of adjustment	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00
Overheating	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Short circuiting	0.16	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.16	0.00
Software failure	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.48	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.16	0.00
Unknown	0.00	0.00	0.00	0.48	0.00	0.96	0.00	0.00	0.16	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.16	0.00	0.00	1.28	0.16	0.32	0.16	0.96	0.00	0.48
Total	17.95	0.96	1.76	15.06	2.08	8.81	0.48	2.56	2.88	1.60

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Combustion Enigens

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
ERROR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Blockage/plugged	0.32	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	1.12
Breakage	0.00	0.32	0.00	0.16	0.16	0.00	0.00	0.16	0.16	4.81
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
Cavitation	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Clearance/ alignment failure	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Combined causes	0.16	0.32	0.16	0.32	0.16	0.00	0.00	0.32	0.00	2.40
Common mode failure	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.32
Contamination	0.00	0.00	0.00	3.69	0.00	0.00	0.00	0.00	0.00	4.33
Control failure	0.16	0.64	0.00	0.00	0.00	0.00	0.00	0.64	0.00	3.04
Corrosion	0.00	0.32	0.00	0.16	0.48	0.00	0.00	0.00	0.00	1.60
Deformation	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.16	0.48
Earth/isolation fault	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.64
Electrical failure - general	0.48	1.44	0.00	0.80	0.00	0.16	0.32	0.00	0.00	6.89
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.48
External influence - general	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.16
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
Faulty power/voltage	0.00	0.48	0.00	0.32	0.00	0.00	0.00	0.00	0.00	1.28
Faulty signal/indication/alarm	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.32	0.00	3.69
Instrument failure - general	0.00	0.80	0.16	0.64	0.00	0.00	0.00	0.16	0.00	4.49
Leakage	0.00	0.64	0.00	0.80	0.16	0.00	0.00	0.32	0.00	10.26
Looseness	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	1.60
Material failure - general	0.16	0.48	0.00	1.12	0.48	0.00	0.00	0.00	0.00	6.09
Mechanical Failure - general	0.32	2.40	0.16	0.80	0.00	0.00	0.16	0.80	0.00	8.17
Misc. external influences	0.00	0.16	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.32
Miscellaneous - general	0.32	0.80	0.00	0.00	0.16	0.00	0.16	0.16	0.00	1.92
No cause found	0.00	0.16	0.00	0.00	0.00	0.00	0.32	0.00	0.00	1.44
No power/ voltage	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	2.08
Open circuit	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.16	0.00	1.92
Other	0.00	3.37	0.32	0.00	0.00	0.00	0.00	0.64	0.00	4.97
Out of adjustment	0.80	0.48	0.16	1.12	0.00	0.00	0.00	0.16	0.00	7.37
Overheating	0.16	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
Short circuiting	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.80
Software failure	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
Sticking	0.16	0.16	0.00	0.64	0.00	0.00	0.00	0.00	0.00	2.08
Unknown	0.32	0.80	0.00	0.80	0.00	0.00	0.32	0.16	0.00	4.01
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.32
Wear	1.12	0.96	0.00	0.96	0.32	0.16	0.00	0.00	0.16	7.21
Total	4.49	16.99	0.96	14.26	1.92	0.32	1.28	4.65	0.96	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item									
1.4.1		Machinery Combustion Enigens Diesel engine									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
69	56	**Calendar time** * 3.0067			**Operational time** † 0.0872			18474			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Critical		**52***	**0.00**	**19.10**	**90.16**	**36.84**	**17.29**	**53.8**	**1.0**	**95.3**	**2730.0**
		52†	**756.39**	**5359.16**	**13454.01**	**4149.86**	**596.01**				
Breakdown		3*	0.00	1.11	6.05	2.83	1.00	38.7	4.0	39.3	108.0
		3†	0.00	183.24	922.91	396.07	34.39				
External leakage - Utility medium		1*	0.00	1.31	6.90	5.72	0.33	-	-	-	-
		1†	3.02	646.59	2383.85	880.47	11.46				
Fail to start on demand		29*	0.00	12.22	63.54	28.24	9.65	9.5	1.0	16.9	52.0
		29†	283.72	4049.45	11650.76	3840.96	332.39				
Low output		1*	0.00	0.58	2.14	2.76	0.33	50.0	100.0	100.0	100.0
		1†	0.01	42.18	189.31	75.00	11.46				
Overheating		3*	0.00	0.81	4.18	1.81	1.00	28.7	1.0	57.0	120.0
		3†	0.00	78.13	405.69	179.68	34.39				
Parameter deviation		1*	0.00	0.58	2.14	2.76	0.33	6.0	12.0	12.0	12.0
		1†	0.01	42.18	189.31	75.00	11.46				
Spurious stop		11*	0.55	3.35	8.12	2.46	3.66	7.2	2.0	13.3	40.0
		11†	17.47	694.47	2127.98	743.18	126.08				
Vibration		3*	0.00	0.74	3.91	1.79	1.00	516.7	140.0	1116.7	2730.0
		3†	5.53	28.86	67.24	19.85	34.39				
Degraded		**123***	**0.00**	**33.40**	**183.95**	**91.72**	**40.91**	**12.3**	**1.0**	**21.6**	**207.0**
		123†	**247.06**	**5683.27**	**17075.33**	**5757.31**	**1409.80**				
Abnormal instrument reading		1*	0.00	0.29	1.43	0.60	0.33	1.5	3.0	3.0	3.0
		1†	0.10	9.62	31.45	11.46	11.46				
Erratic output		6*	0.00	1.78	9.49	7.97	2.00	11.3	1.0	21.5	60.0
		6†	6.35	564.26	1830.47	665.32	68.77				
External leakage - Fuel		5*	0.00	1.33	7.31	3.58	1.66	9.1	3.0	11.8	32.0
		5†	0.00	72.89	415.45	222.87	57.31				
External leakage - Utility medium		45*	0.00	12.10	67.00	34.19	14.97	10.2	1.0	17.3	60.0
		45†	3.62	1543.60	6123.04	2285.30	515.78				
Fail to start on demand		1*	0.00	1.31	6.90	5.72	0.33	-	12.0	12.0	12.0
		1†	3.02	646.59	2383.85	880.47	11.46				
High output		1*	0.00	0.37	0.69	2.08	0.33	4.0	4.0	4.0	4.0
		1†	0.00	88.49	445.73	191.30	11.46				
Internal leakage		9*	0.00	2.85	14.99	6.78	2.99	21.8	2.0	33.1	80.0
		9†	3.41	760.77	2829.38	1044.60	103.16				
Low output		9*	0.00	2.63	11.34	4.40	2.99	7.9	6.0	15.9	30.0
		9†	0.68	300.00	1192.33	445.28	103.16				
Noise		3*	0.00	1.28	6.67	4.78	1.00	14.0	10.0	16.7	28.0
		3†	1.15	512.08	2037.89	761.36	34.39				
Other		25*	0.00	6.22	34.99	18.45	8.31	16.1	2.0	27.7	82.0
		25†	1.96	701.82	2751.26	1022.64	286.55				
Comments											
(cont.)											

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Taxonomy no		Item									
1.4.1		Machinery Combustion Enigens Diesel engine									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
69	56	**Calendar time** * 3.0067			**Operational time** † 0.0872			18474			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	***n*/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Overheating		12*	0.00	3.12	17.02	7.95	3.99	17.3	4.0	33.0	207.0
		12†	0.03	325.76	1494.13	597.80	137.54				
Structural deficiency		6*	0.02	1.90	6.26	2.29	2.00	5.8	3.0	12.8	30.0
		6†	0.38	305.63	1256.44	476.48	68.77				
Incipient		**255***	**0.00**	**63.08**	**359.49**	**202.95**	**84.81**	**5.6**	**0.5**	**12.6**	**132.0**
		255†	**1250.46**	**11839.88**	**31591.96**	**10059.92**	**2922.76**				
Abnormal instrument reading		107*	0.00	21.40	112.73	93.38	35.59	4.6	1.0	9.4	84.0
		107†	2.98	2444.38	10052.24	3812.55	1226.41				
Erratic output		3*	0.00	2.48	14.39	7.87	1.00	-	27.0	27.0	27.0
		3†	50.78	1239.32	3729.28	1262.50	34.39				
External leakage - Fuel		4*	0.00	1.23	6.78	3.34	1.33	2.5	2.5	2.5	2.5
		4†	5.41	695.72	2354.81	865.76	45.85				
External leakage - Utility medium		28*	0.00	8.99	45.81	19.78	9.31	8.7	2.0	17.3	100.0
		28†	83.00	1923.42	5779.95	1949.83	320.93				
Fail to start on demand		2*	0.00	2.62	14.99	8.08	0.67	-	1.0	12.0	23.0
		2†	83.53	1293.10	3761.97	1245.03	22.92				
Internal leakage		5*	0.00	1.22	6.54	3.02	1.66	25.6	6.0	51.5	110.0
		5†	0.00	66.62	366.57	222.86	57.31				
Minor in-service problems		81*	0.00	17.80	92.29	72.96	26.94	4.8	1.0	11.4	132.0
		81†	1.64	2589.30	10985.22	4230.24	928.41				
Noise		6*	0.00	1.87	9.10	3.79	2.00	3.8	1.0	9.3	44.0
		6†	30.18	762.09	2295.42	778.89	68.77				
Other		14*	0.00	3.19	18.25	10.24	4.66	5.6	0.5	11.2	44.0
		14†	0.01	450.41	2179.75	900.69	160.47				
Overheating		2*	0.00	0.77	4.01	3.25	0.67	9.0	3.0	9.0	15.0
		2†	0.00	82.44	400.37	166.28	22.92				
Structural deficiency		3*	0.00	1.15	6.41	3.32	1.00	10.0	10.0	62.0	128.0
		3†	0.64	384.99	1555.54	585.67	34.39				
Unknown		**2***	**0.00**	**3.20**	**16.67**	**11.98**	**0.67**	**-**	**8.0**	**8.0**	**8.0**
		2†	**16.29**	**1492.13**	**4854.89**	**1766.56**	**22.92**				
Unknown		2*	0.00	3.20	16.67	11.98	0.67	-	8.0	8.0	8.0
		2†	16.29	1492.13	4854.89	1766.56	22.92				
All modes		**432***	**0.00**	**120.77**	**663.66**	**321.98**	**143.68**	**12.7**	**0.5**	**24.3**	**2730.0**
		432†	**4999.51**	**25193.92**	**58179.77**	**17089.44**	**4951.51**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.4. 10-3

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Maintainable **item versus failure mode, to be continued**
Item: Combustion Enigens - Diesel engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.69	0.00	0.00	0.23	0.46	0.23	0.00	0.00	0.23	0.00
Air inlet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Cabling & junction boxes	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.89	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Cylinders	0.00	0.00	0.00	0.23	0.00	0.23	0.00	0.46	0.00	0.00
Exhaust	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00	0.00	1.39
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.23
Filter(s)	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Fuel filter	0.00	0.00	0.23	0.00	0.46	0.46	0.00	0.12	0.00	0.00
Fuel pump	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.46	0.23	0.00
Heat exchanger	0.00	0.00	0.00	0.93	0.00	0.23	0.00	0.23	0.00	0.00
Heater	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	1.85	0.12	0.00	0.00	0.12	0.69	0.00
Instrument, flow	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	2.55	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Instrument, pressure	3.24	0.00	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00
Instrument, speed	0.69	0.00	0.00	0.00	0.46	0.69	0.00	0.00	0.00	0.00
Instrument, temperature	9.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.23	0.23	0.23	0.00	0.00	0.23	0.00
Piping	0.00	0.00	0.69	6.48	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.23
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.00	0.00	0.46	1.16	0.00	0.00	0.00	1.04	0.23	0.00
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start control	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.23	0.00	0.00	1.16	0.00	1.16	0.00	0.23	0.00	0.00
Starting unit	0.46	0.00	0.00	0.46	0.00	0.46	0.00	0.00	0.00	0.00
Subunit	0.23	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Super charger	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.23	0.00
Timing chain/V-belt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.58	0.46	0.23	0.46	0.23	1.62	0.23	0.23	0.23	0.00
Valves	0.69	0.23	0.00	0.23	0.12	0.46	0.00	0.35	0.00	0.00
Total	25.00	0.69	2.08	17.13	2.08	7.41	0.23	3.24	2.31	2.08

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Combustion Enigens - Diesel engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	2.55
Air inlet	0.00	0.00	0.00	1.62	0.23	0.00	0.00	0.00	0.00	2.08
Cabling & junction boxes	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Control unit	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	3.82
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.69
Cylinders	0.00	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00	1.39
Exhaust	0.00	0.23	0.00	0.23	0.46	0.00	0.00	0.00	0.00	3.01
Fan w/motor	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Filter(s)	0.00	0.23	0.00	3.01	0.00	0.00	0.00	0.00	0.00	3.47
Fuel filter	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	1.97
Fuel pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
Heat exchanger	0.69	0.46	0.00	0.00	0.23	0.00	0.00	0.00	0.00	2.78
Heater	0.00	0.46	0.00	0.69	0.00	0.00	0.00	0.00	0.00	1.85
Hood	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	1.16
Injections	1.50	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	4.40
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Instrument, general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.69
Instrument, level	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.46	0.00	4.63
Instrument, pressure	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.46	0.00	4.86
Instrument, speed	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	0.00	0.46	0.00	0.69	0.00	0.00	0.00	0.00	0.00	10.88
Internal power supply	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Monitoring	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Oil	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.69
Other	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	1.62
Piping	0.00	0.00	0.00	1.04	0.23	0.00	0.00	0.00	0.00	8.45
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12
Pump	0.93	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
Pump w/motor	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Seals	0.12	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	3.24
Shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.93
Start energy (battery, air)	0.00	3.01	0.00	0.69	0.00	0.00	0.00	0.00	0.00	6.48
Starting unit	0.00	0.23	0.00	0.46	0.00	0.00	0.00	0.00	0.00	2.08
Subunit	0.00	1.39	0.00	1.16	0.23	0.00	0.00	0.00	0.00	3.47
Super charger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	1.16
Timing chain/V-belt	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Unknown	0.23	0.46	0.23	0.69	0.46	0.00	0.46	0.23	0.00	7.06
Valves	0.23	0.23	0.00	2.55	0.00	0.00	0.00	0.23	0.00	5.32
Total	3.94	9.03	0.23	18.75	2.08	0.00	0.46	2.55	0.69	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Combustion Enigens - Diesel engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
ERROR	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blockage/plugged	0.00	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
Breakage	0.46	0.23	0.46	1.62	0.23	0.69	0.00	0.00	0.00	1.16
Burst	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.23	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.23	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Contamination	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Control failure	1.16	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	2.08	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Erosion	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	0.00	0.00	0.23	0.00	0.23	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
Faulty signal/indication/alarm	4.17	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
Instrument failure - general	2.78	0.00	0.00	0.00	0.23	0.46	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	1.16	7.41	0.23	0.00	0.00	0.00	0.46	0.00
Looseness	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.23	0.00	0.00
Material failure - general	0.23	0.00	0.23	3.01	0.00	0.00	0.00	0.69	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	1.16	0.46	0.00	0.00	0.69	0.46	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.69	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.55	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Open circuit	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Short circuiting	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.69	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.23	0.00
Unknown	0.00	0.00	0.00	0.69	0.00	0.46	0.00	0.00	0.23	0.00
Wear	0.23	0.00	0.00	1.16	0.00	0.46	0.23	1.16	0.00	0.69
Total	25.00	0.69	2.08	17.13	2.08	7.41	0.23	3.24	2.31	2.08

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Combustion Enigens - Diesel engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
ERROR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Blockage/plugged	0.46	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.00	1.62
Breakage	0.00	0.46	0.00	0.00	0.23	0.00	0.00	0.23	0.23	6.02
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Cavitation	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Clearance/ alignment failure	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Combined causes	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.69
Contamination	0.00	0.00	0.00	5.09	0.00	0.00	0.00	0.00	0.00	6.02
Control failure	0.23	0.69	0.00	0.00	0.00	0.00	0.00	0.69	0.00	3.01
Corrosion	0.00	0.23	0.00	0.23	0.46	0.00	0.00	0.00	0.00	1.62
Deformation	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.23	0.69
Earth/isolation fault	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.93
Electrical failure - general	0.23	0.93	0.00	0.93	0.00	0.00	0.00	0.00	0.00	6.25
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
External influence - general	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Fatigue	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Faulty power/voltage	0.00	0.69	0.00	0.46	0.00	0.00	0.00	0.00	0.00	1.85
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
Instrument failure - general	0.00	0.93	0.00	0.93	0.00	0.00	0.00	0.23	0.00	5.56
Leakage	0.00	0.69	0.00	0.93	0.00	0.00	0.00	0.46	0.00	11.34
Looseness	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	2.08
Material failure - general	0.00	0.00	0.00	1.62	0.69	0.00	0.00	0.00	0.00	6.48
Mechanical Failure - general	0.46	0.69	0.23	0.69	0.00	0.00	0.00	0.00	0.00	4.86
Misc. external influences	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.23
Miscellaneous - general	0.23	0.23	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.69
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	1.85
No power/ voltage	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Open circuit	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.23	0.00	2.78
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Out of adjustment	1.16	0.46	0.00	1.62	0.00	0.00	0.00	0.23	0.00	9.95
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Short circuiting	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.46
Software failure	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
Sticking	0.23	0.23	0.00	0.93	0.00	0.00	0.00	0.00	0.00	2.78
Unknown	0.23	0.93	0.00	1.16	0.00	0.00	0.00	0.00	0.00	3.70
Wear	0.69	0.00	0.00	1.39	0.46	0.00	0.00	0.00	0.23	6.71
Total	3.94	9.03	0.23	18.75	2.08	0.00	0.46	2.55	0.69	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.4.1.1	Machinery Combustion Enigens Diesel engine Compressed air

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0245	0.0010	

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**33.43**	**122.31**	**316.17**	**122.31**	**122.31**	**19.8**	**7.0**	**39.7**	**100.0**
	3†	**820.00**	**3000.00**	**7755.00**	**3000.00**	**3000.00**				
Fail to start on demand	1*	2.04	40.77	193.45	40.77	40.77	3.5	7.0	7.0	7.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Low output	1*	2.04	40.77	193.45	40.77	40.77	50.0	100.0	100.0	100.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Parameter deviation	1*	2.04	40.77	193.45	40.77	40.77	6.0	12.0	12.0	12.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Incipient	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**15.8**	**4.0**	**31.5**	**100.0**
	5†	**1970.00**	**5000.00**	**10515.00**	**5000.00**	**5000.00**				
Abnormal instrument reading	3*	33.43	122.31	316.17	122.31	122.31	4.3	4.0	8.7	17.0
	3†	820.00	3000.00	7755.00	3000.00	3000.00				
External leakage - Utility medium	1*	2.04	40.77	193.45	40.77	40.77	50.0	100.0	100.0	100.0
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	-	-	-	-
	1†	50.00	1000.00	4745.00	1000.00	1000.00				
All modes	**8***	**162.26**	**326.16**	**588.51**	**326.16**	**326.16**	**17.5**	**4.0**	**35.0**	**100.0**
	8†	**3980.00**	**8000.00**	**14435.00**	**8000.00**	**8000.00**				

Comments

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Taxonomy no	Item
1.4.1.2	Machinery Combustion Enigens Diesel engine Emergency power

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
52	50	2.4802	0.0216	16614

Failure mode	No of failures	Failure rate (per 106 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**21***	**0.00**	**15.67**	**73.92**	**30.19**	**8.47**	**5.5**	**1.0**	**10.3**	**32.0**
	21†	**82.54**	**6651.97**	**21380.05**	**7740.64**	**970.80**				
External leakage - Utility medium	1*	0.00	1.50	7.80	6.26	0.40	-	-	-	-
	1†	0.00	720.29	3732.01	1645.12	46.23				
Fail to start on demand	14*	0.00	12.30	64.18	28.68	5.64	8.2	1.0	12.7	32.0
	14†	16.10	5020.01	19507.96	7224.67	647.20				
Overheating	1*	0.00	0.38	1.95	1.47	0.40	1.0	1.0	1.0	1.0
	1†	0.00	136.35	702.77	305.29	46.23				
Spurious stop	5*	0.00	2.09	10.80	8.44	2.02	4.3	2.0	7.3	16.0
	5†	5.04	979.03	3539.44	1307.85	231.14				
Degraded	**29***	**0.00**	**21.01**	**99.24**	**40.57**	**11.69**	**23.4**	**1.0**	**18.4**	**56.0**
	29†	**15.84**	**5235.02**	**20416.35**	**7572.89**	**1340.63**				
Erratic output	4*	0.35	1.62	3.66	1.06	1.61	1.0	1.0	10.0	19.0
	4†	1.06	734.11	2989.45	1129.53	184.91				
External leakage - Fuel	1*	0.00	0.63	3.32	2.73	0.40	32.0	32.0	32.0	32.0
	1†	1.25	43.78	133.39	46.23	46.23				
External leakage - Utility medium	8*	0.00	5.36	28.74	13.26	3.23	20.0	1.0	13.4	39.0
	8†	0.00	1111.10	5737.73	2507.52	369.83				
Fail to start on demand	1*	0.00	1.50	7.80	6.26	0.40	-	12.0	12.0	12.0
	1†	0.00	720.29	3732.01	1645.12	46.23				
Internal leakage	3*	0.00	2.70	14.90	7.55	1.21	-	2.0	12.0	24.0
	3†	0.17	1089.59	4901.90	1944.11	138.69				
Low output	2*	0.00	0.86	4.18	1.74	0.81	4.0	8.0	8.0	8.0
	2†	0.00	150.79	815.66	516.42	92.46				
Noise	3*	0.00	1.49	8.12	5.07	1.21	14.0	10.0	16.7	28.0
	3†	0.00	624.22	3132.14	1341.05	138.69				
Other	4*	0.00	2.58	13.07	5.63	1.61	48.0	8.0	36.0	56.0
	4†	0.00	445.06	2167.76	903.69	184.91				
Overheating	3*	0.00	1.90	10.87	6.10	1.21	-	18.0	25.5	33.0
	3†	0.00	394.71	2181.30	1105.90	138.69				
Incipient	**47***	**0.03**	**35.10**	**147.19**	**56.34**	**18.95**	**8.1**	**0.5**	**21.6**	**132.0**
	47†	**545.43**	**11563.88**	**34676.61**	**11625.88**	**2172.74**				
Abnormal instrument reading	10*	0.00	7.11	36.64	15.90	4.03	14.9	1.5	21.1	84.0
	10†	0.03	1500.09	7226.57	2981.08	462.28				
Erratic output	3*	0.00	2.85	16.11	8.56	1.21	-	27.0	27.0	27.0
	3†	0.55	1383.41	6013.80	2337.35	138.69				
External leakage - Fuel	4*	0.00	1.47	7.76	3.53	1.61	2.5	2.5	2.5	2.5
	4†	0.12	848.13	3824.78	1518.45	184.91				
External leakage - Utility medium	8*	0.00	6.21	34.17	16.15	3.23	5.0	5.0	15.1	48.0
	8†	1.43	2145.75	9081.64	3493.19	369.83				

Comments

(cont.)

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Taxonomy no		Item								
1.4.1.2		Machinery Combustion Enigens Diesel engine Emergency power								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
52	50	**Calendar time *** 2.4802			**Operational time †** 0.0216		16614			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Fail to start on demand		2*	0.00	2.99	16.80	8.83	0.81	-	1.0	12.0	23.0
		2†	1.08	1440.23	6062.55	2325.42	92.46				
Minor in-service problems		9*	0.00	6.84	36.82	23.63	3.63	18.0	2.0	30.0	132.0
		9†	0.00	1907.37	10114.51	4619.75	416.06				
Noise		6*	0.00	2.23	10.06	4.00	2.42	3.8	1.0	9.3	44.0
		6†	6.24	973.78	3389.83	1250.75	277.37				
Other		2*	0.00	1.43	7.42	5.90	0.81	0.5	0.5	0.5	0.5
		2†	0.00	693.33	3663.27	1666.48	92.46				
Overheating		1*	0.00	0.63	3.32	2.73	0.40	15.0	15.0	15.0	15.0
		1†	1.25	43.78	133.39	46.23	46.23				
Structural deficiency		2*	0.00	1.34	7.64	4.31	0.81	-	48.0	88.0	128.0
		2†	0.00	491.38	2445.33	1040.98	92.46				
Unknown		**2***	**0.00**	**3.64**	**19.14**	**13.16**	**0.81**	**-**	**8.0**	**8.0**	**8.0**
		2†	**0.03**	**1666.36**	**8058.67**	**3329.08**	**92.46**				
Unknown		2*	0.00	3.64	19.14	13.16	0.81	-	8.0	8.0	8.0
		2†	0.03	1666.36	8058.67	3329.08	92.46				
All modes		**99***	**0.31**	**79.15**	**303.91**	**111.93**	**39.92**	**11.6**	**0.5**	**18.5**	**132.0**
		99†	**2617.64**	**25955.46**	**69982.38**	**22414.22**	**4576.62**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 7.2. 10-4

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Taxonomy no	Item
1.4.1.3	Machinery Combustion Enigens Diesel engine Main power

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
6	2	0.1761	0.0487	800

Failure mode	No of failures	Failure rate (per 106 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**23***	**2.84**	**90.12**	**273.49**	**94.20**	**130.63**	**78.8**	**1.0**	**168.5**	**2730.0**
	23†	**7.78**	**324.68**	**997.26**	**349.29**	**472.18**				
Fail to start on demand	12*	7.69	53.39	133.46	41.07	68.16	10.5	1.0	21.0	52.0
	12†	22.10	190.24	495.81	155.62	246.36				
Overheating	2*	0.78	10.14	28.79	9.44	11.36	42.5	50.0	85.0	120.0
	2†	2.57	36.47	104.88	34.57	41.06				
Spurious stop	6*	12.36	31.23	57.07	13.91	34.08	8.7	4.0	17.3	40.0
	6†	44.45	112.61	206.04	50.29	123.18				
Vibration	3*	0.91	14.62	42.73	14.16	17.04	516.7	140.0	1116.7	2730.0
	3†	2.89	52.52	155.74	51.85	61.59				
Degraded	**30***	**25.74**	**132.99**	**309.07**	**91.12**	**170.39**	**11.9**	**3.0**	**23.7**	**80.0**
	30†	**76.78**	**473.57**	**1151.17**	**348.68**	**615.89**				
Abnormal instrument reading	1*	0.11	5.21	16.10	5.68	5.68	1.5	3.0	3.0	3.0
	1†	0.39	18.77	58.12	20.53	20.53				
Erratic output	1*	0.11	5.21	16.10	5.68	5.68	30.0	60.0	60.0	60.0
	1†	0.39	18.77	58.12	20.53	20.53				
External leakage - Utility medium	11*	31.06	60.17	97.05	20.33	62.48	14.0	6.0	27.5	60.0
	11†	99.59	214.70	365.21	82.19	225.83				
Internal leakage	5*	0.84	22.93	69.21	23.61	28.40	25.2	12.0	50.4	80.0
	5†	2.50	82.38	250.34	86.42	102.65				
Low output	1*	0.11	5.21	16.10	5.68	5.68	7.0	14.0	14.0	14.0
	1†	0.39	18.77	58.12	20.53	20.53				
Other	3*	0.91	14.62	42.73	14.16	17.04	4.0	6.0	8.0	12.0
	3†	2.89	52.52	155.74	51.85	61.59				
Overheating	7*	15.71	36.44	64.16	15.03	39.76	3.0	4.0	6.0	12.0
	7†	48.07	129.13	242.16	60.58	143.71				
Structural deficiency	1*	0.11	5.21	16.10	5.68	5.68	6.0	12.0	12.0	12.0
	1†	0.39	18.77	58.12	20.53	20.53				
Incipient	**77***	**1.66**	**270.41**	**947.72**	**349.86**	**437.34**	**6.3**	**1.0**	**12.3**	**110.0**
	77†	**5.76**	**984.66**	**3478.68**	**1284.78**	**1580.78**				
Abnormal instrument reading	34*	1.67	126.84	405.58	146.48	193.11	3.0	1.0	5.9	40.0
	34†	5.23	459.12	1487.62	540.45	698.01				
External leakage - Utility medium	8*	13.43	40.04	78.15	20.28	45.44	11.9	4.0	23.8	100.0
	8†	39.04	141.35	295.61	81.15	164.24				
Internal leakage	4*	0.93	18.85	56.49	18.89	22.72	25.8	6.0	51.5	110.0
	4†	2.72	67.74	203.95	69.14	82.12				
Minor in-service problems	22*	3.15	86.78	262.06	89.43	124.95	4.8	1.0	9.5	40.0
	22†	8.44	312.46	954.27	331.85	451.65				
Other	8*	13.43	40.04	78.15	20.28	45.44	7.8	2.5	15.7	44.0
	8†	39.04	141.35	295.61	81.15	164.24				

Comments

(cont.)

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Taxonomy no		Item								
1.4.1.3		Machinery Combustion Enigens Diesel engine Main power								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
6	2	**Calendar time *** 0.1761		**Operational time †** 0.0487			800			
Failure mode		**No of failures**	**Failure rate (per 106 hours).**				**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**	**Min**	**Mean**	**Max**
Structural deficiency		1* 1†	0.11 0.39	5.21 18.77	16.10 58.12	5.68 20.53	5.68 20.53	10.0	10.0	10.0	10.0
All modes		**130*** **130†**	**4.01** **13.43**	**463.75** **1686.51**	**1548.70** **5690.29**	**567.86** **2090.88**	**738.37** **2668.86**	**20.6**	**1.0**	**43.0**	**2730.0**

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.5. 10-2

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Taxonomy no	Item
1.4.1.4	Machinery Combustion Enigens Diesel engine Process shutdown and ESD

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0526	0.0105	

Failure mode	No of failures	Failure rate (per 106 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.95**	**19.01**	**56.93**	**19.01**	**19.01**	**108.0**	**108.0**	**108.0**	**108.0**
	1†	**4.76**	**95.24**	**285.24**	**95.24**	**95.24**				
Breakdown	1*	0.95	19.01	56.93	19.01	19.01	108.0	108.0	108.0	108.0
	1†	4.76	95.24	285.24	95.24	95.24				
Degraded	**1***	**0.95**	**19.01**	**56.93**	**19.01**	**19.01**	**28.0**	**28.0**	**28.0**	**28.0**
	1†	**4.76**	**95.24**	**285.24**	**95.24**	**95.24**				
External leakage - Utility medium	1*	0.95	19.01	56.93	19.01	19.01	28.0	28.0	28.0	28.0
	1†	4.76	95.24	285.24	95.24	95.24				
All modes	**2***	**1.90**	**38.02**	**113.86**	**38.02**	**38.02**	**68.0**	**28.0**	**68.0**	**108.0**
	2†	**9.52**	**190.48**	**570.48**	**190.48**	**190.48**				

Comments

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Taxonomy no	Item
1.4.1.5	Machinery Combustion Enigens Diesel engine Water fire fighting

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
8	4	0.2734	0.0054	1060

Failure mode	No of failures	Failure rate (per 106 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**4***	**1.45**	**14.66**	**39.68**	**12.74**	**14.63**	**6.1**	**4.0**	**10.8**	**19.0**
	4†	**110.15**	**1994.21**	**5911.31**	**1967.93**	**740.12**				
Breakdown	2*	0.02	7.56	29.97	11.18	7.32	4.0	4.0	5.0	6.0
	2†	2.84	1328.14	5300.98	1982.68	370.06				
Fail to start on demand	2*	0.12	7.17	22.43	7.99	7.32	8.3	14.0	16.5	19.0
	2†	29.45	709.73	2134.96	722.15	370.06				
Degraded	**63***	**14.06**	**219.65**	**639.78**	**211.82**	**230.47**	**10.8**	**2.0**	**21.7**	**207.0**
	63†	**489.73**	**25587.76**	**79588.78**	**28226.98**	**11656.95**				
Erratic output	1*	0.00	3.52	16.48	6.71	3.66	3.0	6.0	6.0	6.0
	1†	0.42	352.65	1452.02	550.95	185.03				
External leakage - Fuel	4*	1.31	14.20	39.00	12.61	14.63	3.4	3.0	6.8	12.0
	4†	9.24	1533.90	5392.51	1991.09	740.12				
External leakage - Utility medium	25*	5.86	87.61	253.68	83.82	91.45	6.7	2.0	13.3	34.0
	25†	106.51	9607.19	31210.58	11350.16	4625.77				
High output	1*	0.20	3.70	10.99	3.66	3.66	4.0	4.0	4.0	4.0
	1†	0.69	596.62	2462.06	934.91	185.03				
Internal leakage	1*	0.00	3.61	17.31	7.12	3.66	5.0	10.0	10.0	10.0
	1†	0.35	377.90	1577.91	602.40	185.03				
Low output	6*	3.43	21.42	52.23	15.85	21.95	8.9	6.0	17.8	30.0
	6†	32.71	2356.20	7500.02	2702.29	1110.19				
Other	18*	0.81	62.27	199.31	72.02	65.85	14.6	2.0	29.2	82.0
	18†	45.67	7045.47	24480.12	9031.03	3330.56				
Overheating	2*	0.12	7.17	22.43	7.99	7.32	67.5	63.0	135.0	207.0
	2†	29.45	709.73	2134.96	722.15	370.06				
Structural deficiency	5*	2.41	18.28	46.53	14.45	18.29	5.7	3.0	13.0	30.0
	5†	188.46	2404.53	6800.70	2227.43	925.15				
Incipient	**126***	**7.91**	**435.34**	**1358.55**	**483.14**	**460.93**	**4.5**	**1.0**	**9.1**	**65.0**
	126†	**540.45**	**50699.91**	**165361.90**	**60223.28**	**23313.90**				
Abnormal instrument reading	60*	2.12	206.49	675.97	246.49	219.49	4.7	1.0	9.5	65.0
	60†	159.75	23565.99	81326.02	29981.86	11101.86				
External leakage - Utility medium	11*	10.47	39.44	83.59	23.18	40.24	3.0	2.0	6.5	18.0
	11†	350.04	4832.51	13836.45	4553.42	2035.34				
Internal leakage	1*	0.00	3.61	17.31	7.12	3.66	25.0	51.5	51.5	51.5
	1†	0.35	377.90	1577.91	602.40	185.03				
Minor in-service problems	49*	2.91	169.62	531.39	189.54	179.25	4.4	1.0	8.7	45.0
	49†	167.63	19394.84	64764.33	23746.48	9066.52				
Other	4*	4.87	14.47	28.22	7.32	14.63	2.5	1.0	4.8	12.0
	4†	27.63	1546.03	4830.02	1719.20	740.12				
Overheating	1*	0.20	3.70	10.99	3.66	3.66	3.0	3.0	3.0	3.0
	1†	0.69	596.62	2462.06	934.91	185.03				

Comments

(cont.)

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Taxonomy no		Item								
1.4.1.5		Machinery Combustion Enigens Diesel engine Water fire fighting								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
8	4	**Calendar time** * 0.2734		**Operational time** † 0.0054			1060			
Failure mode		**No of**	**Failure rate (per 106 hours).**				**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	***n*/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
All modes		**193***	**20.47**	**668.91**	**2032.32**	**701.31**	**706.03**	**6.6**	**1.0**	**13.2**	**207.0**
		193†	**1161.52**	**78593.05**	**248915.80**	**89429.38**	**35710.98**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.9. 10-3

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Taxonomy no		Item								
1.4.2		Machinery Combustion Enigens Gas engine								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
34	18	**Calendar time** * 0.3856		**Operational time** † 0.2651			1536			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	***n*/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Critical		**31***	**11.95**	**69.68**	**166.92**	**50.08**	**80.40**	**26.8**	**0.5**	**20.8**	**121.0**
		31†	**0.79**	**122.33**	**425.38**	**156.94**	**116.94**				
Breakdown		3*	0.00	6.01	26.61	10.47	7.78	36.0	8.0	36.0	84.0
		3†	1.17	10.24	26.84	8.45	11.32				
External leakage - Utility medium		2*	0.00	5.54	30.70	15.72	5.19	-	1.0	3.5	6.0
		2†	1.18	8.04	20.03	6.15	7.54				
Fail to start on demand		5*	0.01	9.13	38.04	14.51	12.97	44.8	6.0	44.8	121.0
		5†	0.32	13.98	43.06	15.12	18.86				
Fail to stop on demand		1*	0.00	2.84	13.31	5.42	2.59	-	6.0	6.0	6.0
		1†	0.00	4.62	23.30	10.00	3.77				
Low output		1*	0.00	2.55	13.55	8.97	2.59	-	0.5	0.5	0.5
		1†	0.00	4.10	21.85	14.35	3.77				
Minor in-service problems		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Other		4*	0.01	8.44	34.78	13.20	10.37	16.0	4.0	39.8	111.0
		4†	0.00	13.46	72.60	46.27	15.09				
Overheating		3*	0.00	8.57	42.06	17.68	7.78	32.0	1.0	4.5	8.0
		3†	0.00	17.27	87.24	37.51	11.32				
Parameter deviation		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Spurious stop		8*	4.65	19.44	42.57	12.08	20.75	8.8	4.0	8.6	16.0
		8†	0.00	36.45	176.90	73.38	30.18				
Structural deficiency		1*	0.00	2.55	13.55	8.97	2.59	-	6.0	6.0	6.0
		1†	0.00	4.10	21.85	14.35	3.77				
Vibration		1*	0.00	2.84	13.31	5.42	2.59	-	-	-	-
		1†	0.00	4.62	23.30	10.00	3.77				
Degraded		**50***	**66.26**	**127.41**	**204.68**	**42.64**	**129.68**	**29.5**	**0.1**	**26.1**	**221.0**
		50†	**76.84**	**196.97**	**362.21**	**88.87**	**188.61**				
Erratic output		1*	0.00	2.84	13.31	5.42	2.59	-	23.0	23.0	23.0
		1†	0.00	4.62	23.30	10.00	3.77				
External leakage - Fuel		1*	0.00	2.55	13.55	8.96	2.59	8.0	8.0	8.0	8.0
		1†	0.00	3.62	19.93	9.43	3.77				
External leakage - Utility medium		7*	3.74	18.21	41.65	12.17	18.16	36.0	1.0	25.1	78.0
		7†	1.46	28.33	84.60	28.22	26.41				
Fail to start on demand		3*	0.00	8.60	44.67	19.82	7.78	-	1.0	9.5	18.0
		3†	2.26	12.28	28.89	8.57	11.32				
High output		2*	0.01	4.02	16.00	5.97	5.19	9.0	6.0	9.0	12.0
		2†	0.31	6.20	18.56	6.20	7.54				
Internal leakage		1*	0.01	2.25	8.08	2.99	2.59	16.0	16.0	16.0	16.0
		1†	0.04	3.24	10.42	3.77	3.77				
Comments											
(cont.)											

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Taxonomy no		Item									
1.4.2		Machinery Combustion Enigens Gas engine									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
34	18	**Calendar time** * 0.3856			**Operational time** † 0.2651			1536			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	**n/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Low output		7*	0.07	16.79	62.97	23.24	18.16	12.7	1.0	25.1	74.0
		7†	0.08	25.07	97.35	36.04	26.41				
Minor in-service problems		1*	0.00	2.84	13.31	5.42	2.59	-	2.0	2.0	2.0
		1†	0.00	4.62	23.30	10.00	3.77				
Noise		1*	0.01	2.25	8.08	2.99	2.59	56.0	56.0	56.0	56.0
		1†	0.04	3.24	10.42	3.77	3.77				
Other		16*	0.55	42.49	136.07	49.18	41.50	24.6	0.1	11.7	63.0
		16†	0.72	69.60	227.74	83.03	60.35				
Overheating		3*	0.00	8.06	40.61	17.43	7.78	-	8.0	29.5	51.0
		3†	0.00	12.20	61.09	26.12	11.32				
Parameter deviation		2*	0.00	4.30	24.93	13.61	5.19	116.0	4.0	60.0	116.0
		2†	0.00	6.34	34.41	21.57	7.54				
Spurious stop		1*	0.00	2.84	13.31	5.42	2.59	-	25.0	25.0	25.0
		1†	0.00	4.62	23.30	10.00	3.77				
Structural deficiency		2*	0.00	6.19	35.49	19.14	5.19	-	85.0	153.0	221.0
		2†	0.00	10.07	57.41	30.79	7.54				
Unknown		1*	0.00	2.55	13.55	8.97	2.59	-	4.0	4.0	4.0
		1†	0.00	4.10	21.85	14.35	3.77				
Vibration		1*	0.00	2.55	13.55	8.96	2.59	42.0	42.0	42.0	42.0
		1†	0.00	7.36	42.32	22.88	3.77				
Incipient		**92***	**56.57**	**229.52**	**498.06**	**140.49**	**238.61**	**23.8**	**1.0**	**16.6**	**170.0**
		92†	**89.33**	**371.06**	**810.90**	**229.79**	**347.04**				
Abnormal instrument reading		4*	0.00	7.70	40.73	18.55	10.37	5.5	1.0	5.5	12.0
		4†	0.00	16.96	93.29	46.10	15.09				
Erratic output		3*	0.00	6.87	35.65	15.76	7.78	-	6.0	35.5	65.0
		3†	0.00	10.46	55.20	25.09	11.32				
External leakage - Fuel		1*	0.00	2.84	13.31	5.42	2.59	-	6.0	6.0	6.0
		1†	0.00	4.62	23.30	10.00	3.77				
External leakage - Utility medium		11*	1.23	27.19	81.60	27.44	28.53	15.3	3.0	11.0	33.0
		11†	0.98	41.91	128.89	45.21	41.49				
Fail to start on demand		13*	0.17	42.97	165.14	60.82	33.72	-	2.0	20.2	148.0
		13†	0.29	70.02	265.43	97.87	49.04				
Fail to stop on demand		1*	0.00	2.84	13.31	5.42	2.59	-	8.0	8.0	8.0
		1†	0.00	4.62	23.30	10.00	3.77				
Internal leakage		1*	0.01	2.25	8.08	2.99	2.59	32.0	32.0	32.0	32.0
		1†	0.04	3.24	10.42	3.77	3.77				
Minor in-service problems		5*	0.00	8.80	42.34	17.46	12.97	11.7	6.0	13.3	18.0
		5†	0.00	12.14	58.61	24.20	18.86				
Other		37*	13.07	92.44	231.98	71.54	95.96	38.0	1.0	17.2	170.0
		37†	18.27	148.06	381.69	119.21	139.57				

Comments

(cont.)

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Taxonomy no		Item								
1.4.2		Machinery Combustion Enigens Gas engine								
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**		
34	18	**Calendar time** * 0.3856			**Operational time** † 0.2651			1536		
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**	
		failures	**Lower**	**Mean**	**Upper**	**SD**	**n/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Overheating		5*	0.01	9.13	38.05	14.51	12.97	23.8	12.0	21.4	35.0
		5†	0.05	13.19	49.90	18.40	18.86				
Parameter deviation		1*	0.00	2.84	13.31	5.42	2.59	-	18.0	18.0	18.0
		1†	0.00	4.62	23.30	10.00	3.77				
Spurious stop		9*	2.94	26.53	69.94	22.11	23.34	-	4.0	15.8	66.0
		9†	3.73	43.57	121.38	39.51	33.95				
Vibration		1*	0.00	2.84	13.31	5.42	2.59	-	16.0	16.0	16.0
		1†	0.00	4.62	23.30	10.00	3.77				
Unknown		**19***	**0.43**	**56.33**	**190.93**	**70.22**	**49.28**	**-**	**1.0**	**18.5**	**142.0**
		19†	**0.69**	**91.38**	**310.34**	**114.16**	**71.67**				
Fail to start on demand		2*	0.00	5.54	30.70	15.72	5.19	-	2.0	2.0	2.0
		2†	1.18	8.04	20.03	6.15	7.54				
Minor in-service problems		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Other		10*	0.00	28.96	139.97	57.81	25.94	-	1.0	28.8	142.0
		10†	0.00	46.89	224.39	92.31	37.72				
Parameter deviation		1*	0.00	2.84	13.31	5.42	2.59	-	1.0	1.0	1.0
		1†	0.00	4.62	23.30	10.00	3.77				
Unknown		5*	0.00	15.61	81.08	35.91	12.97	-	2.0	5.5	12.0
		5†	0.00	25.37	131.10	57.43	18.86				
All modes		**192***	**200.77**	**475.20**	**844.18**	**199.69**	**497.98**	**26.5**	**0.1**	**20.0**	**221.0**
		192†	**246.19**	**786.94**	**1576.63**	**418.23**	**724.25**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.6. 10-3

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Maintainable **item versus failure mode, to be continued**
Item: Combustion Enigens - Gas engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00
Cam shaft	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00
Cylinders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exhaust	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Injections	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	2.08	0.00
Other	0.00	0.00	1.04	2.60	0.00	1.56	0.00	0.00	0.52	0.00
Piping	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00	0.00
Start control	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Starting unit	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00
Timing chain/V-belt	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.56	1.04	0.00	2.60	1.04	2.60	0.52	1.04	1.04	0.52
Total	2.08	1.56	1.04	10.42	2.08	11.98	1.04	1.04	4.17	0.52

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable **item versus failure mode, continued**
Item: Combustion Enigens - Gas engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.52	0.00	1.04
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	1.04
Cam shaft	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Control unit	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Cylinders	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Exhaust	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.56
Heat exchanger	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Injections	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Instrument, level	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Instrument, pressure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Instrument, speed	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	2.08
Instrument, temperature	1.56	1.04	0.00	0.00	0.00	0.00	0.00	0.52	0.00	3.12
Internal power supply	0.52	2.08	0.00	0.00	0.00	0.00	0.52	0.00	0.00	5.73
Other	0.52	11.98	1.04	0.52	0.00	0.00	0.52	3.12	0.52	23.96
Piping	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.52	0.00	3.12
Piston(s)	0.00	0.52	0.52	0.00	0.52	0.00	0.00	0.00	0.00	2.08
Pump	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Start control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Start energy (battery, air)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Starting unit	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	3.12
Timing chain/V-belt	0.52	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.82
Unknown	2.60	13.54	0.52	2.08	0.52	0.00	1.56	3.65	0.52	36.98
Total	5.73	34.90	2.60	4.17	1.56	1.04	3.13	9.38	1.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure **descriptior versus failure mode, to be continued**
Item: Combustion Enigens - Gas engine

	AIR	BRD	ELF	ELU	ERO	FTS	HIO	INL	LOO	NOI
Breakage	0.00	0.52	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	1.04	0.52	0.00	0.00	0.00	0.52	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00
Corrosion	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.52	1.56	0.00	0.00	0.52	0.00
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00
Leakage	0.00	0.00	1.04	4.69	0.00	0.52	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.52	0.52	0.00	1.04	0.00	0.52	0.00	0.52	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.52	0.00	3.65	0.00	0.00	1.04	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.52	0.00	0.52	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.52
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00
Overheating	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.52	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	1.56	0.52	0.00	0.00	0.52	0.00	0.00
Total	2.08	1.56	1.04	10.42	2.08	11.98	1.04	1.04	4.17	0.52

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure **descriptior versus failure mode, continued**
Item: Combustion Enigens - Gas engine

	OHE	OTH	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	2.08
Combined causes	0.52	1.04	0.52	0.52	0.52	0.00	0.00	1.04	0.00	6.25
Common mode failure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.04
Contamination	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Control failure	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52	0.00	3.12
Corrosion	0.00	0.52	0.00	0.00	0.52	0.00	0.00	0.00	0.00	1.56
Electrical failure - general	1.04	2.60	0.00	0.52	0.00	0.52	1.04	0.00	0.00	8.33
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.52
Faulty signal/indication/alarm	0.00	0.52	0.00	0.00	0.00	0.00	0.00	1.04	0.00	1.56
Instrument failure - general	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	2.08
Leakage	0.00	0.52	0.00	0.52	0.52	0.00	0.00	0.00	0.00	7.81
Looseness	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.52
Material failure - general	0.52	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.21
Mechanical Failure - general	0.00	6.25	0.00	1.04	0.00	0.00	0.52	2.60	0.00	15.62
Misc. external influences	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Miscellaneous - general	0.52	2.08	0.00	0.00	0.00	0.00	0.52	0.52	0.00	4.69
No cause found	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.52
Other	0.00	10.94	1.04	0.00	0.00	0.00	0.00	2.08	0.00	15.10
Out of adjustment	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Overheating	0.52	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.65
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
Unknown	0.52	0.52	0.00	0.00	0.00	0.00	1.04	0.52	0.00	4.69
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	1.04
Wear	2.08	3.12	0.00	0.00	0.00	0.52	0.00	0.00	0.00	8.33
Total	5.73	34.90	2.60	4.17	1.56	1.04	3.13	9.38	1.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item									
1.4.2.1		Machinery Combustion Enigens Gas engine Crude oil handling									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
3	1	**Calendar time** * 0.0789			**Operational time** † 0.0761			144			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Critical		**11***	**78.19**	**139.40**	**230.76**	**139.40**	**139.40**	**33.6**	**4.0**	**33.6**	**121.0**
		11†	**81.10**	**144.59**	**239.37**	**144.59**	**144.59**				
Breakdown		2*	4.50	25.34	79.77	25.34	25.34	50.0	16.0	50.0	84.0
		2†	4.67	26.29	82.75	26.29	26.29				
Fail to start on demand		4*	17.30	50.69	116.02	50.69	50.69	54.5	12.0	54.5	121.0
		4†	17.94	52.58	120.34	52.58	52.58				
Other		2*	4.50	25.34	79.77	25.34	25.34	10.0	4.0	10.0	16.0
		2†	4.67	26.29	82.75	26.29	26.29				
Spurious stop		3*	10.39	38.02	98.27	38.02	38.02	10.7	8.0	10.7	16.0
		3†	10.78	39.43	101.94	39.43	39.43				
Degraded		**11***	**78.19**	**139.40**	**230.76**	**139.40**	**139.40**	**32.1**	**6.0**	**32.1**	**116.0**
		11†	**81.10**	**144.59**	**239.37**	**144.59**	**144.59**				
External leakage - Utility medium		1*	0.63	12.67	60.13	12.67	12.67	30.0	30.0	30.0	30.0
		1†	0.66	13.14	62.37	13.14	13.14				
High output		2*	4.50	25.34	79.77	25.34	25.34	9.0	6.0	9.0	12.0
		2†	4.67	26.29	82.75	26.29	26.29				
Internal leakage		1*	0.63	12.67	60.13	12.67	12.67	16.0	16.0	16.0	16.0
		1†	0.66	13.14	62.37	13.14	13.14				
Low output		2*	4.50	25.34	79.77	25.34	25.34	12.0	8.0	12.0	16.0
		2†	4.67	26.29	82.75	26.29	26.29				
Noise		1*	0.63	12.67	60.13	12.67	12.67	56.0	56.0	56.0	56.0
		1†	0.66	13.14	62.37	13.14	13.14				
Other		3*	10.39	38.02	98.27	38.02	38.02	31.0	6.0	31.0	63.0
		3†	10.78	39.43	101.94	39.43	39.43				
Parameter deviation		1*	0.63	12.67	60.13	12.67	12.67	116.0	116.0	116.0	116.0
		1†	0.66	13.14	62.37	13.14	13.14				
Incipient		**23***	**199.19**	**291.46**	**412.92**	**291.46**	**291.46**	**25.9**	**4.0**	**25.9**	**170.0**
		23†	**206.62**	**302.33**	**428.31**	**302.33**	**302.33**				
Abnormal instrument reading		2*	4.50	25.34	79.77	25.34	25.34	10.0	8.0	10.0	12.0
		2†	4.67	26.29	82.75	26.29	26.29				
Erratic output		1*	0.63	12.67	60.13	12.67	12.67	-	-	-	-
		1†	0.66	13.14	62.37	13.14	13.14				
External leakage - Utility medium		3*	10.39	38.02	98.27	38.02	38.02	15.3	14.0	15.3	16.0
		3†	10.78	39.43	101.94	39.43	39.43				
Internal leakage		1*	0.63	12.67	60.13	12.67	12.67	32.0	32.0	32.0	32.0
		1†	0.66	13.14	62.37	13.14	13.14				
Minor in-service problems		4*	17.30	50.69	116.02	50.69	50.69	11.7	6.0	11.7	16.0
		4†	17.94	52.58	120.34	52.58	52.58				
Other		8*	50.44	101.38	182.93	101.38	101.38	39.5	4.0	39.5	170.0
		8†	52.32	105.16	189.74	105.16	105.16				
Comments											
(cont.)											

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Taxonomy no		Item									
1.4.2.1		Machinery Combustion Enigens Gas engine Crude oil handling									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
		Calendar time *			**Operational time** †						
3	1	0.0789			0.0761			144			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Overheating		4*	17.30	50.69	116.02	50.69	50.69	23.8	12.0	23.8	35.0
		4†	17.94	52.58	120.34	52.58	52.58				
All modes		**45***	**437.98**	**570.26**	**731.13**	**570.26**	**570.26**	**29.5**	**4.0**	**29.5**	**170.0**
		45†	**454.31**	**591.51**	**758.38**	**591.51**	**591.51**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 2.8. 10-2

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Taxonomy no		Item								
1.4.2.2		Machinery Combustion Enigens Gas engine Emergency power								
Population	**Installations**	**Aggregated time in service (106 hours)**					**No of demands**			
1	1	**Calendar time *** 0.0263		**Operational time †** 0.0053						
Failure mode		**No of failures**	**Failure rate (per 106 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	**n/τ**		**Min**	**Mean**	**Max**
Critical		**6***	**99.41**	**228.10**	**450.12**	**228.10**	**228.10**	**16.0**	**4.0**	**12.0**	**28.0**
		6†	**498.10**	**1142.86**	**2255.24**	**1142.86**	**1142.86**				
Breakdown		1*	1.90	38.02	180.39	38.02	38.02	8.0	8.0	8.0	8.0
		1†	9.52	190.48	903.81	190.48	190.48				
Other		1*	1.90	38.02	180.39	38.02	38.02	28.0	28.0	28.0	28.0
		1†	9.52	190.48	903.81	190.48	190.48				
Overheating		1*	1.90	38.02	180.39	38.02	38.02	32.0	-	-	-
		1†	9.52	190.48	903.81	190.48	190.48				
Spurious stop		3*	31.17	114.05	294.82	114.05	114.05	6.0	4.0	6.0	8.0
		3†	156.19	571.43	1477.14	571.43	571.43				
Degraded		**3***	**31.17**	**114.05**	**294.82**	**114.05**	**114.05**	**28.0**	**18.0**	**28.0**	**42.0**
		3†	**156.19**	**571.43**	**1477.14**	**571.43**	**571.43**				
External leakage - Utility medium		1*	1.90	38.02	180.39	38.02	38.02	24.0	24.0	24.0	24.0
		1†	9.52	190.48	903.81	190.48	190.48				
Other		1*	1.90	38.02	180.39	38.02	38.02	18.0	18.0	18.0	18.0
		1†	9.52	190.48	903.81	190.48	190.48				
Vibration		1*	1.90	38.02	180.39	38.02	38.02	42.0	42.0	42.0	42.0
		1†	9.52	190.48	903.81	190.48	190.48				
Incipient		**3***	**31.17**	**114.05**	**294.82**	**114.05**	**114.05**	**9.3**	**1.0**	**9.3**	**26.0**
		3†	**156.19**	**571.43**	**1477.14**	**571.43**	**571.43**				
Abnormal instrument reading		2*	13.50	76.03	239.32	76.03	76.03	1.0	1.0	1.0	1.0
		2†	67.62	380.95	1199.05	380.95	380.95				
Other		1*	1.90	38.02	180.39	38.02	38.02	26.0	26.0	26.0	26.0
		1†	9.52	190.48	903.81	190.48	190.48				
All modes		**12***	**263.27**	**456.20**	**739.04**	**456.20**	**456.20**	**17.5**	**1.0**	**16.0**	**42.0**
		12†	**1319.05**	**2285.71**	**3702.80**	**2285.71**	**2285.71**				

Comments

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Taxonomy no	Item
1.4.2.3	Machinery Combustion Enigens Gas engine Main power

Population	Installations	Aggregated time in service (106 hours)		No of demands
		Calendar time *	Operational time †	
30	16	0.2803	0.1838	1392

Failure mode	No of failures	Failure rate (per 106 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**14***	**5.74**	**48.00**	**124.44**	**38.96**	**49.94**	**6.0**	**0.5**	**12.6**	**111.0**
	14†	**7.17**	**74.26**	**202.13**	**65.06**	**76.18**				
External leakage - Utility medium	2*	0.00	6.64	35.83	16.61	7.13	-	1.0	3.5	6.0
	2†	0.00	10.44	56.93	26.58	10.88				
Fail to start on demand	1*	0.00	3.13	17.79	9.50	3.57	6.0	6.0	6.0	6.0
	1†	0.00	4.60	23.25	10.00	5.44				
Fail to stop on demand	1*	0.18	3.58	10.69	3.57	3.57	-	6.0	6.0	6.0
	1†	0.30	5.50	16.33	5.44	5.44				
Low output	1*	0.00	3.13	17.80	9.51	3.57	-	0.5	0.5	0.5
	1†	0.00	4.89	28.14	15.22	5.44				
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
	1†	0.30	5.50	16.33	5.44	5.44				
Other	1*	0.00	3.13	17.80	9.51	3.57	-	111.0	111.0	111.0
	1†	0.00	4.89	28.14	15.22	5.44				
Overheating	2*	0.00	7.26	40.05	20.22	7.13	-	1.0	4.5	8.0
	2†	0.00	11.48	63.57	32.49	10.88				
Parameter deviation	1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
	1†	0.30	5.50	16.33	5.44	5.44				
Spurious stop	2*	0.00	7.25	39.88	19.50	7.13	-	6.0	8.0	10.0
	2†	0.00	11.47	63.09	31.19	10.88				
Structural deficiency	1*	0.00	3.13	17.80	9.51	3.57	-	6.0	6.0	6.0
	1†	0.00	4.89	28.14	15.22	5.44				
Vibration	1*	0.18	3.58	10.69	3.57	3.57	-	-	-	-
	1†	0.30	5.50	16.33	5.44	5.44				
Degraded	**36***	**46.64**	**125.42**	**235.31**	**58.89**	**128.41**	**24.8**	**0.1**	**23.9**	**221.0**
	36†	**78.06**	**191.95**	**346.71**	**83.51**	**195.89**				
Erratic output	1*	0.18	3.58	10.69	3.57	3.57	-	23.0	23.0	23.0
	1†	0.30	5.50	16.33	5.44	5.44				
External leakage - Fuel	1*	0.00	3.13	17.79	9.50	3.57	8.0	8.0	8.0	8.0
	1†	0.00	4.60	23.25	10.00	5.44				
External leakage - Utility medium	5*	0.73	17.29	51.98	17.57	17.84	45.0	1.0	24.4	78.0
	5†	3.45	26.09	66.36	20.60	27.21				
Fail to start on demand	3*	0.00	10.25	49.96	20.84	10.70	-	1.0	9.5	18.0
	3†	0.00	16.14	79.25	33.35	16.32				
Low output	5*	0.06	16.98	65.71	24.28	17.84	14.0	1.0	30.4	74.0
	5†	0.06	25.76	101.70	37.90	27.21				
Minor in-service problems	1*	0.18	3.58	10.69	3.57	3.57	-	2.0	2.0	2.0
	1†	0.30	5.50	16.33	5.44	5.44				
Other	12*	0.20	43.39	160.37	59.23	42.80	12.0	0.1	5.9	24.0
	12†	0.28	67.68	257.13	94.79	65.30				

Comments

(cont.)

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Taxonomy no		Item									
1.4.2.3		Machinery Combustion Enigens Gas engine Main power									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
30	16	**Calendar time** * 0.2803			**Operational time** † 0.1838			1392			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	**n/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Overheating		3*	0.00	9.77	45.35	18.34	10.70	-	8.0	29.5	51.0
		3†	0.00	14.51	67.73	27.49	16.32				
Parameter deviation		1*	0.18	3.58	10.69	3.57	3.57	-	4.0	4.0	4.0
		1†	0.30	5.50	16.33	5.44	5.44				
Spurious stop		1*	0.18	3.58	10.69	3.57	3.57	-	25.0	25.0	25.0
		1†	0.30	5.50	16.33	5.44	5.44				
Structural deficiency		2*	0.00	7.26	40.05	20.22	7.13	-	85.0	153.0	221.0
		2†	0.00	11.48	63.57	32.49	10.88				
Unknown		1*	0.00	3.13	17.80	9.51	3.57	-	4.0	4.0	4.0
		1†	0.00	4.89	28.14	15.22	5.44				
Incipient		**66***	**42.54**	**231.95**	**546.16**	**162.15**	**235.43**	**-**	**1.0**	**13.5**	**148.0**
		66†	**60.65**	**368.70**	**892.92**	**269.83**	**359.13**				
Erratic output		2*	0.00	6.64	35.83	16.61	7.13	-	6.0	35.5	65.0
		2†	0.00	10.44	56.93	26.58	10.88				
External leakage - Fuel		1*	0.18	3.58	10.69	3.57	3.57	-	6.0	6.0	6.0
		1†	0.30	5.50	16.33	5.44	5.44				
External leakage - Utility medium		8*	0.26	27.76	91.79	33.57	28.54	-	3.0	9.1	33.0
		8†	0.31	43.69	149.91	55.23	43.53				
Fail to start on demand		13*	0.35	49.40	169.66	62.51	46.37	-	2.0	20.2	148.0
		13†	0.51	78.53	273.08	100.75	70.74				
Fail to stop on demand		1*	0.18	3.58	10.69	3.57	3.57	-	8.0	8.0	8.0
		1†	0.30	5.50	16.33	5.44	5.44				
Minor in-service problems		1*	0.18	3.58	10.69	3.57	3.57	-	18.0	18.0	18.0
		1†	0.30	5.50	16.33	5.44	5.44				
Other		28*	8.91	95.11	260.45	84.09	99.88	-	1.0	8.7	20.0
		28†	12.07	150.44	423.89	138.62	152.36				
Overheating		1*	0.00	3.13	17.80	9.51	3.57	-	12.0	12.0	12.0
		1†	0.00	4.89	28.14	15.22	5.44				
Parameter deviation		1*	0.18	3.58	10.69	3.57	3.57	-	18.0	18.0	18.0
		1†	0.30	5.50	16.33	5.44	5.44				
Spurious stop		9*	16.86	32.22	51.60	10.70	32.10	-	4.0	15.8	66.0
		9†	21.29	49.72	87.82	20.64	48.97				
Vibration		1*	0.18	3.58	10.69	3.57	3.57	-	16.0	16.0	16.0
		1†	0.30	5.50	16.33	5.44	5.44				
Unknown		**19***	**2.28**	**65.82**	**199.08**	**68.15**	**67.77**	**-**	**1.0**	**18.5**	**142.0**
		19†	**2.64**	**104.14**	**318.97**	**111.33**	**103.39**				
Fail to start on demand		2*	0.00	6.64	35.83	16.61	7.13	-	2.0	2.0	2.0
		2†	0.00	10.44	56.93	26.58	10.88				
Minor in-service problems		1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
		1†	0.30	5.50	16.33	5.44	5.44				

Comments

(cont.)

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Taxonomy no		Item									
1.4.2.3		Machinery Combustion Enigens Gas engine Main power									
Population	**Installations**	**Aggregated time in service (106 hours)**						**No of demands**			
30	16	**Calendar time** * 0.2803			**Operational time** † 0.1838			1392			
Failure mode		**No of**	**Failure rate (per 106 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	n/τ	**rep.hrs**	**Min**	**Mean**	**Max**
Other		10*	0.00	33.58	153.94	61.56	35.67	-	1.0	28.8	142.0
		10†	0.00	53.30	245.23	98.40	54.41				
Parameter deviation		1*	0.18	3.58	10.69	3.57	3.57	-	1.0	1.0	1.0
		1†	0.30	5.50	16.33	5.44	5.44				
Unknown		5*	0.00	18.14	90.19	38.37	17.84	-	2.0	5.5	12.0
		5†	0.00	28.77	143.74	61.37	27.21				
All modes		**135***	**154.18**	**465.50**	**913.12**	**238.02**	**481.55**	**21.7**	**0.1**	**17.0**	**221.0**
		135†	**213.84**	**730.59**	**1498.93**	**405.58**	**734.59**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0. 100

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Turboexpanders

Inventory description

The boundary definition is shown in Figure 14 and corresponding subdivision in Maintainable Items in Table 9. The Turboexpander boundary includes the expander turbine and recompressor with auxiliaries. Included in the boundary are any inlet mesh screens, but any quick closure valve in the inlet stream is excluded. Also included is any system for glycol injection in the inlet stream, but not the power or the glycol feed to such a system.

Note! The boundary for Turboexpanders used for other purposes than recompression (e.g. driving an electric generator or pump) does not include the driven unit (e.g. the generator).

Subunits that are common to the *driver* (i.e. the turboexpander) and the *driven unit* (e.g. a pump or an electric generator) are a part of the *driven unit.*

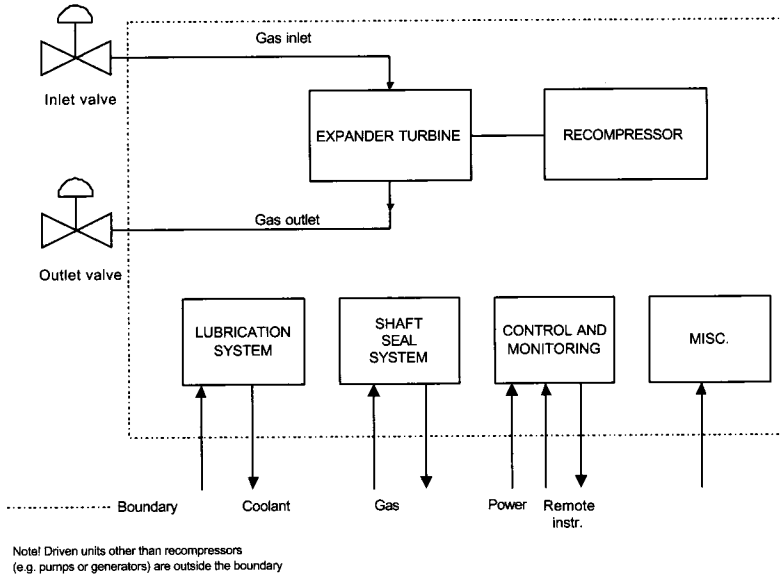

Figure 14 – Turboexpanders, Boundary Definition

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Table 9 Turboexpanders, Subdivision in Maintainable Items

TURBOEXPANDERS					
Expander turbine	Control & monitoring	Lubrication system	Shaft seal system	Miscellaneous	Recompressor
• Casing • Inlet screen • Inlet vanes • Instruments • Piping • Radial bearing • Rotor w/impeller • Seals • Thrust bearing • Valves	• Actuating device • Cabling & junction boxes • Control unit • Instruments • Internal power supply • Monitoring • Valves	• Reservoir • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Instruments • Seals	• Buffer gas system • Dry gas seal • Filters • Instruments • Overhead tank • Pump w/motor/gear • Reservoir • Scrubber • Seal gas • Seal oil • Valves	• Other	• Casing • Instruments • Piping • Radial bearing • Rotor w/impeller • Seals • Thrust bearing • Valves

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR Abnormal instrument reading
BRD Breakdown
ERO Erratic output
ELP External leakage - Process medium
ELU External leakage - Utility medium
FTS Fail to start on demand
INL Internal leakage
SER Minor in-service problems
OTH Other
UST Spurious stop
UNK Unknown
VIB Vibration

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Taxonomy no	Item
1.5	Machinery Turboexpanders

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	4	0.2979	0.2610	96

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**23***	**34.23**	**72.61**	**122.56**	**27.31**	**77.20**	-	**4.0**	**73.4**	**531.0**
	23†	**30.50**	**81.90**	**153.57**	**38.41**	**88.12**				
Breakdown	2*	0.27	6.61	19.91	6.74	6.71	-	6.0	98.0	190.0
	2†	0.09	7.67	24.66	8.93	7.66				
Erratic output	2*	0.27	6.61	19.91	6.74	6.71	-	8.0	19.0	30.0
	2†	0.09	7.67	24.66	8.93	7.66				
External leakage - Utility medium	1*	0.04	2.93	9.32	3.36	3.36	-	4.0	4.0	4.0
	1†	0.04	3.32	10.61	3.83	3.83				
Fail to start on demand	3*	1.27	13.62	37.35	12.06	10.07	-	8.0	10.0	12.0
	3†	1.12	16.09	46.32	15.27	11.49				
Other	2*	0.27	6.61	19.91	6.74	6.71	-	152.0	196.0	240.0
	2†	0.09	7.67	24.66	8.93	7.66				
Spurious stop	12*	15.95	36.36	63.52	14.75	40.28	-	6.0	61.9	531.0
	12†	22.53	42.37	67.27	13.78	45.97				
Unknown	1*	0.04	2.93	9.32	3.36	3.36	-	210.0	210.0	210.0
	1†	0.04	3.32	10.61	3.83	3.83				
Degraded	**31***	**24.34**	**91.82**	**194.68**	**54.01**	**104.05**	-	**1.0**	**12.7**	**98.0**
	31†	**82.94**	**115.65**	**152.83**	**21.33**	**118.77**				
Abnormal instrument reading	4*	0.15	10.03	31.75	11.41	13.43	-	1.0	4.0	8.0
	4†	0.17	11.32	35.80	12.85	15.32				
External leakage - Process medium	2*	1.45	7.09	16.24	4.75	6.71	-	20.0	20.0	20.0
	2†	0.01	8.62	35.64	13.54	7.66				
External leakage - Utility medium	5*	2.96	16.62	39.40	11.74	16.78	-	3.0	5.8	12.0
	5†	4.34	18.92	41.92	11.98	19.16				
Internal leakage	2*	0.23	5.60	16.84	5.70	6.71	-	2.0	2.0	2.0
	2†	0.28	6.35	19.08	6.42	7.66				
Minor in-service problems	1*	0.04	2.93	9.32	3.36	3.36	-	2.0	2.0	2.0
	1†	0.04	3.32	10.61	3.83	3.83				
Other	17*	32.17	56.65	86.72	16.76	57.06	-	2.0	18.2	98.0
	17†	20.04	63.94	128.01	33.94	65.13				
Incipient	**59***	**30.93**	**302.06**	**811.68**	**259.49**	**198.03**	-	**2.0**	**8.1**	**36.0**
	59†	**34.84**	**326.31**	**868.44**	**276.13**	**226.04**				
Abnormal instrument reading	27*	7.74	126.25	369.72	122.62	90.62	-	2.0	10.7	36.0
	27†	8.79	140.45	410.29	135.97	103.44				
External leakage - Process medium	1*	0.01	6.03	24.68	9.34	3.36	-	-	-	-
	1†	0.01	6.16	24.83	9.34	3.83				
External leakage - Utility medium	4*	1.70	23.28	66.55	21.89	13.43	-	2.0	2.0	2.0
	4†	1.99	23.67	66.12	21.55	15.32				
Minor in-service problems	9*	1.07	74.77	237.45	85.44	30.21	-	-	-	-
	9†	0.78	75.06	245.39	89.44	34.48				
Other	15*	19.49	53.45	101.07	25.49	50.35	-	2.0	5.6	12.0
	15†	13.98	62.10	138.41	39.73	57.47				

Comments

(cont.)

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Taxonomy no		Item									
1.5		Machinery Turboexpanders									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
11	4	**Calendar time** * 0.2979			**Operational time** † 0.2610			96			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
Unknown		1*	0.04	2.93	9.32	3.36	3.36	-	4.0	4.0	4.0
		1†	0.04	3.32	10.61	3.83	3.83				
Vibration		2*	0.01	13.43	56.35	21.57	6.71	-	-	-	-
		2†	0.01	13.63	57.99	22.37	7.66				
Unknown		**7***	**1.29**	**17.16**	**48.86**	**16.04**	**23.49**	**-**	**1.0**	**95.7**	**220.0**
		7†	**1.76**	**19.58**	**54.07**	**17.53**	**26.82**				
Abnormal instrument reading		2*	0.23	5.60	16.84	5.70	6.71	-	30.0	39.0	48.0
		2†	0.28	6.35	19.08	6.42	7.66				
External leakage - Utility medium		1*	0.04	2.93	9.32	3.36	3.36	-	1.0	1.0	1.0
		1†	0.04	3.32	10.61	3.83	3.83				
Other		2*	0.23	5.60	16.84	5.70	6.71	-	220.0	220.0	220.0
		2†	0.28	6.35	19.08	6.42	7.66				
Unknown		2*	0.23	5.60	16.84	5.70	6.71	-	3.0	75.5	148.0
		2†	0.28	6.35	19.08	6.42	7.66				
All modes		**120***	**181.79**	**459.16**	**839.00**	**204.50**	**402.77**	**-**	**1.0**	**32.4**	**531.0**
		120†	**211.78**	**510.39**	**913.66**	**217.90**	**459.74**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.0 \cdot 10^{-2}$

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Maintainable item versus failure mode, to be continued
Item: Turboexpanders

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	0.83	0.00	0.00	0.00	0.83	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	6.67	0.00	0.00	0.83	0.00	0.83	0.00
Instrument, speed	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	9.17	0.00	0.83	0.83	0.00	0.00	0.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	2.50	0.00	0.00	1.67	0.00	0.83	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.83	0.00	0.83	1.67	0.00	0.00	1.67
Piping	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	2.50	0.00	0.83	0.83	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	2.50	1.67	0.00	1.67	0.83	0.83	0.00
Valves	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Total	27.50	1.67	2.50	9.17	1.67	2.50	1.67

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Turboexpanders

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.67
Cabling & junction boxes	1.67	0.00	0.00	0.00	0.00	1.67
Control unit	0.00	0.00	0.83	2.50	0.00	4.17
Filter(s)	0.00	0.83	0.00	0.00	0.00	0.83
Instrument, flow	0.00	0.00	0.00	0.83	0.00	1.67
Instrument, general	1.67	0.00	0.00	0.83	0.00	2.50
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	8.33
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.83
Instrument, temperature	0.83	0.83	0.00	0.83	0.00	13.33
Instrument, vibration	0.00	0.00	0.00	0.00	1.67	1.67
Monitoring	0.83	0.00	0.00	0.83	0.00	6.67
Oil	0.83	1.67	0.00	0.00	0.00	2.50
Other	4.17	0.83	0.00	0.83	0.00	10.83
Piping	0.00	0.83	0.00	0.00	0.00	1.67
Radial bearing	1.67	0.00	0.00	0.00	0.00	1.67
Rotor w/ impellers	1.67	0.00	0.83	0.00	0.00	2.50
Seal gas equipment	0.83	0.83	0.00	0.00	0.00	5.83
Subunit	1.67	0.00	0.00	1.67	0.00	3.33
Thrust bearing	0.00	0.00	0.00	0.83	0.00	0.83
Unknown	10.83	0.00	1.67	0.83	0.00	20.83
Valves	3.33	2.50	0.00	0.00	0.00	6.67
Total	30.00	8.33	3.33	10.00	1.67	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Turboexpanders

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.83	0.00	0.83	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	0.83	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.67	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	8.33	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.17	0.00	0.00	0.00	0.83	1.67	0.00
Leakage	0.00	0.00	0.83	5.83	0.00	0.00	1.67
Looseness	0.00	0.00	0.83	0.83	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.83	0.83	0.00	0.83	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.83	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	3.33	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.83	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.83	0.00	0.00	0.83	0.83	0.00	0.00
Total	27.50	1.67	2.50	9.17	1.67	2.50	1.67

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Turboexpanders

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	1.67	0.00	0.00	0.00	3.33
Contamination	0.00	0.83	0.00	0.00	0.00	0.83
Control failure	0.00	0.00	0.00	2.50	0.00	3.33
Deformation	0.83	0.00	0.00	0.00	0.00	0.83
Electrical failure - general	3.33	0.83	0.00	2.50	0.83	9.17
External influence - general	0.00	0.83	0.00	0.00	0.00	0.83
Faulty power/voltage	0.83	0.00	0.00	0.83	0.00	1.67
Faulty signal/indication/alarm	0.00	0.00	0.00	0.83	0.83	10.00
Instrument failure - general	9.17	0.00	1.67	3.33	0.00	20.83
Leakage	0.83	0.83	0.00	0.00	0.00	10.00
Looseness	0.00	0.00	0.00	0.00	0.00	1.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.83
Mechanical Failure - general	4.17	0.00	1.67	0.00	0.00	8.33
Miscellaneous - general	0.83	0.83	0.00	0.00	0.00	1.67
No cause found	0.00	0.83	0.00	0.00	0.00	1.67
No signal/indication/alarm	0.83	0.00	0.00	0.00	0.00	4.17
Other	3.33	0.00	0.00	0.00	0.00	3.33
Out of adjustment	2.50	0.00	0.00	0.00	0.00	9.17
Overheating	1.67	0.00	0.00	0.00	0.00	1.67
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.83
Sticking	0.83	1.67	0.00	0.00	0.00	2.50
Unknown	0.83	0.00	0.00	0.00	0.00	3.33
Total	30.00	8.33	3.33	10.00	1.67	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.5.1	Machinery Turboexpanders Combined function

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
Spurious stop	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
Incipient	**3***	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**	-	-	-	-
	3†	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**				
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
Minor in-service problems	2*	20.26	114.16	359.30	114.16	114.16	-	-	-	-
	2†	20.26	114.16	359.30	114.16	114.16				
All modes	**4***	**77.91**	**228.31**	**522.55**	**228.31**	**228.31**	-	-	-	-
	4†	**77.91**	**228.31**	**522.55**	**228.31**	**228.31**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Turboexpanders - Combined function

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	25.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	25.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Turboexpanders - Combined function

	OTH	SER	UNK	UST	VIB	Sum
Instrument, temperature	0.00	25.00	0.00	25.00	0.00	50.00
Piping	0.00	25.00	0.00	0.00	0.00	50.00
Total	0.00	50.00	0.00	25.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Turboexpanders - Combined function

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.00	0.00	25.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	25.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Turboexpanders - Combined function

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	25.00	0.00	0.00	0.00	50.00
Instrument failure - general	0.00	0.00	0.00	25.00	0.00	25.00
Leakage	0.00	25.00	0.00	0.00	0.00	25.00
Total	0.00	50.00	0.00	25.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.5.1.1	Machinery Turboexpanders Combined function Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
Spurious stop	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
Incipient	**3***	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**	-	-	-	-
	3†	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**				
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
Minor in-service problems	2*	20.26	114.16	359.30	114.16	114.16	-	-	-	-
	2†	20.26	114.16	359.30	114.16	114.16				
All modes	**4***	**77.91**	**228.31**	**522.55**	**228.31**	**228.31**	-	-	-	-
	4†	**77.91**	**228.31**	**522.55**	**228.31**	**228.31**				

Comments

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Taxonomy no	Item
1.5.2	Machinery Turboexpanders Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.2454	0.2085	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**57.35**	**85.59**	**118.43**	**18.68**	**85.58**	-	**4.0**	**73.4**	**531.0**
	21†	**68.64**	**101.91**	**140.56**	**21.98**	**100.74**				
Breakdown	2*	1.63	8.72	20.45	6.06	8.15	-	6.0	98.0	190.0
	2†	1.25	10.81	28.19	8.85	9.59				
Erratic output	2*	1.63	8.72	20.45	6.06	8.15	-	8.0	19.0	30.0
	2†	1.25	10.81	28.19	8.85	9.59				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0
	1†	0.09	4.36	13.55	4.80	4.80				
Fail to start on demand	2*	0.06	13.05	48.92	18.05	8.15	-	8.0	10.0	12.0
	2†	0.07	17.36	66.26	24.42	9.59				
Other	2*	1.63	8.72	20.45	6.06	8.15	-	152.0	196.0	240.0
	2†	1.25	10.81	28.19	8.85	9.59				
Spurious stop	11*	12.32	40.15	81.00	21.62	44.83	-	6.0	61.9	531.0
	11†	22.49	48.89	83.48	18.87	52.77				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	210.0	210.0	210.0
	1†	0.09	4.36	13.55	4.80	4.80				
Degraded	**28***	**81.10**	**114.11**	**151.74**	**21.56**	**114.11**	-	**1.0**	**12.7**	**98.0**
	28†	**96.99**	**135.89**	**180.15**	**25.38**	**134.32**				
Abnormal instrument reading	4*	2.83	14.47	33.55	9.88	16.30	-	1.0	4.0	8.0
	4†	5.19	17.45	35.61	9.59	19.19				
External leakage - Process medium	1*	0.08	3.72	11.53	4.08	4.08	-	20.0	20.0	20.0
	1†	0.09	4.36	13.55	4.80	4.80				
External leakage - Utility medium	4*	5.42	16.12	31.44	8.15	16.30	-	3.0	5.8	12.0
	4†	6.53	19.17	37.18	9.59	19.19				
Internal leakage	2*	0.10	7.06	22.42	8.07	8.15	-	2.0	2.0	2.0
	2†	0.17	8.31	25.73	9.08	9.59				
Minor in-service problems	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	16*	36.85	69.86	111.39	22.96	65.21	-	2.0	18.2	98.0
	16†	32.01	88.79	168.66	42.72	76.76				
Incipient	**31***	**23.88**	**162.54**	**404.51**	**124.20**	**126.34**	-	**2.0**	**8.1**	**36.0**
	31†	**22.19**	**208.65**	**555.86**	**176.84**	**148.71**				
Abnormal instrument reading	16*	5.87	90.57	263.40	87.16	65.21	-	2.0	10.7	36.0
	16†	4.44	117.54	354.53	120.69	76.76				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	13*	14.56	63.60	141.02	40.33	52.98	-	2.0	5.6	12.0
	13†	13.02	81.43	198.62	60.29	62.36				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0
	1†	0.09	4.36	13.55	4.80	4.80				

Comments

(cont.)

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Taxonomy no	Item
1.5.2	Machinery Turboexpanders Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.2454	0.2085	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**7***	**1.31**	**23.03**	**68.05**	**22.64**	**28.53**	-	**1.0**	**95.7**	**220.0**
	7†	**2.48**	**27.16**	**74.74**	**24.19**	**33.58**				
Abnormal instrument reading	2*	0.10	7.06	22.42	8.07	8.15	-	30.0	39.0	48.0
	2†	0.17	8.31	25.73	9.08	9.59				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	1.0	1.0	1.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	2*	0.10	7.06	22.42	8.07	8.15	-	220.0	220.0	220.0
	2†	0.17	8.31	25.73	9.08	9.59				
Unknown	2*	0.10	7.06	22.42	8.07	8.15	-	3.0	75.5	148.0
	2†	0.17	8.31	25.73	9.08	9.59				
All modes	**87***	**251.11**	**374.56**	**518.14**	**81.64**	**354.56**	-	**1.0**	**32.4**	**531.0**
	87†	**236.62**	**469.46**	**766.58**	**163.41**	**417.36**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Turboexpanders - Gas processing

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.60	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	10.34	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	3.45	0.00	0.00	2.30	0.00	1.15	0.00
Other	1.15	0.00	1.15	2.30	0.00	0.00	2.30
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotor w/ impellers	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	0.00	0.00	0.00	1.15	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	3.45	2.30	0.00	2.30	1.15	1.15	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	25.29	2.30	1.15	8.05	2.30	2.30	2.30

Maintainable item versus failure mode, continued
Item: Turboexpanders - Gas processing

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.15
Cabling & junction boxes	2.30	0.00	0.00	0.00	0.00	2.30
Control unit	0.00	0.00	1.15	3.45	0.00	5.75
Instrument, flow	0.00	0.00	0.00	1.15	0.00	1.15
Instrument, general	2.30	0.00	0.00	1.15	0.00	3.45
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	4.60
Instrument, speed	0.00	0.00	0.00	0.00	0.00	1.15
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	10.34
Monitoring	1.15	0.00	0.00	1.15	0.00	9.20
Other	5.75	1.15	0.00	1.15	0.00	14.94
Radial bearing	2.30	0.00	0.00	0.00	0.00	2.30
Rotor w/ impellers	2.30	0.00	1.15	0.00	0.00	3.45
Seal gas equipment	0.00	0.00	0.00	0.00	0.00	1.15
Subunit	2.30	0.00	0.00	2.30	0.00	4.60
Thrust bearing	0.00	0.00	0.00	1.15	0.00	1.15
Unknown	14.94	0.00	2.30	1.15	0.00	28.74
Valves	4.60	0.00	0.00	0.00	0.00	4.60
Total	37.93	1.15	4.60	12.64	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Turboexpanders - Gas processing

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	1.15	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.00	1.15	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	9.20	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.75	0.00	0.00	0.00	1.15	1.15	0.00
Leakage	0.00	0.00	1.15	8.05	0.00	0.00	2.30
Mechanical Failure - general	1.15	1.15	0.00	0.00	0.00	0.00	0.00
No cause found	1.15	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	4.60	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.30	0.00	0.00	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	1.15	0.00	0.00
Total	25.29	2.30	1.15	8.05	2.30	2.30	2.30

Failure descriptior versus failure mode, continued
Item: Turboexpanders - Gas processing

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	1.15
Control failure	0.00	0.00	0.00	3.45	0.00	4.60
Deformation	1.15	0.00	0.00	0.00	0.00	1.15
Electrical failure - general	4.60	0.00	0.00	3.45	0.00	8.05
Faulty power/voltage	1.15	0.00	0.00	1.15	0.00	2.30
Faulty signal/indication/alarm	0.00	0.00	0.00	1.15	0.00	10.34
Instrument failure - general	11.49	0.00	2.30	3.45	0.00	25.29
Leakage	1.15	0.00	0.00	0.00	0.00	12.64
Mechanical Failure - general	5.75	0.00	2.30	0.00	0.00	10.34
No cause found	0.00	0.00	0.00	0.00	0.00	1.15
No signal/indication/alarm	1.15	0.00	0.00	0.00	0.00	5.75
Other	4.60	0.00	0.00	0.00	0.00	4.60
Out of adjustment	3.45	0.00	0.00	0.00	0.00	5.75
Overheating	2.30	0.00	0.00	0.00	0.00	2.30
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.15
Sticking	1.15	1.15	0.00	0.00	0.00	2.30
Unknown	0.00	0.00	0.00	0.00	0.00	1.15
Total	37.93	1.15	4.60	12.64	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.5.2.1	Machinery Turboexpanders Gas processing Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.2454	0.2085	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**57.35**	**85.59**	**118.43**	**18.68**	**85.58**	-	**4.0**	**73.4**	**531.0**
	21†	**68.64**	**101.91**	**140.56**	**21.98**	**100.74**				
Breakdown	2*	1.63	8.72	20.45	6.06	8.15	-	6.0	98.0	190.0
	2†	1.25	10.81	28.19	8.85	9.59				
Erratic output	2*	1.63	8.72	20.45	6.06	8.15	-	8.0	19.0	30.0
	2†	1.25	10.81	28.19	8.85	9.59				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0
	1†	0.09	4.36	13.55	4.80	4.80				
Fail to start on demand	2*	0.06	13.05	48.92	18.05	8.15	-	8.0	10.0	12.0
	2†	0.07	17.36	66.26	24.42	9.59				
Other	2*	1.63	8.72	20.45	6.06	8.15	-	152.0	196.0	240.0
	2†	1.25	10.81	28.19	8.85	9.59				
Spurious stop	11*	12.32	40.15	81.00	21.62	44.83	-	6.0	61.9	531.0
	11†	22.49	48.89	83.48	18.87	52.77				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	210.0	210.0	210.0
	1†	0.09	4.36	13.55	4.80	4.80				
Degraded	**28***	**81.10**	**114.11**	**151.74**	**21.56**	**114.11**	-	**1.0**	**12.7**	**98.0**
	28†	**96.99**	**135.89**	**180.15**	**25.38**	**134.32**				
Abnormal instrument reading	4*	2.83	14.47	33.55	9.88	16.30	-	1.0	4.0	8.0
	4†	5.19	17.45	35.61	9.59	19.19				
External leakage - Process medium	1*	0.08	3.72	11.53	4.08	4.08	-	20.0	20.0	20.0
	1†	0.09	4.36	13.55	4.80	4.80				
External leakage - Utility medium	4*	5.42	16.12	31.44	8.15	16.30	-	3.0	5.8	12.0
	4†	6.53	19.17	37.18	9.59	19.19				
Internal leakage	2*	0.10	7.06	22.42	8.07	8.15	-	2.0	2.0	2.0
	2†	0.17	8.31	25.73	9.08	9.59				
Minor in-service problems	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	16*	36.85	69.86	111.39	22.96	65.21	-	2.0	18.2	98.0
	16†	32.01	88.79	168.66	42.72	76.76				
Incipient	**31***	**23.88**	**162.54**	**404.51**	**124.20**	**126.34**	-	**2.0**	**8.1**	**36.0**
	31†	**22.19**	**208.65**	**555.86**	**176.84**	**148.71**				
Abnormal instrument reading	16*	5.87	90.57	263.40	87.16	65.21	-	2.0	10.7	36.0
	16†	4.44	117.54	354.53	120.69	76.76				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	2.0	2.0	2.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	13*	14.56	63.60	141.02	40.33	52.98	-	2.0	5.6	12.0
	13†	13.02	81.43	198.62	60.29	62.36				
Unknown	1*	0.08	3.72	11.53	4.08	4.08	-	4.0	4.0	4.0
	1†	0.09	4.36	13.55	4.80	4.80				

Comments

(cont.)

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Taxonomy no	Item
1.5.2.1	Machinery Turboexpanders Gas processing Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.2454	0.2085	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**7***	**1.31**	**23.03**	**68.05**	**22.64**	**28.53**	-	**1.0**	**95.7**	**220.0**
	7†	**2.48**	**27.16**	**74.74**	**24.19**	**33.58**				
Abnormal instrument reading	2*	0.10	7.06	22.42	8.07	8.15	-	30.0	39.0	48.0
	2†	0.17	8.31	25.73	9.08	9.59				
External leakage - Utility medium	1*	0.08	3.72	11.53	4.08	4.08	-	1.0	1.0	1.0
	1†	0.09	4.36	13.55	4.80	4.80				
Other	2*	0.10	7.06	22.42	8.07	8.15	-	220.0	220.0	220.0
	2†	0.17	8.31	25.73	9.08	9.59				
Unknown	2*	0.10	7.06	22.42	8.07	8.15	-	3.0	75.5	148.0
	2†	0.17	8.31	25.73	9.08	9.59				
All modes	**87***	**251.11**	**374.56**	**518.14**	**81.64**	**354.56**	-	**1.0**	**32.4**	**531.0**
	87†	**236.62**	**469.46**	**766.58**	**163.41**	**417.36**				

Comments

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Taxonomy no		Item									
1.5.3		Machinery Turboexpanders Gas treatment									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
2	1	**Calendar time** * 0.0350			**Operational time** † 0.0350			96			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**1***	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**	-	-	-	-
		1†	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**				
Fail to start on demand		1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
		1†	1.43	28.54	135.42	28.54	28.54				
Degraded		**3***	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**	-	-	-	-
		3†	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**				
External leakage - Process medium		1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
		1†	1.43	28.54	135.42	28.54	28.54				
External leakage - Utility medium		1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
		1†	1.43	28.54	135.42	28.54	28.54				
Other		1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
		1†	1.43	28.54	135.42	28.54	28.54				
Incipient		**25***	**496.04**	**713.47**	**996.43**	**713.47**	**713.47**	-	-	-	-
		25†	**496.04**	**713.47**	**996.43**	**713.47**	**713.47**				
Abnormal instrument reading		11*	176.08	313.93	519.69	313.93	313.93	-	-	-	-
		11†	176.08	313.93	519.69	313.93	313.93				
External leakage - Process medium		1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
		1†	1.43	28.54	135.42	28.54	28.54				
External leakage - Utility medium		2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
		2†	10.13	57.08	179.65	57.08	57.08				
Minor in-service problems		7*	93.75	199.77	375.29	199.77	199.77	-	-	-	-
		7†	93.75	199.77	375.29	199.77	199.77				
Other		2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
		2†	10.13	57.08	179.65	57.08	57.08				
Vibration		2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
		2†	10.13	57.08	179.65	57.08	57.08				
All modes		**29***	**592.04**	**827.63**	**1128.43**	**827.63**	**827.63**	-	-	-	-
		29†	**592.04**	**827.63**	**1128.43**	**827.63**	**827.63**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.0 \cdot 10^{-2}$

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Maintainable item versus failure mode, to be continued
Item: Turboexpanders - Gas treatment

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Actuating device	3.45	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, flow	3.45	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	13.79	0.00	0.00	3.45	0.00	3.45	0.00
Instrument, temperature	6.90	0.00	3.45	3.45	0.00	0.00	0.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seal gas equipment	10.34	0.00	3.45	0.00	0.00	0.00	0.00
Valves	0.00	0.00	0.00	3.45	0.00	0.00	0.00
Total	37.93	0.00	6.90	10.34	0.00	3.45	0.00

Maintainable item versus failure mode, continued
Item: Turboexpanders - Gas treatment

	OTH	SER	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	3.45
Filter(s)	0.00	3.45	0.00	0.00	0.00	3.45
Instrument, flow	0.00	0.00	0.00	0.00	0.00	3.45
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	20.69
Instrument, temperature	3.45	0.00	0.00	0.00	0.00	17.24
Instrument, vibration	0.00	0.00	0.00	0.00	6.90	6.90
Oil	3.45	6.90	0.00	0.00	0.00	10.34
Seal gas equipment	3.45	3.45	0.00	0.00	0.00	20.69
Valves	0.00	10.34	0.00	0.00	0.00	13.79
Total	10.34	24.14	0.00	0.00	6.90	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Turboexpanders - Gas treatment

	AIR	BRD	ELP	ELU	ERO	FTS	INL
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	6.90	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	6.90	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	3.45	0.00
Looseness	0.00	0.00	3.45	3.45	0.00	0.00	0.00
Material failure - general	0.00	0.00	3.45	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	3.45	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	20.69	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	3.45	0.00	0.00	3.45	0.00	0.00	0.00
Total	37.93	0.00	6.90	10.34	0.00	3.45	0.00

Failure descriptior versus failure mode, continued
Item: Turboexpanders - Gas treatment

	OTH	SER	UNK	UST	VIB	Sum
Breakage	0.00	3.45	0.00	0.00	0.00	3.45
Contamination	0.00	3.45	0.00	0.00	0.00	3.45
Electrical failure - general	0.00	3.45	0.00	0.00	3.45	13.79
External influence - general	0.00	3.45	0.00	0.00	0.00	3.45
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	3.45	10.34
Instrument failure - general	3.45	0.00	0.00	0.00	0.00	6.90
Looseness	0.00	0.00	0.00	0.00	0.00	6.90
Material failure - general	0.00	0.00	0.00	0.00	0.00	3.45
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	3.45
Miscellaneous - general	3.45	3.45	0.00	0.00	0.00	6.90
No cause found	0.00	3.45	0.00	0.00	0.00	3.45
Out of adjustment	0.00	0.00	0.00	0.00	0.00	20.69
Sticking	0.00	3.45	0.00	0.00	0.00	3.45
Unknown	3.45	0.00	0.00	0.00	0.00	10.34
Total	10.34	24.14	0.00	0.00	6.90	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
1.5.3.1	Machinery Turboexpanders Gas treatment Centrifugal

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0350	0.0350	96

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**	-	-	-	-
	1†	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**				
Fail to start on demand	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54				
Degraded	**3***	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**	-	-	-	-
	3†	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**				
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54				
External leakage - Utility medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54				
Other	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54				
Incipient	**25***	**496.04**	**713.47**	**996.43**	**713.47**	**713.47**	-	-	-	-
	25†	**496.04**	**713.47**	**996.43**	**713.47**	**713.47**				
Abnormal instrument reading	11*	176.08	313.93	519.69	313.93	313.93	-	-	-	-
	11†	176.08	313.93	519.69	313.93	313.93				
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	1.43	28.54	135.42	28.54	28.54				
External leakage - Utility medium	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08				
Minor in-service problems	7*	93.75	199.77	375.29	199.77	199.77	-	-	-	-
	7†	93.75	199.77	375.29	199.77	199.77				
Other	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08				
Vibration	2*	10.13	57.08	179.65	57.08	57.08	-	-	-	-
	2†	10.13	57.08	179.65	57.08	57.08				
All modes	**29***	**592.04**	**827.63**	**1128.43**	**827.63**	**827.63**	-	-	-	-
	29†	**592.04**	**827.63**	**1128.43**	**827.63**	**827.63**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 1.0 10^{-2}

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ELECTRIC EQUIPMENT

Electric Generators

Inventory description

The boundary definition is shown in Figure 15 and corresponding subdivision in Maintainable Items in Table 10.

The generator is identified by its interface with the electric distribution system, i.e. terminal box (included), connecting the electrical cables to the bus bar circuit breaker.
The following specific auxiliary equipment/subunits are included in the boundary:

- Generator control, protection and trip devices
- Generator cooling system
- Bearing lubrication system

Remote instrumentation/alarms is excluded from the boundary as well as the generator separate enclosure with its equipment.

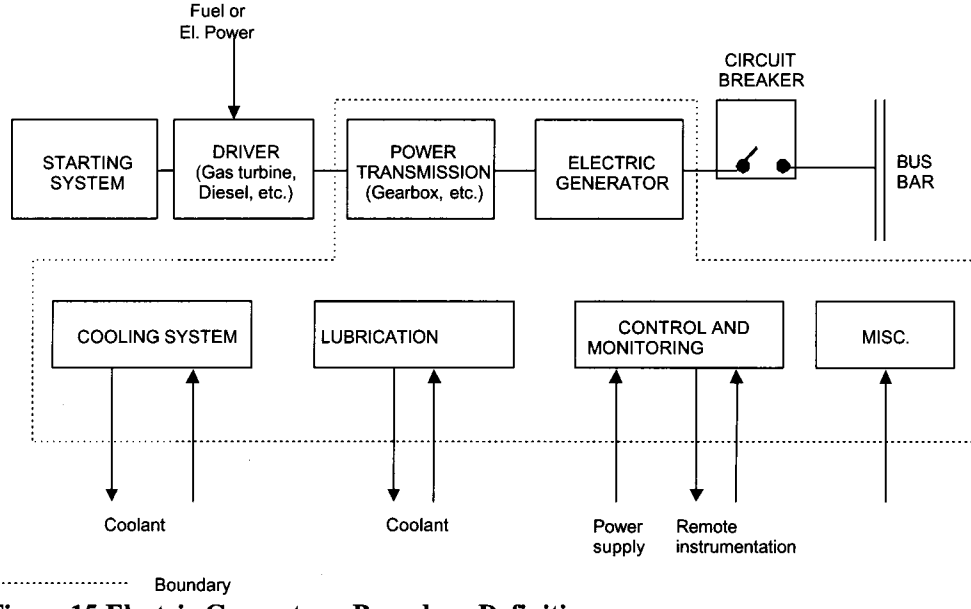

Figure 15 Electric Generators, Boundary Definition

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Table 10 Electric Generators, Subdivision in Maintainable Items

ELECTRIC GENERATOR					
Power transmission	Electric generator unit	Control and Monitoring	Lubrication system	Cooling system	Miscellaneous
• Gearbox • Bearing • Seals • Lubrication • Coupling to driver • Coupling to driven unit • Instruments	• Automatic valtage regulator • Stator • Rotor • Excitation • Instruments • Radial bearing • Thrust bearing	• Instruments • Cabling & junction boxes • Control unit • Actuating device • Monitoring • Internal power supply • Valves	• Reservoir w/heating system • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Instruments • Seals	• Heat exchanger • Fan w/motor • Filter • Valves & piping • Pump • Instruments	• Hood • Purge air • Anti condensation heater

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR	Abnormal instrument reading
BRD	Breakdown
ELU	External leakage - Utility medium
FTS	Fail to start on demand
STP	Fail to stop on demand
SYN	Fail to synchronize
FOF	Faulty output frequency
FOV	Faulty output voltage
LOO	Low output
SER	Minor in-service problems
NOI	Noise
OTH	Other
OHE	Overheating
PDE	Parameter deviation
UST	Spurious stop
STD	Structural deficiency
UNK	Unknown
VIB	Vibration

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Taxonomy no	Item
2.1	Electric Equipment Electric Generators

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
105	59	4.6865	0.9353	24231

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**148***	**5.48**	**32.23**	**77.37**	**23.25**	**31.58**	**15.6**	**1.0**	**23.8**	**566.0**
	148†	**6835.57**	**9743.18**	**13072.43**	**1904.58**	**158.24**				
Breakdown	4*	0.00	1.08	6.13	3.46	0.85	71.7	29.0	103.0	251.0
	4†	1.55	4.39	8.39	2.14	4.28				
External leakage - Utility medium	1*	0.00	0.22	1.23	0.60	0.21	8.5	17.0	17.0	17.0
	1†	0.00	1.09	4.95	1.97	1.07				
Fail to start on demand	66*	1.39	14.31	38.91	12.52	14.08	5.6	1.0	6.5	69.0
	66†	4553.71	6567.14	8881.91	1322.09	70.57				
Fail to stop on demand	5*	0.00	1.37	7.21	4.97	1.07	10.3	1.0	10.3	22.0
	5†	16.78	171.24	464.58	149.29	5.35				
Fail to synchronize	2*	0.00	0.38	2.02	1.36	0.43	15.5	2.0	31.0	60.0
	2†	0.00	2.24	9.27	3.52	2.14				
Faulty output voltage	5*	0.00	1.11	4.51	1.70	1.07	35.4	1.0	137.4	566.0
	5†	36.65	213.68	511.80	153.55	5.35				
Low output	4*	0.00	0.78	4.23	2.68	0.85	21.9	1.0	43.5	121.0
	4†	0.04	60.33	254.58	97.78	4.28				
Other	5*	0.00	1.24	3.75	6.17	1.07	3.0	6.0	6.0	6.0
	5†	0.02	5.33	20.66	7.64	5.35				
Parameter deviation	2*	0.00	0.45	1.41	2.21	0.43	6.0	4.0	7.0	10.0
	2†	0.14	44.37	172.84	64.08	2.14				
Spurious stop	50*	0.79	10.64	30.35	9.97	10.67	9.3	1.0	10.8	109.5
	50†	1068.96	1989.27	3140.52	637.62	53.46				
Structural deficiency	1*	0.00	0.22	1.23	0.60	0.21	8.0	16.0	16.0	16.0
	1†	0.00	1.09	4.95	1.97	1.07				
Vibration	3*	0.00	0.65	3.71	2.09	0.64	216.0	100.0	253.0	390.0
	3†	0.01	3.33	12.66	4.67	3.21				
Degraded	**81***	**0.00**	**18.67**	**86.07**	**34.60**	**17.28**	**52.5**	**1.0**	**83.7**	**1611.0**
	81†	**1044.21**	**2031.08**	**3282.68**	**689.80**	**86.60**				
Abnormal instrument reading	3*	0.00	0.67	3.74	2.19	0.64	8.3	9.0	10.0	11.0
	3†	0.34	77.93	290.66	107.29	3.21				
External leakage - Utility medium	12*	0.00	3.15	17.59	9.19	2.56	8.8	2.0	12.8	51.0
	12†	0.00	24.92	128.48	55.89	12.83				
Fail to stop on demand	4*	0.00	0.94	4.90	3.43	0.85	7.0	1.0	7.0	14.0
	4†	56.03	320.43	763.46	228.22	4.28				
Fail to synchronize	5*	0.41	1.05	1.94	0.48	1.07	18.5	2.0	15.2	54.0
	5†	0.00	26.05	131.41	56.44	5.35				
Faulty output frequency	1*	0.00	0.42	0.80	2.36	0.21	3.0	1.0	1.0	1.0
	1†	0.43	50.20	167.97	61.62	1.07				
Faulty output voltage	9*	0.00	2.19	11.38	5.05	1.92	10.5	1.0	15.1	70.0
	9†	136.11	415.52	818.54	214.15	9.62				
Low output	7*	0.00	1.64	8.64	5.89	1.49	21.4	2.0	21.4	82.0
	7†	0.01	57.50	263.65	105.45	7.48				

Comments

(cont.)

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Taxonomy no	Item
2.1	Electric Equipment Electric Generators

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
105	59	4.6865	0.9353	24231

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	2*	0.00	0.42	2.23	1.87	0.43	3.5	1.0	6.5	12.0
	2†	1.96	68.53	208.78	72.34	2.14				
Other	8*	0.00	1.64	9.08	4.61	1.71	273.6	1.0	467.1	1611.0
	8†	1.78	122.85	389.63	140.10	8.55				
Overheating	1*	0.01	0.21	0.64	0.21	0.21	-	14.0	14.0	14.0
	1†	0.00	1.14	5.57	2.34	1.07				
Parameter deviation	19*	0.00	4.23	23.27	11.33	4.05	4.9	1.0	7.9	32.0
	19†	267.73	724.73	1363.36	342.08	20.31				
Structural deficiency	5*	0.00	1.21	6.25	4.94	1.07	133.0	2.0	240.4	1135.0
	5†	0.03	5.52	19.56	7.22	5.35				
Vibration	5*	0.01	1.03	3.28	1.18	1.07	130.8	4.0	147.8	274.0
	5†	0.38	5.24	15.00	4.94	5.35				
Incipient	**248***	**0.24**	**47.67**	**172.62**	**63.78**	**52.92**	**8.6**	**1.0**	**12.6**	**178.0**
	248†	**6831.68**	**10786.58**	**15475.07**	**2646.55**	**265.16**				
Abnormal instrument reading	120*	0.00	23.05	115.79	49.61	25.61	7.1	1.0	8.6	62.5
	120†	2660.85	5202.04	8429.84	1777.89	128.30				
Breakdown	1*	0.00	0.42	0.80	2.36	0.21	11.0	19.0	19.0	19.0
	1†	0.43	50.20	167.97	61.62	1.07				
External leakage - Utility medium	25*	0.00	4.06	21.95	10.18	5.33	17.4	1.0	27.4	156.0
	25†	0.00	60.04	282.67	115.34	26.73				
Fail to start on demand	1*	0.00	0.42	0.80	2.36	0.21	4.0	3.0	3.0	3.0
	1†	0.43	50.20	167.97	61.62	1.07				
Fail to stop on demand	2*	0.00	0.42	2.18	1.89	0.43	3.0	1.0	5.5	10.0
	2†	37.35	198.79	465.40	137.76	2.14				
Fail to synchronize	1*	0.00	0.42	0.80	2.36	0.21	11.0	19.0	19.0	19.0
	1†	0.43	50.20	167.97	61.62	1.07				
Faulty output voltage	2*	0.00	0.55	2.83	2.23	0.43	3.5	9.0	11.5	14.0
	2†	18.21	144.06	369.70	115.24	2.14				
Low output	2*	0.00	0.44	1.02	2.37	0.43	26.3	12.0	46.5	81.0
	2†	0.08	38.42	153.86	57.65	2.14				
Minor in-service problems	32*	0.00	5.67	28.81	12.42	6.83	8.0	1.0	11.6	60.0
	32†	11.84	232.78	696.00	232.28	34.21				
Noise	9*	0.00	2.01	8.93	3.52	1.92	9.8	1.0	27.8	178.0
	9†	274.36	691.23	1261.71	307.21	9.62				
Other	21*	0.00	3.79	18.14	7.47	4.48	8.0	1.0	13.8	102.0
	21†	6.40	119.65	355.94	118.62	22.45				
Overheating	1*	0.00	0.42	0.80	2.36	0.21	6.0	6.0	6.0	6.0
	1†	0.43	50.20	167.97	61.62	1.07				
Parameter deviation	24*	0.00	4.76	26.14	12.54	5.12	3.9	1.0	4.4	16.0
	24†	1700.05	3247.01	5197.90	1077.36	25.66				
Unknown	3*	0.00	0.76	4.37	2.36	0.64	31.7	22.0	42.5	63.0
	3†	0.01	4.12	16.77	6.33	3.21				

Comments

(cont.)

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Taxonomy no		Item									
2.1		Electric Equipment Electric Generators									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
105	59	**Calendar time** * 4.6865			**Operational time** † 0.9353			24231			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours)**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
Vibration		4*	0.00	0.89	4.81	3.05	0.85	14.5	6.0	22.0	52.0
		4†	15.02	153.93	418.00	134.38	4.28				
Unknown		**4***	**0.00**	**0.84**	**4.86**	**2.63**	**0.85**	-	-	-	-
		4†	**150.99**	**418.77**	**795.37**	**201.42**	**4.28**				
Unknown		4*	0.00	0.84	4.86	2.63	0.85	-	-	-	-
		4†	150.99	418.77	795.37	201.42	4.28				
All modes		**481***	**3.32**	**98.26**	**297.46**	**102.00**	**102.64**	**18.0**	**1.0**	**28.4**	**1611.0**
		481†	**17779.86**	**25033.73**	**33303.98**	**4739.28**	**514.28**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $2.6 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Electric Generators

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	1.77	0.00	0.21	0.00	1.25	1.46	0.00	0.00	0.00
Anti condensation heater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.39	0.00	0.00	0.00	0.00	0.42	0.62	0.21	0.00
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Excitation	0.00	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Fan w/motor	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00
Filter(s)	0.21	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Gearbox	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.25	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Instrument, frequency/RPM	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.49	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Instrument, level	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.95	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.00
Instrument, vibration	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.83	0.00	0.00	0.00	0.21	0.21	0.21	0.21	0.00
Internal power supply	2.39	0.00	0.00	0.00	0.00	1.25	0.21	0.00	0.00
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	4.26	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Other	0.21	0.00	0.62	0.00	0.00	7.48	0.00	0.62	0.00
Piping	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.00
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00
Radial bearing	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Seals	0.00	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	1.04	0.62	0.42	0.00	0.00	1.25	0.42	0.00	0.00
Unknown	1.04	0.21	0.62	0.21	0.62	1.04	0.21	0.21	0.42
Valves	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Total	25.57	1.04	7.90	0.21	3.33	13.93	2.70	1.87	0.42

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric Generators

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	1.46	0.62	0.00	0.21	0.00	0.21	1.25	0.00	8.42
Anti condensation heater	0.00	0.42	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Automatic voltage regulator (AVR)	0.00	0.83	0.00	0.21	0.00	0.00	0.21	0.21	0.00	2.29
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Cabling & junction boxes	0.94	0.83	0.00	0.21	0.00	0.00	0.21	0.00	0.21	2.81
Control unit	1.25	0.00	0.00	0.00	1.04	0.83	0.21	1.25	0.00	8.21
Cooler(s)	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Coupling to driven unit	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Excitation	0.00	0.21	0.42	0.00	0.00	0.00	0.00	0.21	0.00	1.25
Fan w/motor	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.42	0.42	1.87
Filter(s)	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Gearbox	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.21	1.04
Heat exchanger	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.83
Hood	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Instrument, current	0.00	0.21	0.00	0.00	0.00	0.21	0.00	0.62	0.00	2.49
Instrument, frequency/RPM	0.00	0.42	0.00	0.00	0.21	0.00	0.00	0.21	0.00	1.25
Instrument, general	0.94	0.00	0.00	0.00	0.42	0.00	0.00	0.62	0.00	4.89
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.83
Instrument, temperature	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.62	0.00	5.41
Instrument, vibration	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.62	0.21	2.91
Instrument, voltage	0.21	0.42	0.00	0.00	0.00	0.00	0.00	0.42	0.00	2.70
Internal power supply	0.00	2.70	0.21	0.00	0.21	0.00	0.00	0.83	0.00	7.80
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.21
Monitoring	0.21	0.00	0.42	0.00	0.00	0.00	0.00	0.21	0.00	5.30
Other	0.21	0.83	1.04	0.00	0.00	0.00	0.00	0.62	0.00	11.64
Piping	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Piping, pipe support + bellows	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Pump	0.00	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Pump w/motor	0.00	0.00	0.62	0.00	0.00	0.00	0.21	0.00	0.00	1.25
Purge air	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Radial bearing	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.62
Rotor	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.62
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66
Stator	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Subunit	1.04	0.21	0.21	0.42	0.00	0.00	0.00	0.42	0.83	6.86
Unknown	0.83	0.00	0.83	0.00	0.21	0.62	0.42	1.25	0.21	8.94
Valves	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Total	7.07	9.36	7.07	1.25	2.29	1.66	1.46	10.40	2.49	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric Generators

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.21	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Breakage	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Contamination	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	1.04	0.00	0.00	0.21	0.62	0.62	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.83	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Electrical failure - general	1.25	0.21	0.00	0.00	0.42	1.04	0.21	0.21	0.21
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	1.04	0.42	0.00	0.00	0.00
Faulty signal/indication/alarm	6.86	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
Instrument failure - general	4.16	0.00	0.00	0.00	0.21	1.25	0.62	0.21	0.00
Leakage	0.21	0.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	1.46	0.00	0.62	0.00	0.00	0.00	0.21	0.00	0.00
Material failure - general	0.00	0.00	1.04	0.00	0.00	0.21	0.00	0.00	0.00
Mechanical Failure - general	0.62	0.42	1.25	0.00	0.00	0.21	0.00	0.21	0.00
Misc. external influences	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.21	0.00	0.21	0.00	0.21	0.42	0.21	0.21	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	4.78	0.00	0.00	0.00
No signal/indication/alarm	1.66	0.00	0.00	0.00	0.21	0.21	0.00	0.00	0.00
Open circuit	1.04	0.00	0.00	0.00	0.00	0.42	0.21	0.00	0.21
Other	0.00	0.00	0.42	0.00	0.00	0.21	0.00	0.00	0.00
Out of adjustment	2.08	0.00	0.00	0.00	0.00	0.83	0.42	0.00	0.00
Overheating	0.00	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00
Short circuiting	1.46	0.00	0.00	0.00	0.00	0.21	0.21	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.04	0.00	0.42	0.00	0.00	1.46	0.21	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.21	0.00
Wear	0.21	0.00	0.62	0.00	0.00	1.04	0.42	0.83	0.00
Total	25.57	1.04	7.90	0.21	3.33	13.93	2.70	1.87	0.42

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Electric Generators

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.62
Breakage	0.21	0.42	1.66	0.00	0.00	0.00	0.00	0.00	0.21	2.70
Burst	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Cavitation	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Clearance/ alignment failure	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.21	0.83
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Contamination	0.21	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	1.25
Control failure	0.42	0.42	0.21	0.00	0.21	0.42	0.00	1.46	0.00	5.61
Corrosion	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Earth/isolation fault	1.25	0.62	0.21	0.00	0.00	0.00	0.00	0.00	0.21	3.33
Electrical failure - general	1.25	3.53	0.83	0.21	0.62	0.42	0.62	2.08	0.21	13.31
External influence - general	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	1.87
Faulty signal/indication/alarm	0.42	0.00	0.00	0.00	0.21	0.21	0.00	0.42	0.00	8.32
Instrument failure - general	0.83	1.04	0.62	0.00	0.42	0.00	0.42	1.66	0.00	11.43
Leakage	0.21	0.00	0.21	0.00	0.00	0.00	0.00	0.42	0.00	2.49
Looseness	0.00	0.00	0.21	0.00	0.00	0.21	0.00	0.62	0.21	3.53
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25
Mechanical Failure - general	0.62	0.21	0.83	0.21	0.21	0.00	0.21	0.42	0.62	6.03
Misc. external influences	0.21	0.42	0.00	0.42	0.00	0.00	0.00	0.21	0.00	1.66
Miscellaneous - general	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
No cause found	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.21	0.42	2.49
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.78
No signal/indication/alarm	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29
Open circuit	0.00	0.42	0.21	0.00	0.00	0.00	0.00	0.21	0.00	2.70
Other	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.21	0.00	1.04
Out of adjustment	0.62	0.00	0.21	0.00	0.00	0.00	0.00	0.62	0.00	4.78
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.62
Short circuiting	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.42	0.00	2.91
Software failure	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Sticking	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.21	0.00	0.62
Unknown	0.00	0.00	0.00	0.00	0.42	0.00	0.21	0.00	0.00	3.74
Vibration	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.83
Wear	0.00	0.83	0.62	0.21	0.00	0.00	0.00	0.21	0.21	5.20
Total	7.07	9.36	7.07	1.25	2.29	1.66	1.46	10.40	2.49	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item									
2.1.1		Electric Equipment Electric Generators Motor driven (diesel, gas motor)									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
73	50	**Calendar time** * 3.7919		**Operational time** † 0.2323				21089			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours)**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	**n/τ**		**Min**	**Mean**	**Max**
Critical		**102***	**4.57**	**27.08**	**65.15**	**19.61**	**26.90**	**6.3**	**1.0**	**7.8**	**108.0**
		102†	**6411.94**	**12432.75**	**20061.29**	**4205.82**	**439.12**				
Breakdown		1*	0.00	0.50	1.26	2.59	0.26	49.0	49.0	49.0	49.0
		1†	0.00	13.20	64.44	26.94	4.31				
Fail to start on demand		64*	2.94	16.82	40.05	11.97	16.88	5.5	1.0	6.1	69.0
		64†	4006.87	8140.51	13454.00	2915.43	275.53				
Fail to stop on demand		5*	0.00	2.01	11.47	6.15	1.32	10.3	1.0	10.3	22.0
		5†	1.33	246.28	882.49	326.07	21.53				
Fail to synchronize		1*	0.00	0.23	1.19	0.94	0.26	1.0	2.0	2.0	2.0
		1†	0.30	4.50	13.03	4.31	4.31				
Faulty output voltage		3*	0.00	0.87	4.70	2.19	0.79	8.3	1.0	39.0	108.0
		3†	12.21	328.75	992.10	338.09	12.92				
Low output		1*	0.00	0.26	0.47	1.47	0.26	1.0	1.0	1.0	1.0
		1†	0.08	132.04	560.82	216.08	4.31				
Parameter deviation		1*	0.00	0.26	0.47	1.47	0.26	10.0	10.0	10.0	10.0
		1†	0.00	73.35	344.39	140.31	4.31				
Spurious stop		26*	1.86	6.85	14.41	3.97	6.86	6.0	1.0	6.2	58.0
		26†	1041.37	2911.25	5546.30	1408.58	111.93				
Degraded		**36***	**0.12**	**9.62**	**31.01**	**11.25**	**9.49**	**9.5**	**1.0**	**14.6**	**116.0**
		36†	**1098.85**	**3107.24**	**5945.47**	**1515.96**	**154.98**				
Abnormal instrument reading		1*	0.00	0.26	0.47	1.47	0.26	5.0	10.0	10.0	10.0
		1†	0.19	152.19	625.82	237.36	4.31				
External leakage - Utility medium		1*	0.00	0.29	1.63	0.92	0.26	12.0	12.0	12.0	12.0
		1†	0.00	64.31	306.36	125.79	4.31				
Fail to stop on demand		4*	0.00	1.13	6.30	3.71	1.05	7.0	1.0	7.0	14.0
		4†	3.27	406.69	1370.30	503.38	17.22				
Fail to synchronize		4*	0.08	1.00	2.83	0.93	1.05	10.0	2.0	5.5	10.0
		4†	0.00	47.81	249.16	111.16	17.22				
Faulty output frequency		1*	0.00	0.50	1.26	2.59	0.26	3.0	1.0	1.0	1.0
		1†	0.00	69.14	326.83	133.67	4.31				
Faulty output voltage		8*	0.00	2.56	13.18	5.73	2.11	11.0	1.0	16.1	70.0
		8†	74.02	584.87	1500.65	467.73	34.44				
Low output		3*	0.00	0.78	4.07	1.80	0.79	82.0	82.0	82.0	82.0
		3†	0.00	114.75	554.09	228.77	12.92				
Minor in-service problems		2*	0.00	0.51	2.64	2.03	0.53	3.5	1.0	6.5	12.0
		2†	0.10	97.94	407.30	155.09	8.61				
Other		2*	0.00	0.51	2.65	2.05	0.53	1.5	1.0	2.5	4.0
		2†	3.77	271.52	864.21	311.37	8.61				
Parameter deviation		9*	0.00	2.28	11.58	5.00	2.37	5.2	1.0	8.6	32.0
		9†	227.33	1121.84	2576.44	754.33	38.75				

Comments

(cont.)

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Taxonomy no		Item
2.1.1		Electric Equipment Electric Generators Motor driven (diesel, gas motor)

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
73	50	3.7919	0.2323	21089

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Vibration	1*	0.00	0.23	1.27	0.67	0.26	-	116.0	116.0	116.0
	1†	0.05	3.73	11.93	4.31	4.31				
Incipient	**144***	**0.05**	**38.78**	**159.60**	**60.54**	**37.98**	**5.3**	**1.0**	**8.6**	**178.0**
	144†	**5577.20**	**13572.90**	**24403.72**	**5848.52**	**619.94**				
Abnormal instrument reading	74*	0.00	19.75	108.52	52.28	19.52	5.1	1.0	6.9	28.0
	74†	1649.55	6516.63	14025.51	3933.89	318.58				
Breakdown	1*	0.00	0.50	1.26	2.59	0.26	11.0	19.0	19.0	19.0
	1†	0.00	69.14	326.83	133.67	4.31				
External leakage - Utility medium	5*	0.00	1.36	7.08	3.13	1.32	7.0	1.0	7.6	20.0
	5†	0.19	160.41	661.31	251.03	21.53				
Fail to start on demand	1*	0.00	0.50	1.26	2.59	0.26	4.0	3.0	3.0	3.0
	1†	0.00	69.14	326.83	133.67	4.31				
Fail to stop on demand	2*	0.00	0.51	2.65	2.05	0.53	3.0	1.0	5.5	10.0
	2†	3.29	261.02	837.81	303.14	8.61				
Fail to synchronize	1*	0.00	0.50	1.26	2.59	0.26	11.0	19.0	19.0	19.0
	1†	0.00	69.14	326.83	133.67	4.31				
Faulty output voltage	2*	0.00	0.66	3.43	2.41	0.53	3.5	9.0	11.5	14.0
	2†	1.07	191.87	683.56	252.54	8.61				
Low output	1*	0.00	0.29	1.63	0.92	0.26	12.0	12.0	12.0	12.0
	1†	0.00	64.31	306.36	125.79	4.31				
Minor in-service problems	13*	0.00	2.75	15.85	8.78	3.43	3.5	1.0	7.6	37.0
	13†	1.83	375.55	1372.33	507.01	55.97				
Noise	8*	0.00	2.16	9.58	3.77	2.11	6.9	1.0	27.1	178.0
	8†	140.46	904.06	2220.82	676.93	34.44				
Other	7*	0.11	1.85	5.45	1.81	1.85	4.3	1.0	7.6	18.0
	7†	5.18	234.57	723.54	254.60	30.14				
Overheating	1*	0.00	0.50	1.26	2.59	0.26	6.0	6.0	6.0	6.0
	1†	0.00	69.14	326.83	133.67	4.31				
Parameter deviation	24*	0.00	5.72	30.04	13.55	6.33	3.9	1.0	4.4	16.0
	24†	994.81	3945.89	8503.31	2387.12	103.32				
Unknown	2*	0.00	0.78	4.08	2.86	0.53	16.0	22.0	22.0	22.0
	2†	0.01	16.13	70.00	27.19	8.61				
Vibration	2*	0.00	0.51	2.65	2.05	0.53	14.5	6.0	29.0	52.0
	2†	2.91	252.39	816.78	296.58	8.61				
Unknown	**4***	**0.00**	**1.02**	**5.65**	**2.84**	**1.05**	-	-	-	-
	4†	**66.82**	**548.76**	**1417.98**	**443.34**	**17.22**				
Unknown	4*	0.00	1.02	5.65	2.84	1.05	-	-	-	-
	4†	66.82	548.76	1417.98	443.34	17.22				
All modes	**286***	**1.62**	**75.98**	**234.83**	**82.80**	**75.42**	**6.2**	**1.0**	**9.1**	**178.0**
	286†	**15891.73**	**30877.46**	**49876.79**	**10472.44**	**1231.27**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $2.9\ 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Electric Generators - Motor driven (diesel, gas motor)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	2.62	0.00	0.35	0.00	2.10	2.45	0.00	0.00	0.00
Anti condensation heater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.10	0.00	0.00	0.00	0.00	0.35	0.00	0.35	0.00
Excitation	0.00	0.35	0.00	0.00	0.35	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00
Heat exchanger	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.75	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Instrument, frequency/RPM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	3.85	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	3.50	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00
Instrument, voltage	0.35	0.00	0.00	0.00	0.35	0.35	0.35	0.00	0.00
Internal power supply	3.67	0.00	0.00	0.00	0.00	2.10	0.35	0.00	0.00
Monitoring	5.24	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Other	0.00	0.00	0.35	0.00	0.00	12.59	0.00	1.05	0.00
Piping	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Piping, pipe support + bellows	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	1.40	0.00	0.00	0.00	0.00	2.10	0.70	0.00	0.00
Unknown	1.05	0.35	0.70	0.35	1.05	1.40	0.00	0.35	0.35
Valves	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	26.22	0.70	2.10	0.35	4.55	22.73	1.75	2.80	0.35

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric Generators - Motor driven (diesel, gas motor)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	2.45	1.05	0.00	0.35	0.00	0.35	2.10	0.00	13.81
Anti condensation heater	0.00	0.70	0.35	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Automatic voltage regulator (AVR)	0.00	0.70	0.00	0.00	0.00	0.00	0.35	0.35	0.00	2.10
Cabling & junction boxes	0.00	0.35	0.00	0.00	0.00	0.00	0.35	0.00	0.35	1.40
Control unit	1.05	0.00	0.00	0.00	1.75	0.70	0.35	1.05	0.00	7.69
Excitation	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.35	2.10
Heat exchanger	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Instrument, current	0.00	0.35	0.00	0.00	0.00	0.35	0.00	0.35	0.00	3.15
Instrument, frequency/RPM	0.00	0.70	0.00	0.00	0.35	0.00	0.00	0.35	0.00	1.40
Instrument, general	1.40	0.00	0.00	0.00	0.70	0.00	0.00	0.70	0.00	7.34
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.35
Instrument, temperature	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	4.20
Instrument, voltage	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.70	0.00	2.45
Internal power supply	0.00	4.55	0.00	0.00	0.35	0.00	0.00	0.70	0.00	11.71
Monitoring	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.35	0.00	6.64
Other	0.00	1.05	0.35	0.00	0.00	0.00	0.00	0.70	0.00	16.08
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Piping, pipe support + bellows	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.35
Stator	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Subunit	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	4.90
Unknown	0.70	0.00	1.40	0.00	0.35	1.05	0.70	0.70	0.00	10.49
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Total	3.15	11.89	5.24	0.00	3.85	2.10	2.10	9.09	1.05	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric Generators - Motor driven (diesel, gas motor)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.35	0.00	0.00	0.35	1.05	0.70	0.00	0.00	0.00
Earth/isolation fault	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.75	0.00	0.00	0.00	0.35	1.75	0.00	0.35	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty power/voltage	0.00	0.00	0.00	0.00	1.75	0.70	0.00	0.00	0.00
Faulty signal/indication/alarm	8.39	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Instrument failure - general	4.90	0.00	0.00	0.00	0.35	2.10	0.35	0.00	0.00
Leakage	0.35	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.70	0.00	0.35	0.00	0.00	0.00	0.35	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Mechanical Failure - general	1.05	0.00	0.00	0.00	0.00	0.35	0.00	0.35	0.00
Misc. external influences	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.35	0.70	0.35	0.35	0.00
No power/ voltage	0.00	0.00	0.00	0.00	0.00	8.04	0.00	0.00	0.00
No signal/indication/alarm	1.40	0.00	0.00	0.00	0.35	0.35	0.00	0.00	0.00
Open circuit	1.05	0.00	0.00	0.00	0.00	0.35	0.35	0.00	0.35
Other	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Out of adjustment	1.40	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
Overheating	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	2.45	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00
Sticking	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.05	0.00	0.70	0.00	0.00	2.45	0.35	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.35	0.00
Wear	0.35	0.00	0.35	0.00	0.00	1.75	0.00	1.40	0.00
Total	26.22	0.70	2.10	0.35	4.55	22.73	1.75	2.80	0.35

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Electric Generators - Motor driven (diesel, gas motor)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.70
Breakage	0.00	0.70	1.40	0.00	0.00	0.00	0.00	0.00	0.35	2.45
Burst	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Contamination	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Control failure	0.35	0.70	0.00	0.00	0.35	0.70	0.00	1.40	0.00	5.94
Earth/isolation fault	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.35	1.75
Electrical failure - general	0.35	4.90	1.05	0.00	1.05	0.00	1.05	1.40	0.00	13.99
External influence - general	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	2.80
Faulty signal/indication/alarm	0.35	0.00	0.00	0.00	0.35	0.35	0.00	0.00	0.00	9.79
Instrument failure - general	1.40	0.70	0.35	0.00	0.70	0.00	0.70	2.45	0.00	13.99
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.40
Looseness	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.70	0.35	2.80
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Mechanical Failure - general	0.35	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	2.45
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
No cause found	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	2.45
No power/ voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.04
No signal/indication/alarm	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45
Open circuit	0.00	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00	2.80
Other	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Out of adjustment	0.35	0.00	0.35	0.00	0.00	0.00	0.00	0.70	0.00	4.20
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Short circuiting	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.70	0.00	4.55
Sticking	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.35	0.00	1.05
Unknown	0.00	0.00	0.00	0.00	0.70	0.00	0.35	0.00	0.00	5.59
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Wear	0.00	1.40	0.70	0.00	0.00	0.00	0.00	0.35	0.00	6.29
Total	3.15	11.89	5.24	0.00	3.85	2.10	2.10	9.09	1.05	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no 2.1.1.1

Item
Electric Equipment
Electric Generators
Motor driven (diesel, gas motor)
Emergency power

Population	Installations
65	47

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
3.5632	0.1533

No of demands 20289

Failure mode	No of failures	Failure rate (per 10^6 hours) Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**96***	**4.05**	**26.77**	**66.17**	**20.24**	**26.94**	**5.3**	**1.0**	**7.1**	**108.0**
	96†	**5382.20**	**13579.71**	**24802.36**	**6042.84**	**626.14**				
Breakdown	1*	0.00	0.53	1.50	2.68	0.28	49.0	49.0	49.0	49.0
	1†	0.06	19.13	74.81	27.78	6.52				
Fail to start on demand	62*	3.32	17.18	39.95	11.78	17.40	5.0	1.0	6.0	69.0
	62†	3340.96	8945.95	16755.19	4186.65	404.38				
Fail to stop on demand	4*	0.00	1.60	8.43	5.80	1.12	4.5	1.0	4.5	8.0
	4†	0.40	301.15	1231.35	466.02	26.09				
Faulty output voltage	3*	0.00	0.92	4.91	2.25	0.84	8.3	1.0	39.0	108.0
	3†	2.37	375.93	1311.71	484.08	19.57				
Low output	1*	0.00	0.27	0.54	1.51	0.28	1.0	1.0	1.0	1.0
	1†	0.00	151.07	739.24	309.88	6.52				
Parameter deviation	1*	0.00	0.27	0.54	1.51	0.28	10.0	10.0	10.0	10.0
	1†	0.00	83.06	438.86	199.65	6.52				
Spurious stop	24*	1.25	6.70	15.73	4.66	6.74	3.6	1.0	3.6	18.0
	24†	787.26	3268.75	7142.40	2023.77	156.53				
Degraded	**36***	**0.18**	**10.20**	**31.85**	**11.34**	**10.10**	**9.5**	**1.0**	**14.6**	**116.0**
	36†	**818.51**	**3470.04**	**7628.20**	**2169.68**	**234.80**				
Abnormal instrument reading	1*	0.00	0.27	0.54	1.51	0.28	5.0	10.0	10.0	10.0
	1†	0.00	174.82	830.82	340.72	6.52				
External leakage - Utility medium	1*	0.00	0.30	1.75	0.95	0.28	12.0	12.0	12.0	12.0
	1†	0.00	72.92	388.62	178.38	6.52				
Fail to stop on demand	4*	0.00	1.20	6.88	3.82	1.12	7.0	1.0	7.0	14.0
	4†	0.37	450.56	1888.69	722.76	26.09				
Fail to synchronize	4*	0.11	1.07	2.88	0.93	1.12	10.0	2.0	5.5	10.0
	4†	0.00	62.31	324.86	145.02	26.09				
Faulty output frequency	1*	0.00	0.53	1.50	2.68	0.28	3.0	1.0	1.0	1.0
	1†	0.00	78.31	415.56	189.94	6.52				
Faulty output voltage	8*	0.00	2.71	13.70	5.90	2.25	11.0	1.0	16.1	70.0
	8†	39.24	680.18	2006.40	666.97	52.18				
Low output	3*	0.00	0.83	4.27	1.85	0.84	82.0	82.0	82.0	82.0
	3†	0.00	138.59	724.35	324.70	19.57				
Minor in-service problems	2*	0.00	0.54	2.80	2.09	0.56	3.5	1.0	6.5	12.0
	2†	0.00	112.57	533.73	218.63	13.04				
Other	2*	0.00	0.54	2.81	2.12	0.56	1.5	1.0	2.5	4.0
	2†	1.02	310.90	1206.55	446.57	13.04				
Parameter deviation	9*	0.00	2.42	12.04	5.13	2.53	5.2	1.0	8.6	32.0
	9†	129.22	1260.56	3386.50	1082.50	58.70				
Vibration	1*	0.00	0.24	1.33	0.69	0.28	-	116.0	116.0	116.0
	1†	0.07	5.61	18.02	6.52	6.52				

Comments

(cont.)

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Taxonomy no	Item
2.1.1.1	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
65	47	3.5632	0.1533	20289

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Incipient	**128***	**0.01**	**36.69**	**159.63**	**62.07**	**35.92**	**5.3**	**1.0**	**8.9**	**178.0**
	128†	**4061.48**	**14673.29**	**30667.11**	**8414.32**	**834.85**				
Abnormal instrument reading	66*	0.00	18.42	103.12	54.00	18.52	5.1	1.0	7.1	28.0
	66†	870.72	7038.43	18135.29	5663.08	430.47				
Breakdown	1*	0.00	0.53	1.50	2.68	0.28	11.0	19.0	19.0	19.0
	1†	0.00	78.31	415.56	189.94	6.52				
External leakage - Utility medium	3*	0.00	0.77	4.00	2.86	0.84	10.5	1.0	10.3	20.0
	3†	0.05	208.77	923.81	363.38	19.57				
Fail to start on demand	1*	0.00	0.53	1.50	2.68	0.28	4.0	3.0	3.0	3.0
	1†	0.00	78.31	415.56	189.94	6.52				
Fail to stop on demand	2*	0.00	0.54	2.81	2.12	0.56	3.0	1.0	5.5	10.0
	2†	0.84	298.53	1169.60	434.64	13.04				
Fail to synchronize	1*	0.00	0.53	1.50	2.68	0.28	11.0	19.0	19.0	19.0
	1†	0.00	78.31	415.56	189.94	6.52				
Faulty output voltage	2*	0.00	0.70	3.68	2.49	0.56	3.5	9.0	11.5	14.0
	2†	0.12	218.74	934.81	361.14	13.04				
Low output	1*	0.00	0.30	1.75	0.95	0.28	12.0	12.0	12.0	12.0
	1†	0.00	72.92	388.62	178.38	6.52				
Minor in-service problems	9*	0.00	2.14	11.05	8.52	2.53	4.3	1.0	9.2	37.0
	9†	0.19	435.88	1882.25	729.99	58.70				
Noise	8*	0.00	2.29	9.94	3.86	2.25	6.9	1.0	27.1	178.0
	8†	64.96	1008.10	2933.76	971.03	52.18				
Other	6*	0.01	1.72	6.68	2.48	1.68	4.2	1.0	7.2	18.0
	6†	1.44	271.88	977.27	361.10	39.13				
Overheating	1*	0.00	0.53	1.50	2.68	0.28	6.0	6.0	6.0	6.0
	1†	0.00	78.31	415.56	189.94	6.52				
Parameter deviation	24*	0.00	6.08	31.50	13.89	6.74	3.9	1.0	4.4	16.0
	24†	535.77	4283.81	11015.61	3436.80	156.53				
Unknown	1*	0.00	0.53	1.50	2.68	0.28	10.0	-	-	-
	1†	0.06	19.13	74.81	27.78	6.52				
Vibration	2*	0.00	0.54	2.81	2.12	0.56	14.5	6.0	29.0	52.0
	2†	0.71	288.44	1140.28	425.12	13.04				
Unknown	**4***	**0.00**	**1.09**	**5.98**	**2.92**	**1.12**	**-**	**-**	**-**	**-**
	4†	**27.78**	**628.53**	**1887.64**	**635.72**	**26.09**				
Unknown	4*	0.00	1.09	5.98	2.92	1.12	-	-	-	-
	4†	27.78	628.53	1887.64	635.72	26.09				
All modes	**264***	**1.00**	**74.00**	**236.03**	**85.13**	**74.09**	**5.9**	**1.0**	**9.1**	**178.0**
	264†	**12896.16**	**33218.32**	**61214.46**	**15052.99**	**1721.88**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.0 \cdot 10^{-3}$

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Taxonomy no	Item
2.1.1.1.1	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (-1000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
28	28	2.4656	0.0143	15789

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**88***	**13.47**	**35.71**	**66.60**	**16.58**	**35.69**	**4.7**	**1.0**	**5.5**	**69.0**
	88†	**4626.18**	**22581.24**	**51708.18**	**15112.06**	**6173.40**				
Breakdown	1*	0.00	0.82	4.27	3.35	0.41	49.0	49.0	49.0	49.0
	1†	1.34	64.21	198.71	70.15	70.15				
Fail to start on demand	59*	10.95	23.77	40.57	9.17	23.93	4.7	1.0	5.9	69.0
	59†	2847.29	15167.28	35516.13	10513.91	4138.98				
Fail to stop on demand	4*	0.00	2.49	13.85	7.19	1.62	4.5	1.0	4.5	8.0
	4†	0.02	538.70	2518.39	1023.23	280.61				
Faulty output voltage	2*	0.00	0.79	4.29	2.72	0.81	2.5	1.0	4.5	8.0
	2†	0.01	555.57	2708.67	1130.55	140.30				
Low output	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	272.44	1517.35	786.63	70.15				
Parameter deviation	1*	0.00	0.40	1.25	1.96	0.41	10.0	10.0	10.0	10.0
	1†	0.00	175.17	910.28	403.84	70.15				
Spurious stop	20*	4.69	8.09	12.26	2.32	8.11	2.3	1.0	2.3	10.0
	20†	425.82	5432.13	15363.24	5031.86	1403.05				
Degraded	**23***	**0.13**	**9.90**	**31.69**	**11.45**	**9.33**	**7.3**	**1.0**	**9.0**	**82.0**
	23†	**381.01**	**5442.52**	**15660.65**	**5163.14**	**1613.50**				
Abnormal instrument reading	1*	0.00	0.40	1.25	1.96	0.41	5.0	10.0	10.0	10.0
	1†	0.00	307.28	1709.55	884.09	70.15				
Fail to stop on demand	2*	0.00	0.79	4.25	2.75	0.81	1.0	1.0	1.0	1.0
	2†	0.00	572.64	3205.97	1679.21	140.30				
Faulty output voltage	6*	0.00	3.05	15.78	6.91	2.43	3.5	1.0	3.5	13.0
	6†	4.98	1072.21	3956.77	1461.37	420.91				
Low output	2*	0.00	1.05	6.02	3.24	0.81	82.0	82.0	82.0	82.0
	2†	0.00	274.04	1507.37	744.09	140.30				
Minor in-service problems	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	178.47	935.93	421.69	70.15				
Other	2*	0.00	0.79	4.29	2.72	0.81	1.5	1.0	2.5	4.0
	2†	0.01	557.11	2716.10	1133.62	140.30				
Parameter deviation	9*	1.90	3.65	5.85	1.22	3.65	5.2	1.0	8.6	32.0
	9†	19.75	2258.72	7531.91	2760.75	631.37				
Incipient	**74***	**2.84**	**29.60**	**80.65**	**25.97**	**30.01**	**3.4**	**1.0**	**4.9**	**52.0**
	74†	**2319.15**	**20694.26**	**54433.21**	**17185.74**	**5191.27**				
Abnormal instrument reading	31*	2.35	12.38	28.89	8.54	12.57	2.3	1.0	3.6	18.0
	31†	896.92	8746.39	23495.26	7509.99	2174.72				
External leakage - Utility medium	1*	0.00	0.40	1.25	1.96	0.41	1.0	1.0	1.0	1.0
	1†	0.00	286.67	1596.67	827.84	70.15				
Fail to stop on demand	2*	0.00	0.79	4.29	2.72	0.81	3.0	1.0	5.5	10.0
	2†	0.01	539.13	2626.65	1095.35	140.30				

Comments

(cont.)

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Taxonomy no	Item
2.1.1.1.1	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (-1000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
28	28	2.4656	0.0143	15789

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Faulty output voltage	1*	0.00	0.40	1.25	1.96	0.41	3.0	9.0	9.0	9.0
	1†	0.00	269.80	1502.45	778.72	70.15				
Minor in-service problems	2*	0.00	0.79	4.29	2.72	0.81	1.5	1.0	1.5	2.0
	2†	0.01	568.71	2773.10	1157.63	140.30				
Noise	7*	0.01	2.80	10.85	4.02	2.84	3.6	1.0	5.6	15.0
	7†	5.74	1707.02	6614.88	2446.60	491.07				
Other	3*	0.00	1.37	7.06	3.06	1.22	1.3	1.0	1.3	2.0
	3†	1.97	370.07	1329.20	491.14	210.46				
Parameter deviation	24*	0.00	9.31	41.65	16.48	9.73	3.9	1.0	4.4	16.0
	24†	47.70	7345.17	25514.17	9412.26	1683.65				
Unknown	1*	0.00	0.82	4.27	3.35	0.41	10.0	-	-	-
	1†	1.34	64.21	198.71	70.15	70.15				
Vibration	2*	0.00	0.79	4.29	2.72	0.81	14.5	6.0	29.0	52.0
	2†	0.01	524.27	2553.67	1064.62	140.30				
Unknown	**4***	**0.00**	**1.59**	**8.28**	**3.70**	**1.62**	-	-	-	-
	4†	**3.95**	**1121.79**	**4335.08**	**1601.24**	**280.61**				
Unknown	4*	0.00	1.59	8.28	3.70	1.62	-	-	-	-
	4†	3.95	1121.79	4335.08	1601.24	280.61				
All modes	**189***	**17.55**	**77.29**	**171.80**	**49.22**	**76.65**	**4.6**	**1.0**	**5.7**	**82.0**
	189†	**9870.39**	**50604.91**	**117379.20**	**34566.35**	**13258.78**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.7 \cdot 10^{-3}$

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Taxonomy no	Item
2.1.1.1.2	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power (1000-3000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	3	0.3703	0.0987	1470

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**0.06**	**25.86**	**102.47**	**38.23**	**13.50**	**9.0**	**2.0**	**9.0**	**18.0**
	5†	**247.63**	**4942.87**	**14801.03**	**4941.65**	**50.65**				
Fail to start on demand	2*	0.02	9.59	38.19	14.27	5.40	8.0	2.0	8.0	14.0
	2†	94.14	1966.76	5895.82	1974.63	20.26				
Spurious stop	3*	0.03	15.00	59.63	22.27	8.10	10.0	2.0	10.0	18.0
	3†	145.30	2958.78	8864.81	2963.64	30.39				
Degraded	**11***	**14.26**	**31.83**	**55.06**	**12.64**	**29.71**	**12.2**	**2.0**	**22.6**	**116.0**
	11†	**394.62**	**4497.46**	**12472.62**	**4050.92**	**111.43**				
External leakage - Utility medium	1*	0.01	4.22	16.62	6.19	2.70	12.0	12.0	12.0	12.0
	1†	43.25	974.82	2927.34	985.62	10.13				
Fail to stop on demand	2*	0.02	9.59	38.19	14.27	5.40	13.0	12.0	13.0	14.0
	2†	94.14	1966.76	5895.82	1974.63	20.26				
Fail to synchronize	4*	1.03	10.26	27.72	8.89	10.80	10.0	2.0	5.5	10.0
	4†	33.54	935.44	2826.09	965.32	40.52				
Faulty output voltage	1*	0.13	3.04	9.13	3.08	2.70	19.0	38.0	38.0	38.0
	1†	0.03	281.73	1289.18	514.58	10.13				
Low output	1*	0.03	2.40	7.63	2.74	2.70	-	-	-	-
	1†	0.42	9.98	30.00	10.13	10.13				
Minor in-service problems	1*	0.13	3.04	9.13	3.08	2.70	6.0	12.0	12.0	12.0
	1†	0.03	281.73	1289.18	514.58	10.13				
Vibration	1*	0.03	2.40	7.63	2.74	2.70	-	116.0	116.0	116.0
	1†	0.42	9.98	30.00	10.13	10.13				
Incipient	**45***	**8.58**	**198.29**	**595.82**	**200.96**	**121.52**	**7.4**	**1.0**	**9.9**	**37.0**
	45†	**2617.94**	**31102.25**	**86907.11**	**28320.80**	**455.85**				
Abnormal instrument reading	33*	1.30	157.82	529.97	194.56	89.12	7.2	1.0	8.8	24.0
	33†	1784.92	26893.21	77958.66	25769.08	334.29				
External leakage - Utility medium	2*	0.03	6.17	22.72	8.39	5.40	20.0	10.0	15.0	20.0
	2†	39.60	961.35	2892.42	978.85	20.26				
Low output	1*	0.01	4.22	16.62	6.19	2.70	12.0	12.0	12.0	12.0
	1†	43.25	974.82	2927.34	985.62	10.13				
Minor in-service problems	7*	0.09	21.98	82.71	30.51	18.90	5.4	1.0	11.4	37.0
	7†	0.12	1675.33	7733.27	3112.26	70.91				
Other	2*	0.02	6.61	25.49	9.40	5.40	9.0	15.0	16.5	18.0
	2†	0.04	559.81	2578.31	1035.63	20.26				
All modes	**61***	**14.06**	**261.78**	**778.33**	**259.34**	**164.73**	**8.2**	**1.0**	**12.0**	**116.0**
	61†	**3328.36**	**40602.46**	**113977.20**	**37215.61**	**617.93**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.4 \cdot 10^{-3}$

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Taxonomy no	Item
2.1.1.1.3	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Emergency power Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	16	0.7273	0.0403	3030

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.47**	**4.18**	**11.00**	**3.47**	**4.12**	**15.7**	**10.0**	**44.3**	**108.0**
	3†	**0.07**	**377.42**	**1687.59**	**667.46**	**74.35**				
Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	12.0	10.0	10.0	10.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	20.0	108.0	108.0	108.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Spurious stop	1*	0.01	1.21	4.08	1.50	1.37	15.0	15.0	15.0	15.0
	1†	0.34	21.88	69.10	24.78	24.78				
Degraded	**2***	**0.00**	**3.73**	**16.89**	**6.71**	**2.75**	**25.5**	**1.0**	**35.5**	**70.0**
	2†	**0.06**	**388.59**	**1752.73**	**695.89**	**49.57**				
Faulty output frequency	1*	0.00	1.89	10.37	4.96	1.37	3.0	1.0	1.0	1.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	48.0	70.0	70.0	70.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Incipient	**9***	**0.07**	**16.07**	**59.23**	**21.88**	**12.37**	**9.7**	**3.0**	**31.9**	**178.0**
	9†	**8.34**	**1514.06**	**5406.11**	**1997.36**	**223.05**				
Abnormal instrument reading	2*	0.51	2.78	6.55	1.94	2.75	6.5	14.0	21.0	28.0
	2†	0.00	250.94	1241.13	525.73	49.57				
Breakdown	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Fail to start on demand	1*	0.00	1.89	10.37	4.96	1.37	4.0	3.0	3.0	3.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Fail to synchronize	1*	0.00	1.89	10.37	4.96	1.37	11.0	19.0	19.0	19.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Faulty output voltage	1*	0.00	1.89	10.37	4.96	1.37	4.0	14.0	14.0	14.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Noise	1*	0.00	1.89	10.37	4.96	1.37	30.0	178.0	178.0	178.0
	1†	0.00	194.40	1059.06	494.15	24.78				
Other	1*	0.00	1.22	5.81	2.38	1.37	8.0	6.0	6.0	6.0
	1†	0.00	81.19	424.66	190.58	24.78				
Overheating	1*	0.00	1.89	10.37	4.96	1.37	6.0	6.0	6.0	6.0
	1†	0.00	194.40	1059.06	494.15	24.78				
All modes	**14***	**0.75**	**24.68**	**75.01**	**25.90**	**19.25**	**13.2**	**1.0**	**35.1**	**178.0**
	14†	**49.80**	**2318.46**	**7162.47**	**2524.28**	**346.96**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.3 \cdot 10^{-4}$

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Taxonomy no	Item
2.1.1.2	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	3	0.2287	0.0790	800

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**10.67**	**30.48**	**58.54**	**14.98**	**26.24**	**20.3**	**2.0**	**19.8**	**58.0**
	6†	**10.20**	**88.50**	**231.14**	**72.64**	**75.99**				
Fail to start on demand	2*	0.03	12.59	50.36	18.86	8.75	18.0	8.0	8.0	8.0
	2†	2.75	25.67	68.29	21.71	25.33				
Fail to stop on demand	1*	0.02	9.91	39.33	14.68	4.37	22.0	22.0	22.0	22.0
	1†	0.33	46.70	160.18	59.01	12.66				
Fail to synchronize	1*	0.06	3.85	12.18	4.37	4.37	1.0	2.0	2.0	2.0
	1†	0.12	11.84	38.72	14.11	12.66				
Spurious stop	2*	0.27	9.16	27.88	9.64	8.75	31.3	9.0	33.5	58.0
	2†	4.21	24.80	59.58	17.91	25.33				
Incipient	**16***	**45.34**	**71.49**	**102.47**	**17.49**	**69.97**	**5.1**	**1.0**	**6.3**	**22.0**
	16†	**126.24**	**201.75**	**291.63**	**50.66**	**202.63**				
Abnormal instrument reading	8*	16.10	37.24	65.50	15.32	34.98	4.9	1.0	5.6	16.0
	8†	33.86	105.83	210.32	55.43	101.32				
External leakage - Utility medium	2*	0.03	12.59	50.36	18.86	8.75	3.5	1.0	3.5	6.0
	2†	2.75	25.67	68.29	21.71	25.33				
Minor in-service problems	4*	4.34	15.41	32.01	8.75	17.49	2.0	2.0	4.0	6.0
	4†	2.24	44.63	133.62	44.61	50.66				
Other	1*	0.06	3.85	12.18	4.37	4.37	5.0	10.0	10.0	10.0
	1†	0.12	11.84	38.72	14.11	12.66				
Unknown	1*	0.05	5.78	19.45	7.14	4.37	22.0	22.0	22.0	22.0
	1†	0.06	12.81	47.68	17.60	12.66				
All modes	**22***	**47.97**	**104.76**	**179.28**	**40.64**	**96.21**	**9.2**	**1.0**	**9.5**	**58.0**
	22†	**186.26**	**281.53**	**392.83**	**63.17**	**278.62**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
2.1.1.2.1	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power (-1000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	2	0.0789	0.0381	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**16.53**	**49.71**	**97.37**	**25.34**	**50.69**	**29.0**	**8.0**	**29.3**	**58.0**
	4†	**29.20**	**115.76**	**249.43**	**70.01**	**105.12**				
Fail to start on demand	2*	0.21	22.18	73.46	26.88	25.34	18.0	8.0	8.0	8.0
	2†	3.93	47.21	132.19	43.12	52.56				
Fail to stop on demand	1*	0.16	15.84	52.06	19.01	12.67	22.0	22.0	22.0	22.0
	1†	0.22	84.20	331.55	123.44	26.28				
Spurious stop	1*	0.15	11.62	37.19	13.44	12.67	58.0	58.0	58.0	58.0
	1†	0.52	24.16	74.60	26.28	26.28				
Incipient	**7***	**38.14**	**84.81**	**146.39**	**33.53**	**88.71**	**8.9**	**1.0**	**8.9**	**22.0**
	7†	**86.81**	**184.49**	**311.67**	**69.53**	**183.97**				
Abnormal instrument reading	4*	16.53	49.71	97.37	25.34	50.69	8.3	1.0	8.3	16.0
	4†	29.20	115.76	249.43	70.01	105.12				
External leakage - Utility medium	2*	0.21	22.18	73.46	26.88	25.34	3.5	1.0	3.5	6.0
	2†	3.93	47.21	132.19	43.12	52.56				
Unknown	1*	0.15	11.62	37.19	13.44	12.67	22.0	22.0	22.0	22.0
	1†	0.52	24.16	74.60	26.28	26.28				
All modes	**11***	**73.61**	**134.52**	**210.27**	**42.03**	**139.40**	**16.2**	**1.0**	**15.0**	**58.0**
	11†	**169.10**	**296.51**	**452.89**	**87.16**	**289.09**				

Comments

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Taxonomy no	Item
2.1.1.2.2	Electric Equipment Electric Generators Motor driven (diesel, gas motor) Main power (1000-3000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.1498	0.0409	800

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**2.37**	**13.35**	**42.03**	**13.35**	**13.35**	**2.8**	**2.0**	**5.5**	**9.0**
	2†	**8.68**	**48.89**	**153.87**	**48.89**	**48.89**				
Fail to synchronize	1*	0.33	6.68	31.68	6.68	6.68	1.0	2.0	2.0	2.0
	1†	1.22	24.44	115.99	24.44	24.44				
Spurious stop	1*	0.33	6.68	31.68	6.68	6.68	4.5	9.0	9.0	9.0
	1†	1.22	24.44	115.99	24.44	24.44				
Incipient	**9***	**31.35**	**60.10**	**104.87**	**60.10**	**60.10**	**2.1**	**2.0**	**4.2**	**10.0**
	9†	**114.76**	**220.00**	**383.89**	**220.00**	**220.00**				
Abnormal instrument reading	4*	9.11	26.71	61.13	26.71	26.71	1.5	2.0	3.0	5.0
	4†	33.37	97.78	223.78	97.78	97.78				
Minor in-service problems	4*	9.11	26.71	61.13	26.71	26.71	2.0	2.0	4.0	6.0
	4†	33.37	97.78	223.78	97.78	97.78				
Other	1*	0.33	6.68	31.68	6.68	6.68	5.0	10.0	10.0	10.0
	1†	1.22	24.44	115.99	24.44	24.44				
All modes	**11***	**41.20**	**73.45**	**121.59**	**73.45**	**73.45**	**2.2**	**2.0**	**4.5**	**10.0**
	11†	**150.82**	**268.88**	**445.12**	**268.88**	**268.88**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
2.1.2	Electric Equipment Electric Generators Turbine driven (gas, steam)

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	11	0.8946	0.7030	3142

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**46***	**15.99**	**53.26**	**108.31**	**29.10**	**51.42**	**39.1**	**1.0**	**58.6**	**566.0**
	46†	**25.17**	**67.06**	**125.33**	**31.26**	**65.43**				
Breakdown	3*	0.00	3.64	15.01	5.70	3.35	83.0	29.0	121.0	251.0
	3†	0.02	4.42	16.35	6.04	4.27				
External leakage - Utility medium	1*	0.01	1.16	4.23	1.56	1.12	8.5	17.0	17.0	17.0
	1†	0.00	1.45	8.38	4.56	1.42				
Fail to start on demand	2*	0.43	2.28	5.34	1.58	2.24	9.5	3.0	17.5	32.0
	2†	0.00	2.88	14.26	6.05	2.84				
Fail to synchronize	1*	0.00	0.99	5.33	2.46	1.12	30.0	60.0	60.0	60.0
	1†	0.00	1.32	7.26	3.64	1.42				
Faulty output voltage	2*	0.00	2.15	10.72	4.56	2.24	76.0	4.0	285.0	566.0
	2†	0.00	2.74	13.23	5.46	2.84				
Low output	3*	0.00	2.83	14.53	6.30	3.35	28.8	6.0	57.7	121.0
	3†	0.00	4.35	23.89	11.42	4.27				
Other	5*	0.00	6.41	32.53	14.02	5.59	3.0	6.0	6.0	6.0
	5†	0.00	6.94	34.52	14.69	7.11				
Parameter deviation	1*	0.02	1.14	3.57	1.27	1.12	2.0	4.0	4.0	4.0
	1†	0.00	1.43	8.23	4.46	1.42				
Spurious stop	24*	8.96	27.72	54.90	14.43	26.83	13.6	1.0	15.5	109.5
	24†	12.22	35.26	67.99	17.45	34.14				
Structural deficiency	1*	0.01	1.16	4.23	1.56	1.12	8.0	16.0	16.0	16.0
	1†	0.00	1.45	8.38	4.56	1.42				
Vibration	3*	0.02	3.32	11.90	4.40	3.35	216.0	100.0	253.0	390.0
	3†	0.02	4.42	17.09	6.31	4.27				
Degraded	**45***	**0.45**	**56.38**	**189.91**	**69.76**	**50.30**	**86.5**	**1.0**	**139.6**	**1611.0**
	45†	**0.60**	**67.00**	**222.85**	**81.63**	**64.01**				
Abnormal instrument reading	2*	0.00	2.36	12.26	5.45	2.24	10.0	9.0	10.0	11.0
	2†	0.00	3.01	15.70	7.03	2.84				
External leakage - Utility medium	11*	0.09	14.74	51.64	19.06	12.30	8.4	2.0	12.9	51.0
	11†	0.15	17.33	57.78	21.18	15.65				
Fail to synchronize	1*	0.00	0.99	5.33	2.46	1.12	27.0	54.0	54.0	54.0
	1†	0.00	1.32	7.26	3.64	1.42				
Faulty output voltage	1*	0.00	1.09	6.18	3.28	1.12	6.5	6.5	6.5	6.5
	1†	0.00	1.38	7.79	4.13	1.42				
Low output	4*	0.00	4.74	26.16	13.21	4.47	6.3	2.0	6.3	11.0
	4†	0.00	6.05	33.45	16.95	5.69				
Other	6*	0.04	6.80	23.91	8.83	6.71	382.5	6.0	622.0	1611.0
	6†	0.08	8.59	28.28	10.33	8.53				
Overheating	1*	0.06	1.13	3.36	1.12	1.12	-	14.0	14.0	14.0
	1†	0.01	1.47	5.19	1.92	1.42				

Comments

(cont.)

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Taxonomy no	Item
2.1.2	Electric Equipment Electric Generators Turbine driven (gas, steam)

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	11	0.8946	0.7030	3142

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Parameter deviation	10*	0.00	12.78	62.28	25.97	11.18	4.4	1.0	7.3	26.0
	10†	0.00	14.39	69.94	29.07	14.22				
Structural deficiency	5*	0.00	6.18	27.56	10.88	5.59	133.0	2.0	240.4	1135.0
	5†	0.00	7.34	31.62	12.25	7.11				
Vibration	4*	0.43	4.59	12.58	4.06	4.47	130.8	4.0	155.8	274.0
	4†	0.65	5.77	15.18	4.79	5.69				
Incipient	**104***	**1.09**	**106.69**	**349.61**	**127.53**	**116.25**	**13.0**	**1.0**	**17.9**	**156.0**
	104†	**1.41**	**136.73**	**447.44**	**163.14**	**147.94**				
Abnormal instrument reading	46*	0.28	48.74	172.67	63.78	51.42	9.8	1.0	10.9	62.5
	46†	0.35	61.30	217.70	80.42	65.43				
External leakage - Utility medium	20*	0.01	19.99	84.26	32.34	22.36	19.7	1.0	32.9	156.0
	20†	0.02	25.84	108.72	41.69	28.45				
Low output	1*	0.00	1.00	5.43	2.53	1.12	40.5	81.0	81.0	81.0
	1†	0.00	1.45	8.39	4.62	1.42				
Minor in-service problems	19*	0.13	22.08	77.44	28.59	21.24	10.8	1.0	14.4	60.0
	19†	0.19	26.70	91.58	33.74	27.03				
Noise	1*	0.06	1.13	3.36	1.12	1.12	33.0	33.0	33.0	33.0
	1†	0.08	1.44	4.27	1.42	1.42				
Other	14*	0.09	13.31	45.95	16.94	15.65	10.0	1.0	17.2	102.0
	14†	0.05	18.85	74.39	27.72	19.91				
Unknown	1*	0.00	1.04	5.73	2.87	1.12	63.0	63.0	63.0	63.0
	1†	0.00	1.24	6.52	2.93	1.42				
Vibration	2*	0.42	2.27	5.33	1.58	2.24	-	8.0	8.0	8.0
	2†	0.00	2.97	15.20	6.57	2.84				
All modes	**195***	**28.39**	**216.14**	**550.63**	**171.06**	**217.97**	**35.1**	**1.0**	**55.3**	**1611.0**
	195†	**40.20**	**270.40**	**671.09**	**205.75**	**277.38**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.2 \cdot 10^{-4}$

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Maintainable item versus failure mode, to be continued
Item: Electric Generators - Turbine driven (gas, steam)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Actuating device	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automatic voltage regulator (AVR)	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00
Bearing	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	2.82	0.00	0.00	0.00	0.00	0.51	1.54	0.00	0.00
Cooler(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Coupling to driven unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coupling to driver	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filter(s)	0.51	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Gearbox	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Heat exchanger	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, frequency/RPM	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	4.62	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00
Internal power supply	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	2.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.51	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	5.13	0.00	0.00	0.00	0.00	0.00	0.00
Pump	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.51	0.00	0.00	0.00	0.51	0.00	0.00
Purge air	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Radial bearing	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Rotor	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Seals	0.00	0.00	4.10	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.51	1.54	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.03	0.00	0.51	0.00	0.00	0.51	0.51	0.00	0.51
Valves	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Total	24.62	1.54	16.41	0.00	1.54	1.03	4.10	0.51	0.51

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric Generators - Turbine driven (gas, steam)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Automatic voltage regulator (AVR)	0.00	1.03	0.00	0.51	0.00	0.00	0.00	0.00	0.00	2.56
Bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Cabling & junction boxes	2.31	1.54	0.00	0.51	0.00	0.00	0.00	0.00	0.00	4.87
Control unit	1.54	0.00	0.00	0.00	0.00	1.03	0.00	1.54	0.00	8.97
Cooler(s)	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Coupling to driven unit	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51
Coupling to driver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Excitation	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.51	0.00	1.54
Fan w/motor	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.54
Filter(s)	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Gearbox	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.51	2.56
Heat exchanger	0.51	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.54
Hood	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Instrument, current	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	1.54
Instrument, frequency/RPM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Instrument, general	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.28
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Instrument, temperature	0.00	0.00	0.51	0.00	0.00	0.00	0.00	1.54	0.00	7.18
Instrument, vibration	0.00	0.51	0.00	0.00	0.00	0.00	0.00	1.54	0.51	7.18
Instrument, voltage	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.08
Internal power supply	0.00	0.00	0.51	0.00	0.00	0.00	0.00	1.03	0.00	2.05
Lubrication	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.51
Monitoring	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33
Other	0.51	0.51	2.05	0.00	0.00	0.00	0.00	0.51	0.00	5.13
Piping	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	6.15
Pump	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Pump w/motor	0.00	0.00	1.54	0.00	0.00	0.00	0.51	0.00	0.00	3.08
Purge air	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Radial bearing	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Rotor	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.54
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10
Stator	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Subunit	2.56	0.00	0.00	1.03	0.00	0.00	0.00	1.03	2.05	9.74
Unknown	1.03	0.00	0.00	0.00	0.00	0.00	0.00	2.05	0.51	6.67
Valves	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	1.54
Total	12.82	5.64	9.74	3.08	0.00	1.03	0.51	12.31	4.62	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric Generators - Turbine driven (gas, steam)

	AIR	BRD	ELU	FOF	FOV	FTS	LOO	NOI	OHE
Blockage/plugged	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	2.05	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	1.54	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Electrical failure - general	0.51	0.51	0.00	0.00	0.51	0.00	0.51	0.00	0.51
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.08	0.00	0.00	0.00	0.00	0.00	1.03	0.51	0.00
Leakage	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	2.56	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.03	3.08	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	1.03	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00
Other	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	3.08	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	1.03	0.00	0.00	0.00	1.03	0.00	0.00
Total	24.62	1.54	16.41	0.00	1.54	1.03	4.10	0.51	0.51

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Electric Generators - Turbine driven (gas, steam)

	OTH	PDE	SER	STD	STP	SYN	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Breakage	0.51	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	3.08
Cavitation	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Clearance/ alignment failure	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.51	2.05
Contamination	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Control failure	0.51	0.00	0.51	0.00	0.00	0.00	0.00	1.54	0.00	5.13
Corrosion	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Earth/isolation fault	3.08	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	5.64
Electrical failure - general	2.56	1.54	0.51	0.51	0.00	1.03	0.00	3.08	0.51	12.31
Faulty power/voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.51
Faulty signal/indication/alarm	0.51	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	6.15
Instrument failure - general	0.00	1.54	1.03	0.00	0.00	0.00	0.00	0.51	0.00	7.69
Leakage	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.00	4.10
Looseness	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.00	4.62
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Mechanical Failure - general	1.03	0.51	2.05	0.51	0.00	0.00	0.51	1.03	1.54	11.28
Misc. external influences	0.51	1.03	0.00	1.03	0.00	0.00	0.00	0.51	0.00	3.59
Miscellaneous - general	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.03	2.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Open circuit	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.51	0.00	2.56
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.54
Out of adjustment	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	5.64
Overheating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	1.03
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Software failure	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03
Vibration	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.51	1.03
Wear	0.00	0.00	0.51	0.51	0.00	0.00	0.00	0.00	0.51	3.59
Total	12.82	5.64	9.74	3.08	0.00	1.03	0.51	12.31	4.62	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
2.1.2.1	Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	3	0.1840	0.1588	166

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**15***	**52.25**	**83.61**	**120.97**	**21.05**	**81.53**	**35.9**	**1.0**	**42.6**	**251.0**
	15†	**41.29**	**98.74**	**176.17**	**41.87**	**94.48**				
Breakdown	3*	1.02	19.75	58.98	19.68	16.31	83.0	29.0	121.0	251.0
	3†	1.73	22.52	63.90	20.96	18.90				
Fail to start on demand	1*	0.03	7.27	27.75	10.22	5.44	3.0	3.0	3.0	3.0
	1†	0.04	7.88	28.65	10.59	6.30				
Other	4*	0.07	20.25	78.33	28.94	21.74	-	-	-	-
	4†	0.14	21.47	74.73	27.57	25.20				
Spurious stop	7*	10.14	38.89	82.90	23.09	38.05	5.3	1.0	10.0	30.0
	7†	21.81	45.33	75.77	16.67	44.09				
Degraded	**8***	**8.67**	**50.08**	**119.62**	**35.82**	**43.48**	**3.5**	**1.0**	**6.0**	**14.0**
	8†	**11.31**	**57.62**	**133.44**	**39.26**	**50.39**				
External leakage - Utility medium	1*	0.01	5.25	21.69	8.24	5.44	-	-	-	-
	1†	0.02	5.75	22.28	8.24	6.30				
Other	1*	0.01	5.03	19.71	7.32	5.44	-	6.0	6.0	6.0
	1†	0.00	6.29	26.86	10.38	6.30				
Overheating	1*	0.01	5.03	19.71	7.32	5.44	-	14.0	14.0	14.0
	1†	0.00	6.29	26.86	10.38	6.30				
Parameter deviation	3*	1.02	19.75	58.98	19.68	16.31	4.0	1.0	5.3	8.0
	3†	1.73	22.52	63.90	20.96	18.90				
Structural deficiency	1*	0.03	7.27	27.75	10.22	5.44	2.0	2.0	2.0	2.0
	1†	0.04	7.88	28.65	10.59	6.30				
Vibration	1*	0.03	7.27	27.75	10.22	5.44	4.0	4.0	4.0	4.0
	1†	0.04	7.88	28.65	10.59	6.30				
Incipient	**10***	**5.26**	**70.87**	**202.15**	**66.43**	**54.35**	**3.3**	**1.0**	**5.0**	**14.0**
	10†	**6.64**	**76.24**	**211.69**	**68.79**	**62.99**				
Abnormal instrument reading	5*	0.32	39.54	133.33	48.99	27.18	2.3	1.0	2.3	6.0
	5†	0.32	42.01	142.37	52.35	31.49				
Minor in-service problems	3*	1.08	20.19	60.07	20.02	16.31	5.5	4.0	9.0	14.0
	3†	1.67	21.59	61.21	20.07	18.90				
Vibration	2*	1.66	10.51	25.72	7.82	10.87	-	8.0	8.0	8.0
	2†	1.70	12.20	30.72	9.49	12.60				
All modes	**33***	**46.59**	**215.80**	**486.97**	**140.99**	**179.36**	**14.2**	**1.0**	**21.0**	**251.0**
	33†	**60.47**	**240.24**	**517.96**	**145.46**	**207.86**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $6.0 \cdot 10^{-3}$

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Taxonomy no	Item
2.1.2.1.1	Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (-1000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0701	0.0701	26

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**28.11**	**71.35**	**150.04**	**71.35**	**71.35**	-	-	-	-
	5†	**28.11**	**71.35**	**150.04**	**71.35**	**71.35**				
Other	4*	19.48	57.08	130.64	57.08	57.08	-	-	-	-
	4†	19.48	57.08	130.64	57.08	57.08				
Spurious stop	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27				
Degraded	**1***	**0.71**	**14.27**	**67.71**	**14.27**	**14.27**	-	-	-	-
	1†	**0.71**	**14.27**	**67.71**	**14.27**	**14.27**				
External leakage - Utility medium	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27				
Incipient	**3***	**11.70**	**42.81**	**110.66**	**42.81**	**42.81**	-	-	-	-
	3†	**11.70**	**42.81**	**110.66**	**42.81**	**42.81**				
Abnormal instrument reading	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27				
Minor in-service problems	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27				
Vibration	1*	0.71	14.27	67.71	14.27	14.27	-	-	-	-
	1†	0.71	14.27	67.71	14.27	14.27				
All modes	**9***	**66.99**	**128.42**	**224.10**	**128.42**	**128.42**	-	-	-	-
	9†	**66.99**	**128.42**	**224.10**	**128.42**	**128.42**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no		Item								
2.1.2.1.2		Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (1000-3000)kVA								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
1	1	**Calendar time** * 0.0351		**Operational time** † 0.0330			140			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**5***	**56.18**	**142.60**	**299.88**	**142.60**	**142.60**	**35.9**	**1.0**	**71.4**	**251.0**
		5†	**59.62**	**151.33**	**318.25**	**151.33**	**151.33**				
Breakdown		2*	10.12	57.04	179.53	57.04	57.04	83.0	83.0	167.0	251.0
		2†	10.74	60.53	190.53	60.53	60.53				
Fail to start on demand		1*	1.43	28.52	135.32	28.52	28.52	3.0	3.0	3.0	3.0
		1†	1.51	30.27	143.61	30.27	30.27				
Spurious stop		2*	10.12	57.04	179.53	57.04	57.04	5.3	1.0	10.0	19.0
		2†	10.74	60.53	190.53	60.53	60.53				
Degraded		**4***	**38.93**	**114.08**	**261.09**	**114.08**	**114.08**	**3.5**	**1.0**	**3.5**	**7.0**
		4†	**41.31**	**121.07**	**277.09**	**121.07**	**121.07**				
Parameter deviation		2*	10.12	57.04	179.53	57.04	57.04	4.0	1.0	4.0	7.0
		2†	10.74	60.53	190.53	60.53	60.53				
Structural deficiency		1*	1.43	28.52	135.32	28.52	28.52	2.0	2.0	2.0	2.0
		1†	1.51	30.27	143.61	30.27	30.27				
Vibration		1*	1.43	28.52	135.32	28.52	28.52	4.0	4.0	4.0	4.0
		1†	1.51	30.27	143.61	30.27	30.27				
Incipient		**6***	**74.58**	**171.12**	**337.67**	**171.12**	**171.12**	**3.3**	**1.0**	**4.5**	**14.0**
		6†	**79.15**	**181.60**	**358.35**	**181.60**	**181.60**				
Abnormal instrument reading		4*	38.93	114.08	261.09	114.08	114.08	2.3	1.0	2.3	6.0
		4†	41.31	121.07	277.09	121.07	121.07				
Minor in-service problems		2*	10.12	57.04	179.53	57.04	57.04	5.5	4.0	9.0	14.0
		2†	10.74	60.53	190.53	60.53	60.53				
All modes		**15***	**263.66**	**427.79**	**658.65**	**427.79**	**427.79**	**14.2**	**1.0**	**26.5**	**251.0**
		15†	**279.81**	**454.00**	**699.00**	**454.00**	**454.00**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $7.1 \cdot 10^{-3}$

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Taxonomy no	Item
2.1.2.1.3	Electric Equipment Electric Generators Turbine driven (gas, steam) Essential power (3000-10000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0788	0.0556	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**24.99**	**63.42**	**133.37**	**63.42**	**63.42**	-	**1.0**	**13.8**	**30.0**
	5†	**35.41**	**89.87**	**188.99**	**89.87**	**89.87**				
Breakdown	1*	0.63	12.68	60.19	12.68	12.68	-	29.0	29.0	29.0
	1†	0.90	17.97	85.28	17.97	17.97				
Spurious stop	4*	17.31	50.74	116.12	50.74	50.74	-	1.0	10.0	30.0
	4†	24.53	71.89	164.55	71.89	71.89				
Degraded	**3***	**10.40**	**38.05**	**98.36**	**38.05**	**38.05**	-	**6.0**	**9.3**	**14.0**
	3†	**14.74**	**53.92**	**139.39**	**53.92**	**53.92**				
Other	1*	0.63	12.68	60.19	12.68	12.68	-	6.0	6.0	6.0
	1†	0.90	17.97	85.28	17.97	17.97				
Overheating	1*	0.63	12.68	60.19	12.68	12.68	-	14.0	14.0	14.0
	1†	0.90	17.97	85.28	17.97	17.97				
Parameter deviation	1*	0.63	12.68	60.19	12.68	12.68	-	8.0	8.0	8.0
	1†	0.90	17.97	85.28	17.97	17.97				
Incipient	**1***	**0.63**	**12.68**	**60.19**	**12.68**	**12.68**	-	**8.0**	**8.0**	**8.0**
	1†	**0.90**	**17.97**	**85.28**	**17.97**	**17.97**				
Vibration	1*	0.63	12.68	60.19	12.68	12.68	-	8.0	8.0	8.0
	1†	0.90	17.97	85.28	17.97	17.97				
All modes	**9***	**59.55**	**114.16**	**199.20**	**114.16**	**114.16**	-	**1.0**	**11.7**	**30.0**
	9†	**84.39**	**161.76**	**282.28**	**161.76**	**161.76**				

Comments

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Taxonomy no	Item
2.1.2.2	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
24	9	0.7106	0.5442	2976

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**31***	**12.59**	**47.63**	**101.09**	**28.07**	**43.62**	**39.6**	**1.0**	**64.0**	**566.0**
	31†	**19.12**	**61.61**	**123.79**	**32.91**	**56.96**				
External leakage - Utility medium	1*	0.00	2.22	11.52	5.07	1.41	8.5	17.0	17.0	17.0
	1†	0.00	2.48	12.53	5.39	1.84				
Fail to start on demand	1*	0.09	1.44	4.24	1.41	1.41	16.0	32.0	32.0	32.0
	1†	0.00	1.83	10.06	4.93	1.84				
Fail to synchronize	1*	0.00	1.26	6.34	2.72	1.41	30.0	60.0	60.0	60.0
	1†	0.00	1.70	8.91	4.02	1.84				
Faulty output voltage	2*	0.00	2.73	12.49	4.98	2.81	76.0	4.0	285.0	566.0
	2†	0.00	3.52	15.33	5.96	3.67				
Low output	3*	0.00	3.61	16.87	6.86	4.22	28.8	6.0	57.7	121.0
	3†	0.00	5.51	28.67	12.77	5.51				
Other	1*	0.09	1.44	4.24	1.41	1.41	3.0	6.0	6.0	6.0
	1†	0.00	1.83	10.06	4.93	1.84				
Parameter deviation	1*	0.09	1.44	4.24	1.41	1.41	2.0	4.0	4.0	4.0
	1†	0.00	1.83	10.06	4.93	1.84				
Spurious stop	17*	5.18	26.75	62.15	18.32	23.92	14.6	1.0	17.6	109.5
	17†	8.40	34.30	74.59	21.07	31.24				
Structural deficiency	1*	0.00	2.22	11.52	5.07	1.41	8.0	16.0	16.0	16.0
	1†	0.00	2.48	12.53	5.39	1.84				
Vibration	3*	0.10	4.22	12.95	4.53	4.22	216.0	100.0	253.0	390.0
	3†	0.08	5.67	18.05	6.50	5.51				
Degraded	**37***	**0.83**	**73.71**	**239.14**	**86.92**	**52.07**	**96.2**	**2.0**	**166.3**	**1611.0**
	37†	**0.86**	**85.66**	**281.10**	**102.58**	**67.98**				
Abnormal instrument reading	2*	0.00	2.98	14.53	6.05	2.81	10.0	9.0	10.0	11.0
	2†	0.00	3.83	18.66	7.77	3.67				
External leakage - Utility medium	10*	0.11	23.74	87.12	32.18	14.07	8.4	2.0	12.9	51.0
	10†	0.13	27.14	99.97	36.93	18.37				
Fail to synchronize	1*	0.00	1.26	6.34	2.72	1.41	27.0	54.0	54.0	54.0
	1†	0.00	1.70	8.91	4.02	1.84				
Faulty output voltage	1*	0.00	1.39	7.63	3.62	1.41	6.5	6.5	6.5	6.5
	1†	0.00	1.77	9.74	4.57	1.84				
Low output	4*	0.00	5.95	32.01	14.81	5.63	6.3	2.0	6.3	11.0
	4†	0.00	7.60	41.15	19.12	7.35				
Other	5*	0.04	7.12	25.30	9.35	7.04	382.5	8.0	745.2	1611.0
	5†	0.10	9.01	29.24	10.63	9.19				
Parameter deviation	7*	0.00	17.51	79.57	31.68	9.85	4.6	3.0	8.4	26.0
	7†	0.00	18.98	89.07	36.28	12.86				
Structural deficiency	4*	0.01	7.82	32.79	12.55	5.63	165.8	5.0	300.0	1135.0
	4†	0.01	9.24	37.98	14.41	7.35				

Comments

(cont.)

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Taxonomy no	Item
2.1.2.2	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
24	9	0.7106	0.5442	2976

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Vibration	3*	0.06	4.34	13.78	4.96	4.22	173.0	88.0	206.3	274.0
	3†	0.10	5.60	17.51	6.24	5.51				
Incipient	**94***	**2.27**	**123.99**	**386.74**	**137.48**	**132.28**	**13.7**	**1.0**	**18.9**	**156.0**
	94†	**3.08**	**160.49**	**499.14**	**177.01**	**172.72**				
Abnormal instrument reading	41*	0.41	54.89	186.59	68.65	57.70	10.5	1.0	11.8	62.5
	41†	0.54	70.18	237.86	87.47	75.33				
External leakage - Utility medium	20*	0.12	25.18	92.68	34.23	28.14	19.7	1.0	32.9	156.0
	20†	0.16	32.59	119.52	44.15	36.75				
Low output	1*	0.00	1.27	6.48	2.80	1.41	40.5	81.0	81.0	81.0
	1†	0.00	1.86	10.24	5.11	1.84				
Minor in-service problems	16*	0.24	26.80	89.31	32.73	22.52	11.4	1.0	15.1	60.0
	16†	0.33	32.64	107.08	39.08	29.40				
Noise	1*	0.08	1.43	4.23	1.41	1.41	33.0	33.0	33.0	33.0
	1†	0.00	1.92	10.63	5.45	1.84				
Other	14*	1.03	17.16	50.40	16.73	19.70	10.0	1.0	17.2	102.0
	14†	0.22	23.95	79.22	28.98	25.72				
Unknown	1*	0.00	1.32	6.97	3.17	1.41	63.0	63.0	63.0	63.0
	1†	0.00	1.61	7.82	3.24	1.84				
All modes	**162***	**36.64**	**247.72**	**615.52**	**188.83**	**227.97**	**37.1**	**1.0**	**60.6**	**1611.0**
	162†	**49.96**	**310.18**	**755.22**	**228.98**	**297.66**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
2.1.2.2.1	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (-1000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1512	0.1393	285

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**3.99**	**22.93**	**54.68**	**16.36**	**19.84**	**17.3**	**12.0**	**17.3**	**22.0**
	3†	**2.62**	**28.04**	**76.82**	**24.81**	**21.54**				
Spurious stop	3*	3.99	22.93	54.68	16.36	19.84	17.3	12.0	17.3	22.0
	3†	2.62	28.04	76.82	24.81	21.54				
Degraded	**3***	**0.13**	**30.76**	**115.56**	**42.64**	**19.84**	**52.8**	**6.5**	**63.5**	**96.0**
	3†	**0.15**	**38.78**	**148.08**	**54.56**	**21.54**				
Faulty output voltage	1*	0.06	9.01	31.28	11.54	6.61	6.5	6.5	6.5	6.5
	1†	0.05	11.38	42.12	15.56	7.18				
Other	1*	0.06	9.01	31.28	11.54	6.61	96.0	96.0	96.0	96.0
	1†	0.05	11.38	42.12	15.56	7.18				
Vibration	1*	0.06	9.01	31.28	11.54	6.61	56.0	88.0	88.0	88.0
	1†	0.05	11.38	42.12	15.56	7.18				
Incipient	**26***	**1.91**	**262.11**	**894.88**	**329.46**	**171.96**	**20.2**	**1.0**	**25.3**	**156.0**
	26†	**2.07**	**326.88**	**1140.25**	**420.79**	**186.65**				
Abnormal instrument reading	12*	1.35	115.79	374.28	135.84	79.37	12.2	2.0	12.2	60.0
	12†	1.27	143.71	478.77	175.45	86.15				
External leakage - Utility medium	6*	0.26	63.38	241.01	88.84	39.68	36.7	1.0	58.3	156.0
	6†	0.31	79.87	306.04	112.73	43.07				
Minor in-service problems	5*	0.22	52.51	199.22	73.45	33.07	13.8	3.0	17.8	60.0
	5†	0.26	66.17	253.41	93.35	35.90				
Other	2*	0.09	19.89	73.62	27.19	13.23	6.0	4.0	5.0	6.0
	2†	0.10	25.08	95.31	35.13	14.36				
Unknown	1*	0.11	6.05	18.89	6.72	6.61	63.0	63.0	63.0	63.0
	1†	0.13	6.53	20.28	7.18	7.18				
All modes	**32***	**2.50**	**321.19**	**1086.84**	**399.56**	**211.64**	**23.0**	**1.0**	**28.1**	**156.0**
	32†	**2.66**	**400.19**	**1384.89**	**510.70**	**229.73**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
2.1.2.2.2	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (3000-10000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1400	0.1085	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**8***	**28.25**	**56.94**	**93.73**	**20.20**	**57.14**	**18.0**	**3.0**	**22.6**	**109.5**
	8†	**36.65**	**73.69**	**121.15**	**26.06**	**73.71**				
Fail to start on demand	1*	0.03	6.98	26.03	9.61	7.14	16.0	32.0	32.0	32.0
	1†	0.07	8.53	28.51	10.46	9.21				
Faulty output voltage	1*	0.03	6.98	26.03	9.61	7.14	2.0	4.0	4.0	4.0
	1†	0.07	8.53	28.51	10.46	9.21				
Other	1*	0.03	6.98	26.03	9.61	7.14	3.0	6.0	6.0	6.0
	1†	0.07	8.53	28.51	10.46	9.21				
Parameter deviation	1*	0.03	6.98	26.03	9.61	7.14	2.0	4.0	4.0	4.0
	1†	0.07	8.53	28.51	10.46	9.21				
Spurious stop	4*	9.98	28.84	55.62	14.28	28.57	30.3	3.0	33.6	109.5
	4†	5.94	41.03	102.42	31.50	36.86				
Degraded	**4***	**0.30**	**27.56**	**89.79**	**32.69**	**28.57**	**378.6**	**3.0**	**757.3**	**1611.0**
	4†	**1.85**	**32.58**	**96.30**	**32.03**	**36.86**				
Other	2*	1.13	13.97	39.29	12.84	14.28	755.8	1412.0	1511.5	1611.0
	2†	2.63	17.26	42.63	13.03	18.43				
Parameter deviation	2*	1.13	13.97	39.29	12.84	14.28	1.5	3.0	3.0	3.0
	2†	2.63	17.26	42.63	13.03	18.43				
Incipient	**6***	**18.49**	**42.65**	**74.90**	**17.49**	**42.85**	**1.1**	**1.0**	**1.9**	**2.5**
	6†	**23.74**	**54.88**	**96.51**	**22.57**	**55.29**				
Abnormal instrument reading	1*	0.41	7.27	21.48	7.14	7.14	2.0	2.0	2.0	2.0
	1†	0.33	10.40	31.57	10.87	9.21				
External leakage - Utility medium	3*	0.40	20.77	64.58	22.90	21.43	1.0	2.5	2.5	2.5
	3†	2.79	25.19	66.44	21.01	27.64				
Minor in-service problems	2*	2.54	14.30	33.90	10.10	14.28	0.8	1.0	1.0	1.0
	2†	3.54	18.81	44.03	13.03	18.43				
All modes	**18***	**49.32**	**126.89**	**233.73**	**57.45**	**128.56**	**92.5**	**1.0**	**178.9**	**1611.0**
	18†	**90.23**	**162.16**	**251.13**	**49.47**	**165.86**				

Comments

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Taxonomy no	Item
2.1.2.2.3	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (10000-20000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**16.0**	**16.0**	**16.0**
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	16.0	16.0	16.0
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**16.0**	**16.0**	**16.0**
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				

Comments

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Taxonomy no	Item
2.1.2.2.4	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (20000-30000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	5	0.4019	0.2789	2691

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**20***	**12.48**	**57.67**	**130.04**	**37.63**	**49.77**	**52.2**	**1.0**	**88.7**	**566.0**
	20†	**25.66**	**75.99**	**147.94**	**38.30**	**71.71**				
External leakage - Utility medium	1*	0.00	4.07	18.31	7.26	2.49	8.5	17.0	17.0	17.0
	1†	0.00	4.57	19.53	7.55	3.59				
Fail to synchronize	1*	0.00	2.25	9.48	3.64	2.49	30.0	60.0	60.0	60.0
	1†	0.00	3.19	13.88	5.39	3.59				
Faulty output voltage	1*	0.00	2.25	9.48	3.64	2.49	150.0	566.0	566.0	566.0
	1†	0.00	3.19	13.88	5.39	3.59				
Low output	3*	0.03	6.47	23.61	8.72	7.46	28.8	6.0	57.7	121.0
	3†	0.00	10.05	43.70	16.99	10.76				
Spurious stop	10*	3.52	32.17	85.13	26.98	24.88	6.8	1.0	10.6	38.0
	10†	8.59	39.98	90.35	26.18	35.85				
Structural deficiency	1*	0.00	4.07	18.31	7.26	2.49	8.0	16.0	16.0	16.0
	1†	0.00	4.57	19.53	7.55	3.59				
Vibration	3*	1.73	7.51	16.61	4.74	7.46	216.0	100.0	253.0	390.0
	3†	2.91	10.71	22.53	6.21	10.76				
Degraded	**29***	**1.80**	**105.59**	**330.87**	**118.04**	**72.16**	**59.2**	**2.0**	**95.8**	**1135.0**
	29†	**2.06**	**123.98**	**389.30**	**139.09**	**103.98**				
Abnormal instrument reading	2*	0.01	5.32	21.82	8.27	4.98	10.0	9.0	10.0	11.0
	2†	0.02	7.07	27.43	10.15	7.17				
External leakage - Utility medium	9*	0.31	34.65	115.28	42.23	22.39	8.4	2.0	12.6	51.0
	9†	0.44	40.54	131.95	48.02	32.27				
Fail to synchronize	1*	0.00	2.25	9.48	3.64	2.49	27.0	54.0	54.0	54.0
	1†	0.00	3.19	13.88	5.39	3.59				
Low output	4*	0.00	10.56	49.42	20.10	9.95	6.3	2.0	6.3	11.0
	4†	0.00	13.73	64.08	26.01	14.34				
Other	2*	0.04	4.83	16.16	5.93	4.98	152.5	8.0	303.5	599.0
	2†	0.08	6.74	21.81	7.92	7.17				
Parameter deviation	5*	0.01	26.54	114.46	44.37	12.44	6.7	4.0	12.0	26.0
	5†	0.00	28.59	131.05	52.41	17.93				
Structural deficiency	4*	0.14	13.90	45.74	16.71	9.95	165.8	5.0	300.0	1135.0
	4†	0.33	16.58	51.43	18.19	14.34				
Vibration	2*	0.01	5.32	21.82	8.27	4.98	231.5	257.0	265.5	274.0
	2†	0.02	7.07	27.43	10.15	7.17				
Incipient	**62***	**50.03**	**180.80**	**377.91**	**103.70**	**154.27**	**12.2**	**1.0**	**17.7**	**102.0**
	62†	**81.26**	**238.48**	**462.64**	**119.38**	**222.30**				
Abnormal instrument reading	28*	12.62	85.01	211.06	64.72	69.67	10.2	1.0	11.9	62.5
	28†	19.65	109.80	260.01	77.42	100.39				
External leakage - Utility medium	11*	1.56	28.35	84.06	27.98	27.37	14.6	2.0	26.1	50.0
	11†	2.80	39.14	112.25	36.96	39.44				

Comments

(cont.)

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Taxonomy no	Item
2.1.2.2.4	Electric Equipment Electric Generators Turbine driven (gas, steam) Main power (20000-30000)kVA

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	5	0.4019	0.2789	2691

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.00	2.26	9.70	3.75	2.49	40.5	81.0	81.0	81.0
	1†	0.00	3.44	16.60	6.85	3.59				
Minor in-service problems	9*	1.84	35.52	106.02	35.36	22.39	12.5	3.0	16.8	51.0
	9†	2.95	41.81	120.16	39.60	32.27				
Noise	1*	0.16	2.57	7.51	2.49	2.49	33.0	33.0	33.0	33.0
	1†	0.00	3.53	17.36	7.31	3.59				
Other	12*	12.59	28.72	50.20	11.66	29.86	10.4	1.0	19.4	102.0
	12†	8.42	41.24	94.52	27.64	43.03				
All modes	**111***	**114.48**	**348.04**	**684.53**	**178.85**	**276.20**	**31.7**	**1.0**	**50.7**	**1135.0**
	111†	**208.60**	**437.81**	**735.24**	**162.76**	**397.99**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Electric Motors

Inventory description

The boundary definition is shown in Figure 16 and corresponding subdivision in Maintainable Items in Table 11.The boundary definition applies to electric motors. Included within the boundary are the starting system and possible auxiliaries related to the motor. Subunits that are common to the driver (i.e. the electric motor) and the *driven unit* (e.g. a pump) are a part of the *driven unit.* The power transmission system is also regarded as part of the driven unit.

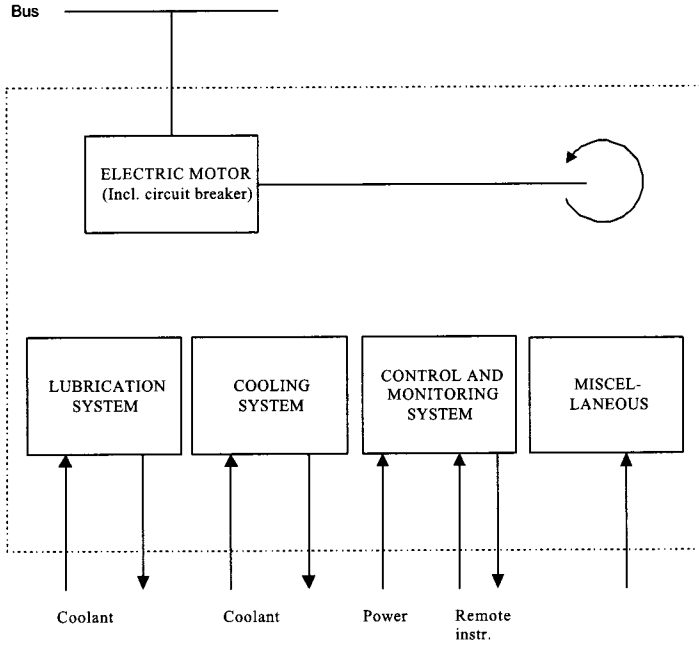

Figure 16 - Electric motors, Boundary Definition

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Table 11 Electric Motors, Subdivision in Maintainable Items

ELECTRICAL MOTORS				
Control & monitoring	Cooling system	Electric motor	Lubrication system	Miscellaneous
• Actuating device • Cabling & junction boxes • Control unit • Instruments • Internal power supply • Monitoring • Valves	• Heat exchanger • Fan w/motor • Filter • Valves & piping • Pump • Instruments	• Casing • Circuit breaker • Coupling • Excitation • Instruments • Overload protection • Radial bearing • Rotor • Stator • Thrust bearing	• Reservoir • Pump w/motor • Filter • Cooler • Valves & piping • Oil • Instruments • Seals	• Hood

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR Abnormal instrument reading
BRD Breakdown
ERO Erratic output
ELU External leakage - Utility medium
FTS Fail to start on demand
STP Fail to stop on demand
LOO Low output
SER Minor in-service problems
NOI Noise
OTH Other
OHE Overheating
PDE Parameter deviation
UST Spurious stop
STD Structural deficiency
UNK Unknown
VIB Vibration

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Taxonomy no	Item
2.2	Electric Equipment Electric motors

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
178	16	5.4324	4.3894	6368

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**119***	**2.24**	**28.44**	**80.34**	**26.30**	**21.91**	**35.3**	**1.0**	**55.6**	**1140.0**
	119†	**3.36**	**32.75**	**87.95**	**28.11**	**27.11**				
Breakdown	9*	0.16	1.53	4.06	1.29	1.66	12.4	4.0	21.9	45.0
	9†	0.75	1.93	3.54	0.87	2.05				
External leakage - Utility medium	2*	0.00	0.48	2.22	0.89	0.37	34.5	38.0	45.5	53.0
	2†	0.00	0.56	2.19	0.81	0.46				
Fail to start on demand	22*	2.08	3.97	6.36	1.32	4.05	17.2	1.0	27.4	250.0
	22†	0.04	4.77	15.81	5.79	5.01				
Fail to stop on demand	2*	0.00	0.52	2.45	1.00	0.37	11.0	2.0	20.5	39.0
	2†	0.00	0.64	3.02	1.23	0.46				
Low output	13*	0.00	5.89	27.44	11.12	2.39	13.9	1.0	19.2	48.0
	13†	0.00	6.51	31.06	12.76	2.96				
Noise	3*	0.01	0.49	1.51	0.53	0.55	6.3	5.0	26.7	60.0
	3†	0.00	0.58	2.50	0.97	0.68				
Other	5*	0.00	1.31	7.37	3.89	0.92	15.5	3.0	30.6	37.5
	5†	0.00	1.57	8.80	4.64	1.14				
Overheating	2*	0.00	0.44	1.95	0.77	0.37	3.0	2.0	3.0	4.0
	2†	0.00	0.50	1.88	0.69	0.46				
Parameter deviation	4*	0.00	0.66	3.76	2.09	0.74	5.0	2.0	9.5	26.0
	4†	0.00	0.76	4.24	2.22	0.91				
Spurious stop	37*	0.03	13.62	54.22	20.26	6.81	99.1	1.0	145.5	1140.0
	37†	0.03	14.98	60.06	22.52	8.43				
Structural deficiency	11*	0.00	1.13	4.70	1.80	2.02	17.1	4.0	33.2	146.0
	11†	0.19	1.70	4.48	1.42	2.51				
Vibration	9*	0.12	1.32	3.60	1.16	1.66	17.1	4.0	25.4	57.0
	9†	0.14	1.60	4.43	1.44	2.05				
Degraded	**76***	**1.23**	**15.95**	**45.23**	**14.83**	**13.99**	**16.1**	**1.0**	**22.7**	**484.0**
	76†	**1.93**	**18.54**	**49.60**	**15.82**	**17.31**				
Abnormal instrument reading	1*	0.00	0.24	1.31	0.61	0.18	6.0	6.0	6.0	6.0
	1†	0.00	0.28	1.45	0.63	0.23				
Erratic output	4*	0.00	2.15	9.99	4.05	0.74	3.0	3.0	5.8	12.0
	4†	0.00	2.82	13.11	5.30	0.91				
External leakage - Utility medium	7*	0.04	2.13	6.63	2.36	1.29	8.0	1.5	13.6	74.0
	7†	0.10	2.40	7.22	2.43	1.59				
Low output	1*	0.00	0.46	2.45	1.11	0.18	3.5	7.0	7.0	7.0
	1†	0.00	0.53	2.75	1.22	0.23				
Noise	4*	0.00	1.82	9.02	3.83	0.74	3.5	4.0	5.0	6.0
	4†	0.00	1.96	9.83	4.21	0.91				
Other	5*	0.00	2.30	10.59	4.26	0.92	161.0	19.0	174.0	484.0
	5†	0.00	2.49	11.57	4.68	1.14				
Overheating	5*	0.00	0.99	5.07	2.20	0.92	3.0	2.0	3.6	6.0
	5†	0.00	1.15	5.53	2.28	1.14				

Comments

(cont.)

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Taxonomy no		Item									
2.2		Electric Equipment Electric motors									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
178	16	**Calendar time** * 5.4324			**Operational time** † 4.3894			6368			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Parameter deviation		18*	0.01	2.97	11.94	4.48	3.31	3.9	1.0	6.1	34.0
		18†	0.01	3.57	14.51	5.48	4.10				
Structural deficiency		27*	0.00	2.82	14.56	6.36	4.97	14.3	3.0	27.0	173.0
		27†	0.00	3.51	17.28	7.29	6.15				
Vibration		4*	0.04	0.58	1.67	0.55	0.74	5.5	10.0	11.0	12.0
		4†	0.08	0.72	1.89	0.60	0.91				
Incipient		**80***	**4.39**	**19.93**	**44.69**	**12.88**	**14.73**	**6.9**	**1.0**	**11.4**	**100.0**
		80†	**5.73**	**24.71**	**54.60**	**15.58**	**18.23**				
Abnormal instrument reading		24*	0.93	4.61	10.61	3.11	4.42	6.8	1.0	11.0	100.0
		24†	0.97	5.64	13.51	4.05	5.47				
External leakage - Utility medium		2*	0.00	0.57	2.91	1.26	0.37	5.0	4.0	10.0	16.0
		2†	0.00	0.74	3.85	1.70	0.46				
Minor in-service problems		37*	0.77	7.91	21.52	6.93	6.81	4.7	1.0	6.8	57.0
		37†	0.82	10.02	28.10	9.17	8.43				
Other		6*	0.01	2.27	8.29	3.06	1.10	1.2	1.0	1.4	2.0
		6†	0.01	3.14	11.86	4.37	1.37				
Parameter deviation		3*	0.00	1.04	5.36	2.33	0.55	1.3	1.0	1.3	2.0
		3†	0.00	1.18	6.04	2.61	0.68				
Structural deficiency		4*	0.00	1.08	5.96	3.03	0.74	39.0	77.5	77.5	77.5
		4†	0.00	1.29	7.13	3.61	0.91				
Unknown		3*	0.00	1.52	6.79	2.69	0.55	4.5	1.0	4.7	12.0
		3†	0.00	1.72	7.67	3.03	0.68				
Vibration		1*	0.00	0.46	2.45	1.11	0.18	1.5	1.5	1.5	1.5
		1†	0.00	0.53	2.75	1.22	0.23				
Unknown		**4***	**0.00**	**1.51**	**6.53**	**2.53**	**0.74**	**4.0**	**4.0**	**4.0**	**4.0**
		4†	**0.00**	**1.72**	**7.30**	**2.81**	**0.91**				
Overheating		1*	0.00	0.46	2.45	1.11	0.18	-	-	-	-
		1†	0.00	0.53	2.75	1.22	0.23				
Unknown		3*	0.00	0.87	3.45	1.29	0.55	4.0	4.0	4.0	4.0
		3†	0.00	0.98	3.54	1.31	0.68				
All modes		**279***	**13.12**	**67.45**	**156.55**	**46.12**	**51.36**	**21.4**	**1.0**	**33.3**	**1140.0**
		279†	**20.44**	**79.84**	**171.25**	**47.91**	**63.56**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.7 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Electric motors

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.08	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.72	0.00	0.00	0.72	2.51	0.72	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.36	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	0.72	0.00	0.00	0.00	1.43	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Other	0.00	0.00	0.36	0.00	0.00	1.79	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Piping	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Radial bearing	0.00	1.08	0.00	0.00	0.00	0.00	1.79	0.00	0.36
Rotor	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.72	0.00
Subunit	0.00	1.08	1.43	0.00	0.36	0.72	0.00	0.36	1.43
Thrust bearing	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.36	0.72	0.72	0.00	2.87	0.72	0.72	0.00	2.51
Valves	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Total	8.96	3.23	3.94	1.43	7.89	5.02	2.51	2.87	5.73

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric motors

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.08
Cabling & junction boxes	0.00	1.08	0.36	0.00	0.00	0.36	0.00	3.58
Circuit breaker	0.00	1.43	0.00	0.36	0.00	1.08	0.00	2.87
Control unit	1.08	0.72	2.15	0.00	0.00	1.79	0.00	10.39
Coupling	0.00	0.00	0.00	0.00	0.00	0.36	0.00	1.43
Excitation	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.72
Fan w/motor	2.51	0.36	0.00	0.00	0.00	0.00	0.00	3.23
Hood	0.00	0.36	1.08	0.00	0.00	0.00	0.00	1.43
Instrument, current	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.43
Instrument, general	0.72	1.08	0.00	0.00	0.00	0.00	0.00	3.58
Instrument, speed	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.72
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Instrument, vibration	0.36	0.72	0.00	0.00	0.00	0.36	0.36	3.58
Instrument, voltage	0.00	0.36	0.00	0.00	0.00	0.00	0.00	2.51
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.36
Monitoring	0.00	0.72	0.00	0.00	0.00	0.00	0.00	1.08
Oil	0.72	0.00	0.00	0.00	0.00	0.00	0.00	1.43
Other	0.72	1.08	1.08	0.00	0.36	0.72	0.00	6.09
Overload protection	0.00	0.72	0.00	0.00	0.00	0.00	0.00	1.08
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Pump w/motor	0.36	0.72	0.00	0.00	0.00	0.00	0.00	1.43
Radial bearing	0.00	0.36	2.87	0.00	0.00	0.00	1.79	8.24
Rotor	0.36	0.00	0.72	0.00	0.00	0.00	0.00	1.43
Stator	0.00	0.00	0.00	0.00	0.00	0.36	0.00	1.43
Subunit	0.36	1.08	4.66	0.36	0.00	0.72	0.72	13.26
Thrust bearing	0.00	0.00	0.36	0.00	0.36	0.00	1.43	2.51
Unknown	1.79	1.08	1.79	0.00	1.08	7.17	0.72	22.22
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Total	8.96	13.26	15.05	0.72	2.15	13.26	5.02	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric motors

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Blockage/plugged	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.36	0.36	0.00	0.36	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00
Contamination	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00
Corrosion	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Deformation	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Electrical failure - general	0.72	0.00	0.00	0.00	3.94	2.51	0.36	1.79	0.72
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.51	0.00	0.00	0.72	1.08	1.43	0.00	0.36	1.08
Leakage	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Looseness	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.36	1.43	1.43	0.00	0.36	0.72	1.79	0.00	0.36
Misc. external influences	0.36	0.00	0.00	0.00	0.36	0.36	0.00	0.00	0.36
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43
Out of adjustment	0.36	0.00	0.00	0.72	0.36	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Software failure	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.36	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.72	1.43	0.00	0.00	0.00	0.00	0.72	0.36
Total	8.96	3.23	3.94	1.43	7.89	5.02	2.51	2.87	5.73

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Electric motors

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
Breakage	0.00	0.36	0.00	0.00	0.00	0.00	0.36	1.79
Cavitation	0.36	0.36	1.43	0.00	0.00	0.00	0.00	2.15
Clearance/ alignment failure	0.00	0.72	0.72	0.00	0.00	0.00	1.08	2.87
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Control failure	0.36	0.36	0.00	0.00	0.00	0.36	0.00	2.15
Corrosion	0.00	0.72	0.36	0.00	0.00	0.00	0.00	2.51
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Earth/isolation fault	0.00	0.36	0.00	0.00	0.00	2.15	0.00	2.87
Electrical failure - general	2.15	1.79	1.08	0.00	0.36	5.02	0.00	20.43
Faulty signal/indication/alarm	0.00	0.36	0.00	0.00	0.00	0.36	0.00	0.72
Instrument failure - general	4.30	2.15	0.00	0.00	0.72	0.36	0.36	15.05
Leakage	0.36	0.36	0.00	0.00	0.00	0.00	0.00	1.79
Looseness	0.00	0.36	0.00	0.00	0.00	0.00	0.00	1.08
Material failure - general	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.72
Mechanical Failure - general	0.36	1.08	4.30	0.00	0.72	2.15	0.36	15.41
Misc. external influences	0.36	1.43	2.87	0.00	0.36	0.00	0.00	6.45
Miscellaneous - general	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.36
Open circuit	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.72
Other	0.00	0.36	0.00	0.00	0.00	0.36	0.00	2.15
Out of adjustment	0.36	0.72	0.00	0.00	0.00	0.00	0.00	2.51
Short circuiting	0.00	0.00	0.36	0.00	0.00	1.08	0.00	1.79
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Unknown	0.00	0.00	0.36	0.36	0.00	0.36	0.72	2.15
Vibration	0.36	0.00	0.72	0.00	0.00	1.08	1.08	4.30
Wear	0.00	1.08	2.87	0.00	0.00	0.00	1.08	8.24
Total	8.96	13.26	15.05	0.72	2.15	13.26	5.02	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
2.2.1	Electric Equipment Electric motors Compressor

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
43	10	1.2443	0.9931	1348

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**41***	**2.81**	**53.66**	**159.96**	**53.34**	**32.95**	**47.5**	**2.0**	**61.7**	**847.0**
	41†	**3.42**	**58.64**	**172.80**	**57.42**	**41.29**				
External leakage - Utility medium	2*	0.01	1.62	6.18	2.28	1.61	34.5	38.0	45.5	53.0
	2†	0.33	1.97	4.74	1.42	2.01				
Fail to start on demand	6*	0.06	7.90	26.91	9.90	4.82	32.9	3.0	59.6	250.0
	6†	0.07	9.47	32.04	11.78	6.04				
Fail to stop on demand	2*	0.00	1.70	7.48	2.93	1.61	11.0	2.0	20.5	39.0
	2†	0.00	2.09	10.23	4.28	2.01				
Low output	11*	0.00	9.74	48.24	20.46	8.84	16.2	4.0	22.5	48.0
	11†	0.00	10.62	52.69	22.39	11.08				
Overheating	1*	0.06	0.85	2.44	0.80	0.80	4.0	4.0	4.0	4.0
	1†	0.00	1.06	5.80	2.79	1.01				
Parameter deviation	2*	0.00	2.51	11.03	4.32	1.61	1.8	2.0	2.5	3.0
	2†	0.00	2.79	12.13	4.71	2.01				
Spurious stop	17*	0.07	28.76	113.61	42.34	13.66	140.6	3.0	166.3	847.0
	17†	0.05	30.46	122.67	46.12	17.12				
Degraded	**29***	**0.31**	**45.69**	**157.27**	**57.96**	**23.31**	**3.6**	**1.0**	**4.8**	**34.0**
	29†	**0.26**	**49.79**	**178.94**	**66.12**	**29.20**				
Abnormal instrument reading	1*	0.00	0.80	4.15	1.82	0.80	6.0	6.0	6.0	6.0
	1†	0.00	0.93	4.52	1.88	1.01				
Erratic output	2*	0.01	1.62	6.18	2.28	1.61	3.0	3.0	3.0	3.0
	2†	0.33	1.97	4.74	1.42	2.01				
External leakage - Utility medium	5*	0.52	4.26	11.00	3.44	4.02	3.5	1.5	3.7	7.0
	5†	1.98	5.03	9.21	2.25	5.03				
Low output	1*	0.06	0.85	2.44	0.80	0.80	3.5	7.0	7.0	7.0
	1†	0.00	1.06	5.80	2.79	1.01				
Noise	2*	0.00	3.29	17.07	7.54	1.61	-	-	-	-
	2†	0.00	3.40	17.80	8.00	2.01				
Other	2*	0.00	3.29	17.07	7.54	1.61	-	-	-	-
	2†	0.00	3.40	17.80	8.00	2.01				
Overheating	2*	0.01	1.62	6.18	2.28	1.61	2.0	2.0	2.0	2.0
	2†	0.33	1.97	4.74	1.42	2.01				
Parameter deviation	12*	0.01	26.56	117.28	46.07	9.64	3.8	1.0	6.1	34.0
	12†	0.00	29.71	134.77	53.62	12.08				
Structural deficiency	2*	0.00	4.62	22.86	9.68	1.61	3.5	3.0	3.5	4.0
	2†	0.00	5.20	26.16	11.22	2.01				
Incipient	**27***	**3.88**	**25.28**	**62.29**	**19.02**	**21.70**	**5.4**	**1.0**	**8.8**	**100.0**
	27†	**6.24**	**29.33**	**66.45**	**19.29**	**27.19**				
Abnormal instrument reading	6*	0.08	7.49	24.34	8.85	4.82	11.7	1.0	23.9	100.0
	6†	0.11	8.57	27.39	9.89	6.04				

Comments

(cont.)

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Taxonomy no		Item								
2.2.1		Electric Equipment Electric motors Compressor								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
43	10	**Calendar time** * 1.2443		**Operational time** † 0.9931			1348			
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
External leakage - Utility medium		2*	0.00	1.82	8.87	3.70	1.61	5.0	4.0	10.0	16.0
		2†	0.00	2.58	13.37	5.89	2.01				
Minor in-service problems		10*	0.06	7.10	23.79	8.73	8.04	4.9	1.0	4.8	18.0
		10†	0.17	8.59	26.67	9.45	10.07				
Other		2*	0.00	1.86	9.21	3.89	1.61	1.5	1.0	1.5	2.0
		2†	0.00	2.11	9.78	3.95	2.01				
Parameter deviation		3*	0.00	3.50	14.73	5.65	2.41	1.3	1.0	1.3	2.0
		3†	0.00	3.88	16.00	6.07	3.02				
Unknown		3*	0.02	2.78	9.52	3.51	2.41	4.5	1.0	4.7	12.0
		3†	0.21	3.17	9.22	3.05	3.02				
Vibration		1*	0.06	0.85	2.44	0.80	0.80	1.5	1.5	1.5	1.5
		1†	0.00	1.06	5.80	2.79	1.01				
Unknown		**3***	**0.02**	**2.78**	**9.52**	**3.51**	**2.41**	**4.0**	**4.0**	**4.0**	**4.0**
		3†	**0.21**	**3.17**	**9.22**	**3.05**	**3.02**				
Overheating		1*	0.06	0.85	2.44	0.80	0.80	-	-	-	-
		1†	0.00	1.06	5.80	2.79	1.01				
Unknown		2*	0.00	1.87	8.67	3.51	1.61	4.0	4.0	4.0	4.0
		2†	0.00	2.12	9.42	3.72	2.01				
All modes		**100***	**10.97**	**130.06**	**363.29**	**118.37**	**80.37**	**20.8**	**1.0**	**27.1**	**847.0**
		100†	**12.07**	**142.95**	**399.19**	**130.05**	**100.70**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.0 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Electric motors - Compressor

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	0.00
Excitation	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	2.00	0.00	0.00	0.00	2.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	1.00	0.00	0.00	5.00	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
Pump w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Stator	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	4.00	0.00	0.00	2.00	0.00	1.00	0.00
Thrust bearing	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	2.00	2.00	2.00	0.00	2.00
Valves	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	7.00	0.00	9.00	2.00	6.00	12.00	2.00	4.00	4.00

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric motors - Compressor

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Cabling & junction boxes	0.00	0.00	1.00	0.00	0.00	1.00	0.00	2.00
Circuit breaker	0.00	4.00	0.00	1.00	0.00	2.00	0.00	7.00
Control unit	1.00	0.00	0.00	0.00	0.00	3.00	0.00	6.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
Excitation	0.00	0.00	0.00	0.00	1.00	0.00	0.00	2.00
Fan w/motor	7.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
Hood	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, current	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, general	2.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Instrument, speed	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Instrument, vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Instrument, voltage	0.00	1.00	0.00	0.00	0.00	0.00	0.00	5.00
Oil	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Other	2.00	0.00	1.00	0.00	1.00	0.00	0.00	10.00
Overload protection	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Pump w/motor	1.00	2.00	0.00	0.00	0.00	0.00	0.00	4.00
Radial bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Subunit	0.00	0.00	0.00	1.00	0.00	0.00	1.00	9.00
Thrust bearing	0.00	0.00	0.00	0.00	1.00	0.00	0.00	2.00
Unknown	2.00	0.00	0.00	0.00	2.00	11.00	0.00	23.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Total	17.00	10.00	2.00	2.00	5.00	17.00	1.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric motors - Compressor

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Breakage	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Deformation	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	3.00	5.00	1.00	2.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.00	0.00	0.00	0.00	2.00	4.00	0.00	0.00	1.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	1.00	0.00	3.00	0.00	0.00	2.00	1.00	0.00	1.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Unknown	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	4.00	0.00	0.00	0.00	0.00	2.00	1.00
Total	7.00	0.00	9.00	2.00	6.00	12.00	2.00	4.00	4.00

Failure descriptior versus failure mode, continued
Item: Electric motors - Compressor

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Earth/isolation fault	0.00	1.00	0.00	0.00	0.00	3.00	0.00	4.00
Electrical failure - general	3.00	4.00	1.00	0.00	1.00	10.00	0.00	30.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
Instrument failure - general	10.00	2.00	0.00	0.00	2.00	0.00	1.00	27.00
Leakage	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Mechanical Failure - general	1.00	2.00	1.00	0.00	2.00	2.00	0.00	16.00
Misc. external influences	1.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Open circuit	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
Other	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00
Out of adjustment	1.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00
Unknown	0.00	0.00	0.00	1.00	0.00	0.00	0.00	2.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
Total	17.00	10.00	2.00	2.00	5.00	17.00	1.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
2.2.1.1	Electric Equipment Electric motors Compressor Compressed air

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1279	0.1219	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.80	14.57	5.37	0.00	-	-	-	-
	0†	0.02	3.99	15.31	5.64	0.00				

Comments

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Taxonomy no	Item
2.2.1.2	Electric Equipment Electric motors Compressor Cooling systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.2464	0.1825	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**4***	**5.54**	**16.24**	**37.16**	**16.24**	**16.24**	**6.0**	**2.0**	**6.0**	**18.0**
	4†	**7.48**	**21.92**	**50.16**	**21.92**	**21.92**				
Minor in-service problems	4*	5.54	16.24	37.16	16.24	16.24	6.0	2.0	6.0	18.0
	4†	7.48	21.92	50.16	21.92	21.92				
All modes	**4***	**5.54**	**16.24**	**37.16**	**16.24**	**16.24**	**6.0**	**2.0**	**6.0**	**18.0**
	4†	**7.48**	**21.92**	**50.16**	**21.92**	**21.92**				

Comments

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Taxonomy no		Item
2.2.1.3		Electric Equipment Electric motors Compressor Gas (re)injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0917	0.0367	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	5.23	20.10	7.40	0.00	-	-	-	-
	0†	0.05	12.42	47.71	17.57	0.00				

Comments

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Taxonomy no	Item
2.2.1.4	Electric Equipment Electric motors Compressor Gas export

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0767	0.0437	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.02 0.04	6.21 10.59	23.84 40.67	8.78 14.98	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
2.2.1.5	Electric Equipment Electric motors Compressor Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	7	0.6031	0.5352	1348

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**41***	**15.29**	**80.43**	**187.74**	**55.48**	**67.98**	**47.5**	**2.0**	**61.7**	**847.0**
	41†	**19.22**	**87.03**	**195.08**	**56.23**	**76.61**				
External leakage - Utility medium	2*	0.00	3.63	17.03	6.93	3.32	34.5	38.0	45.5	53.0
	2†	0.00	3.87	17.63	7.03	3.74				
Fail to start on demand	6*	0.91	11.25	31.63	10.33	9.95	32.9	3.0	59.6	250.0
	6†	0.89	13.33	38.59	12.75	11.21				
Fail to stop on demand	2*	0.00	3.24	13.61	5.21	3.32	11.0	2.0	20.5	39.0
	2†	0.00	3.85	16.37	6.31	3.74				
Low output	11*	0.01	14.65	62.79	24.28	18.24	16.2	4.0	22.5	48.0
	11†	0.01	15.81	66.70	25.61	20.55				
Overheating	1*	0.00	1.52	7.46	3.14	1.66	4.0	4.0	4.0	4.0
	1†	0.00	1.67	8.07	3.33	1.87				
Parameter deviation	2*	0.03	3.68	12.33	4.52	3.32	1.8	2.0	2.5	3.0
	2†	0.04	4.06	13.50	4.95	3.74				
Spurious stop	17*	0.26	43.11	151.58	55.97	28.19	140.6	3.0	166.3	847.0
	17†	0.29	45.40	158.45	58.48	31.76				
Degraded	**29***	**1.80**	**73.13**	**224.32**	**78.45**	**48.09**	**3.6**	**1.0**	**4.8**	**34.0**
	29†	**1.62**	**78.96**	**244.55**	**86.40**	**54.19**				
Abnormal instrument reading	1*	0.10	1.70	5.00	1.66	1.66	6.0	6.0	6.0	6.0
	1†	0.00	1.93	10.54	4.92	1.87				
Erratic output	2*	0.00	3.63	17.03	6.93	3.32	3.0	3.0	3.0	3.0
	2†	0.00	3.87	17.63	7.03	3.74				
External leakage - Utility medium	5*	0.22	8.33	25.46	8.87	8.29	3.5	1.5	3.7	7.0
	5†	0.69	9.06	25.74	8.45	9.34				
Low output	1*	0.00	1.52	7.46	3.14	1.66	3.5	7.0	7.0	7.0
	1†	0.00	1.67	8.07	3.33	1.87				
Noise	2*	0.00	4.78	23.54	9.92	3.32	-	-	-	-
	2†	0.00	4.91	24.10	10.15	3.74				
Other	2*	0.00	4.78	23.54	9.92	3.32	-	-	-	-
	2†	0.00	4.91	24.10	10.15	3.74				
Overheating	2*	0.00	3.63	17.03	6.93	3.32	2.0	2.0	2.0	2.0
	2†	0.00	3.87	17.63	7.03	3.74				
Parameter deviation	12*	0.02	38.01	163.70	63.43	19.90	3.8	1.0	6.1	34.0
	12†	0.02	42.43	183.42	71.17	22.42				
Structural deficiency	2*	0.00	6.64	31.96	13.18	3.32	3.5	3.0	3.5	4.0
	2†	0.00	7.42	35.85	14.80	3.74				
Incipient	**23***	**25.10**	**37.99**	**53.05**	**8.55**	**38.14**	**5.3**	**1.0**	**9.3**	**100.0**
	23†	**29.09**	**42.68**	**58.41**	**8.96**	**42.97**				
Abnormal instrument reading	6*	1.60	10.73	26.62	8.16	9.95	11.7	1.0	23.9	100.0
	6†	1.78	12.13	30.16	9.26	11.21				

Comments

(cont.)

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Taxonomy no	Item
2.2.1.5	Electric Equipment Electric motors Compressor Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	7	0.6031	0.5352	1348

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	2*	0.11	3.10	9.38	3.22	3.32	5.0	4.0	10.0	16.0
	2†	0.00	3.84	17.41	6.92	3.74				
Minor in-service problems	6*	2.23	9.95	22.19	6.37	9.95	3.8	1.0	3.8	7.0
	6†	4.30	11.05	20.33	4.99	11.21				
Other	2*	0.04	3.10	10.06	3.66	3.32	1.5	1.0	1.5	2.0
	2†	0.18	3.49	10.38	3.46	3.74				
Parameter deviation	3*	0.09	5.21	16.31	5.81	4.97	1.3	1.0	1.3	2.0
	3†	0.14	5.72	17.55	6.13	5.61				
Unknown	3*	0.01	4.43	17.55	6.54	4.97	4.5	1.0	4.7	12.0
	3†	0.02	4.87	18.79	6.94	5.61				
Vibration	1*	0.00	1.52	7.46	3.14	1.66	1.5	1.5	1.5	1.5
	1†	0.00	1.67	8.07	3.33	1.87				
Unknown	**3***	**0.01**	**4.43**	**17.55**	**6.54**	**4.97**	**4.0**	**4.0**	**4.0**	**4.0**
	3†	**0.02**	**4.87**	**18.79**	**6.94**	**5.61**				
Overheating	1*	0.00	1.52	7.46	3.14	1.66	-	-	-	-
	1†	0.00	1.67	8.07	3.33	1.87				
Unknown	2*	0.02	3.07	10.98	4.06	3.32	4.0	4.0	4.0	4.0
	2†	0.02	3.39	11.67	4.30	3.74				
All modes	**96***	**42.28**	**197.45**	**446.61**	**129.51**	**159.18**	**21.6**	**1.0**	**28.2**	**847.0**
	96†	**48.25**	**214.56**	**478.35**	**137.34**	**179.37**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.0 \cdot 10^{-3}$

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Taxonomy no	Item
2.2.1.6	Electric Equipment Electric motors Compressor Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0730	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.88	18.75	6.91	0.00	-	-	-	-
	0†	0.03	6.54	25.10	9.24	0.00				

Comments

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Taxonomy no	Item
2.2.2	Electric Equipment Electric motors Pump

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
135	11	4.1881	3.3963	5020

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**78***	**1.62**	**15.09**	**40.10**	**12.74**	**18.62**	**30.0**	**1.0**	**53.2**	**1140.0**
	78†	**4.09**	**19.40**	**44.08**	**12.82**	**22.97**				
Breakdown	9*	0.22	2.04	5.43	1.72	2.15	12.4	4.0	21.9	45.0
	9†	0.67	2.51	5.30	1.47	2.65				
Fail to start on demand	16*	0.29	3.43	9.57	3.12	3.82	11.6	1.0	17.3	146.0
	16†	0.48	4.36	11.53	3.65	4.71				
Low output	2*	0.05	0.41	1.08	0.34	0.48	1.5	1.0	1.5	2.0
	2†	0.06	0.50	1.32	0.42	0.59				
Noise	3*	0.03	0.63	1.90	0.64	0.72	6.3	5.0	26.7	60.0
	3†	0.00	0.78	3.10	1.16	0.88				
Other	5*	0.00	2.10	11.24	5.17	1.19	15.5	3.0	30.6	37.5
	5†	0.00	2.55	13.68	6.31	1.47				
Overheating	1*	0.00	0.21	0.66	0.24	0.24	2.0	2.0	2.0	2.0
	1†	0.00	0.25	0.81	0.29	0.29				
Parameter deviation	2*	0.05	0.41	1.08	0.34	0.48	8.3	7.0	16.5	26.0
	2†	0.06	0.50	1.32	0.42	0.59				
Spurious stop	20*	0.92	4.71	10.92	3.21	4.78	82.0	1.0	138.2	1140.0
	20†	1.72	5.98	12.35	3.36	5.89				
Structural deficiency	11*	0.01	1.51	5.50	2.03	2.63	17.1	4.0	33.2	146.0
	11†	0.52	2.34	5.23	1.50	3.24				
Vibration	9*	0.09	1.67	5.00	1.67	2.15	17.1	4.0	25.4	57.0
	9†	0.17	2.10	5.91	1.93	2.65				
Degraded	**47***	**0.93**	**10.86**	**30.26**	**9.85**	**11.22**	**23.8**	**3.0**	**32.9**	**484.0**
	47†	**1.45**	**13.28**	**35.16**	**11.14**	**13.84**				
Erratic output	2*	0.00	2.90	12.30	4.74	0.48	-	5.0	8.5	12.0
	2†	0.01	4.09	16.78	6.36	0.59				
External leakage - Utility medium	2*	0.00	0.82	3.97	1.64	0.48	19.3	3.0	38.5	74.0
	2†	0.00	0.96	4.55	1.86	0.59				
Noise	2*	0.05	0.41	1.08	0.34	0.48	3.5	4.0	5.0	6.0
	2†	0.06	0.50	1.32	0.42	0.59				
Other	3*	0.00	1.33	6.89	3.03	0.72	161.0	19.0	174.0	484.0
	3†	0.00	1.50	7.73	3.38	0.88				
Overheating	3*	0.00	0.96	4.16	1.61	0.72	3.7	4.0	4.7	6.0
	3†	0.00	1.11	4.40	1.64	0.88				
Parameter deviation	6*	0.00	1.32	5.74	2.24	1.43	4.0	3.0	6.0	12.0
	6†	0.00	2.00	9.80	4.12	1.77				
Structural deficiency	25*	0.00	3.78	16.58	6.48	5.97	15.2	3.0	29.0	173.0
	25†	0.01	4.75	19.69	7.49	7.36				
Vibration	4*	0.06	0.74	2.08	0.68	0.96	5.5	10.0	11.0	12.0
	4†	0.13	0.93	2.36	0.73	1.18				

Comments

(cont.)

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Taxonomy no		Item								
2.2.2		Electric Equipment Electric motors Pump								
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**		
135	11	**Calendar time** * 4.1881		**Operational time** † 3.3963				5020		
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Incipient		**53***	**3.36**	**16.66**	**38.32**	**11.23**	**12.65**	**7.7**	**1.0**	**12.8**	**77.5**
		53†	**4.28**	**21.83**	**50.55**	**14.87**	**15.61**				
Abnormal instrument reading		18*	0.45	4.74	12.97	4.18	4.30	5.3	1.0	6.7	28.0
		18†	0.45	5.85	16.61	5.45	5.30				
Minor in-service problems		27*	0.15	7.97	24.85	8.84	6.45	4.7	1.0	7.7	57.0
		27†	0.17	10.54	33.16	11.86	7.95				
Other		4*	0.01	1.79	6.69	2.47	0.96	1.0	1.0	1.3	2.0
		4†	0.01	3.03	11.70	4.32	1.18				
Structural deficiency		4*	0.00	1.70	8.98	4.06	0.96	39.0	77.5	77.5	77.5
		4†	0.00	2.08	10.93	4.95	1.18				
Unknown		**1***	**0.00**	**0.21**	**0.66**	**0.24**	**0.24**	**4.0**	**4.0**	**4.0**	**4.0**
		1†	**0.00**	**0.25**	**0.81**	**0.29**	**0.29**				
Unknown		1*	0.00	0.21	0.66	0.24	0.24	4.0	4.0	4.0	4.0
		1†	0.00	0.25	0.81	0.29	0.29				
All modes		**179***	**10.31**	**42.95**	**93.94**	**26.63**	**42.74**	**21.6**	**1.0**	**36.3**	**1140.0**
		179†	**18.77**	**54.31**	**104.80**	**26.92**	**52.70**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.4 \cdot 10^{-3}$

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Maintainable item versus failure mode, to be continued
Item: Electric motors - Pump

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Actuating device	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.68	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control unit	0.56	0.00	0.00	1.12	3.35	1.12	0.00	0.00	0.00
Coupling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fan w/motor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, current	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, vibration	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Overload protection	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Radial bearing	0.00	1.68	0.00	0.00	0.00	0.00	2.79	0.00	0.00
Rotor	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00
Subunit	0.00	1.68	0.00	0.00	0.56	0.00	0.00	0.00	2.23
Thrust bearing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.56	1.12	1.12	0.00	3.35	0.00	0.00	0.00	2.79
Total	10.06	5.03	1.12	1.12	8.94	1.12	2.79	2.23	6.70

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Electric motors - Pump

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Actuating device	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Cabling & junction boxes	0.00	1.68	0.00	0.00	0.00	0.00	0.00	4.47
Circuit breaker	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Control unit	1.12	1.12	3.35	0.00	0.00	1.12	0.00	12.85
Coupling	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Fan w/motor	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Hood	0.00	0.00	1.68	0.00	0.00	0.00	0.00	1.68
Instrument, current	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.68
Instrument, general	0.00	1.68	0.00	0.00	0.00	0.00	0.00	3.35
Instrument, speed	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68
Instrument, vibration	0.56	1.12	0.00	0.00	0.00	0.56	0.56	5.03
Instrument, voltage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Monitoring	0.00	1.12	0.00	0.00	0.00	0.00	0.00	1.68
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Other	0.00	1.68	1.12	0.00	0.00	1.12	0.00	3.91
Overload protection	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Radial bearing	0.00	0.56	4.47	0.00	0.00	0.00	2.79	12.29
Rotor	0.56	0.00	1.12	0.00	0.00	0.00	0.00	2.23
Stator	0.00	0.00	0.00	0.00	0.00	0.56	0.00	1.68
Subunit	0.56	1.68	7.26	0.00	0.00	1.12	0.56	15.64
Thrust bearing	0.00	0.00	0.56	0.00	0.00	0.00	2.23	2.79
Unknown	1.68	1.68	2.79	0.00	0.56	5.03	1.12	21.79
Total	4.47	15.08	22.35	0.00	0.56	11.17	7.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Electric motors - Pump

	AIR	BRD	ELU	ERO	FTS	LOO	NOI	OHE	OTH
Blockage/plugged	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.56	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00
Contamination	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	1.68	0.00	0.00	0.00	0.00
Corrosion	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Electrical failure - general	1.12	0.00	0.00	0.00	4.47	1.12	0.00	1.68	1.12
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.12	0.00	0.00	1.12	0.56	0.00	0.00	0.56	1.12
Leakage	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Looseness	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	2.23	0.56	0.00	0.56	0.00	2.23	0.00	0.00
Misc. external influences	0.56	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.56
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.23
Out of adjustment	0.56	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Software failure	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	0.56	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.06	5.03	1.12	1.12	8.94	1.12	2.79	2.23	6.70

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Electric motors - Pump

	PDE	SER	STD	STP	UNK	UST	VIB	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Breakage	0.00	0.56	0.00	0.00	0.00	0.00	0.56	2.23
Cavitation	0.56	0.56	2.23	0.00	0.00	0.00	0.00	3.35
Clearance/ alignment failure	0.00	1.12	1.12	0.00	0.00	0.00	1.68	4.47
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Control failure	0.56	0.56	0.00	0.00	0.00	0.56	0.00	3.35
Corrosion	0.00	1.12	0.56	0.00	0.00	0.00	0.00	3.35
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	1.68	0.00	2.23
Electrical failure - general	1.68	0.56	1.12	0.00	0.00	2.23	0.00	15.08
Faulty signal/indication/alarm	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Instrument failure - general	1.12	2.23	0.00	0.00	0.00	0.56	0.00	8.38
Leakage	0.00	0.56	0.00	0.00	0.00	0.00	0.00	2.23
Looseness	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.68
Material failure - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00	1.12
Mechanical Failure - general	0.00	0.56	6.15	0.00	0.00	2.23	0.56	15.08
Misc. external influences	0.00	2.23	4.47	0.00	0.56	0.00	0.00	8.94
Miscellaneous - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.56
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Other	0.00	0.00	0.00	0.00	0.00	0.56	0.00	2.79
Out of adjustment	0.00	1.12	0.00	0.00	0.00	0.00	0.00	2.23
Short circuiting	0.00	0.00	0.56	0.00	0.00	1.12	0.00	1.68
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Unknown	0.00	0.00	0.56	0.00	0.00	0.56	1.12	2.23
Vibration	0.56	0.00	1.12	0.00	0.00	1.68	1.68	6.70
Wear	0.00	1.68	4.47	0.00	0.00	0.00	1.68	8.94
Total	4.47	15.08	22.35	0.00	0.56	11.17	7.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
2.2.2.1	Electric Equipment Electric motors Pump Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	1	0.8766	0.8660	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.40**	**2.28**	**7.18**	**2.28**	**2.28**	**5.0**	**5.0**	**5.0**	**5.0**
	2†	**0.41**	**2.31**	**7.27**	**2.31**	**2.31**				
Structural deficiency	2*	0.40	2.28	7.18	2.28	2.28	5.0	5.0	5.0	5.0
	2†	0.41	2.31	7.27	2.31	2.31				
Degraded	**6***	**2.98**	**6.84**	**13.51**	**6.84**	**6.84**	**9.0**	**5.0**	**9.0**	**14.0**
	6†	**3.02**	**6.93**	**13.67**	**6.93**	**6.93**				
Structural deficiency	6*	2.98	6.84	13.51	6.84	6.84	9.0	5.0	9.0	14.0
	6†	3.02	6.93	13.67	6.93	6.93				
Incipient	**1***	**0.06**	**1.14**	**5.41**	**1.14**	**1.14**	**-**	**-**	**-**	**-**
	1†	**0.06**	**1.15**	**5.48**	**1.15**	**1.15**				
Minor in-service problems	1*	0.06	1.14	5.41	1.14	1.14	-	-	-	-
	1†	0.06	1.15	5.48	1.15	1.15				
All modes	**9***	**5.36**	**10.27**	**17.92**	**10.27**	**10.27**	**8.0**	**5.0**	**8.0**	**14.0**
	9†	**5.42**	**10.39**	**18.14**	**10.39**	**10.39**				

Comments

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Taxonomy no	Item
2.2.2.2	Electric Equipment Electric motors Pump Combined function

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1478	0.1095	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**2***	**2.40**	**13.53**	**42.59**	**13.53**	**13.53**	**1.5**	**1.0**	**1.5**	**2.0**
	2†	**3.24**	**18.26**	**57.48**	**18.26**	**18.26**				
Minor in-service problems	1*	0.34	6.77	32.10	6.77	6.77	2.0	2.0	2.0	2.0
	1†	0.46	9.13	43.33	9.13	9.13				
Other	1*	0.34	6.77	32.10	6.77	6.77	1.0	1.0	1.0	1.0
	1†	0.46	9.13	43.33	9.13	9.13				
All modes	**2***	**2.40**	**13.53**	**42.59**	**13.53**	**13.53**	**1.5**	**1.0**	**1.5**	**2.0**
	2†	**3.24**	**18.26**	**57.48**	**18.26**	**18.26**				

Comments

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Taxonomy no	Item
2.2.2.3	Electric Equipment Electric motors Pump Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	4	0.3189	0.2216	549

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**3.57**	**18.01**	**41.59**	**12.22**	**18.81**	**11.2**	**5.0**	**19.3**	**45.0**
	6†	**4.36**	**25.95**	**62.49**	**18.82**	**27.08**				
Breakdown	1*	0.23	3.30	9.51	3.14	3.14	22.5	45.0	45.0	45.0
	1†	0.00	4.35	18.98	7.39	4.51				
Fail to start on demand	2*	0.01	7.14	28.70	10.78	6.27	5.5	5.0	5.5	6.0
	2†	0.23	8.74	26.72	9.30	9.03				
Spurious stop	2*	0.02	5.10	19.35	7.13	6.27	-	12.0	18.0	24.0
	2†	0.27	8.72	26.50	9.15	9.03				
Vibration	1*	0.02	2.76	9.66	3.57	3.14	-	24.0	24.0	24.0
	1†	0.00	4.33	18.77	7.29	4.51				
Degraded	**2***	**0.62**	**7.61**	**21.38**	**6.98**	**6.27**	**37.0**	**12.0**	**43.0**	**74.0**
	2†	**0.18**	**11.70**	**36.92**	**13.23**	**9.03**				
External leakage - Utility medium	1*	0.23	3.30	9.51	3.14	3.14	37.0	74.0	74.0	74.0
	1†	0.00	4.35	18.98	7.39	4.51				
Parameter deviation	1*	0.00	5.19	22.07	8.51	3.14	-	12.0	12.0	12.0
	1†	0.01	9.93	41.59	15.91	4.51				
Incipient	**1***	**0.00**	**5.19**	**22.07**	**8.51**	**3.14**	**-**	**6.0**	**6.0**	**6.0**
	1†	**0.01**	**9.93**	**41.59**	**15.91**	**4.51**				
Abnormal instrument reading	1*	0.00	5.19	22.07	8.51	3.14	-	6.0	6.0	6.0
	1†	0.01	9.93	41.59	15.91	4.51				
All modes	**9***	**9.35**	**30.01**	**60.21**	**15.99**	**28.22**	**17.6**	**5.0**	**23.1**	**74.0**
	9†	**4.56**	**47.21**	**128.46**	**41.34**	**40.61**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
2.2.2.4	Electric Equipment Electric motors Pump Cooling systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	1	0.1051	0.0601	150

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.48**	**9.51**	**45.14**	**9.51**	**9.51**	-	**4.0**	**4.0**	**4.0**
	1†	**0.83**	**16.65**	**78.98**	**16.65**	**16.65**				
Fail to start on demand	1*	0.48	9.51	45.14	9.51	9.51	-	4.0	4.0	4.0
	1†	0.83	16.65	78.98	16.65	16.65				
All modes	**1***	**0.48**	**9.51**	**45.14**	**9.51**	**9.51**	-	**4.0**	**4.0**	**4.0**
	1†	**0.83**	**16.65**	**78.98**	**16.65**	**16.65**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $6.7 \cdot 10^{-3}$

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Taxonomy no	Item
2.2.2.5	Electric Equipment Electric motors Pump Crude oil handling

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.2018	0.1424	1220

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.08**	**5.97**	**19.07**	**6.88**	**4.96**	**2.0**	**4.0**	**4.0**	**4.0**
	1†	**0.15**	**8.20**	**25.55**	**9.08**	**7.02**				
Spurious stop	1*	0.08	5.97	19.07	6.88	4.96	2.0	4.0	4.0	4.0
	1†	0.15	8.20	25.55	9.08	7.02				
Degraded	**3***	**2.26**	**13.57**	**32.73**	**9.87**	**14.87**	**13.7**	**42.0**	**47.7**	**52.0**
	3†	**2.67**	**19.19**	**48.31**	**14.92**	**21.07**				
Structural deficiency	3*	2.26	13.57	32.73	9.87	14.87	13.7	42.0	47.7	52.0
	3†	2.67	19.19	48.31	14.92	21.07				
Incipient	**12***	**35.12**	**60.33**	**91.05**	**17.17**	**59.47**	**3.4**	**1.0**	**6.5**	**28.0**
	12†	**49.47**	**85.16**	**128.72**	**24.33**	**84.27**				
Abnormal instrument reading	3*	0.10	20.22	74.20	27.41	14.87	6.8	6.0	13.7	28.0
	3†	0.14	27.65	100.64	37.18	21.07				
Minor in-service problems	8*	18.99	38.83	64.40	14.02	39.64	2.2	1.0	4.1	8.0
	8†	26.87	54.99	91.22	19.86	56.18				
Other	1*	0.05	4.55	14.78	5.37	4.96	1.0	2.0	2.0	2.0
	1†	0.06	6.47	21.28	7.77	7.02				
All modes	**16***	**50.16**	**79.74**	**114.89**	**19.82**	**79.29**	**5.3**	**1.0**	**14.6**	**52.0**
	16†	**70.76**	**112.66**	**162.47**	**28.09**	**112.36**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0 10^0

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Taxonomy no	Item
2.2.2.6	Electric Equipment Electric motors Pump Flare, vent & blow-down

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1971	0.1460	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.40	9.20	3.39	0.00	-	-	-	-
	0†	0.01	3.22	12.37	4.56	0.00				

Comments

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Taxonomy no	Item
2.2.2.7	Electric Equipment Electric motors Pump Gas processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1403	0.1319	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**5.85**	**21.39**	**55.29**	**21.39**	**21.39**	**7.8**	**2.0**	**14.5**	**27.0**
	3†	**6.22**	**22.75**	**58.80**	**22.75**	**22.75**				
Spurious stop	1*	0.36	7.13	33.83	7.13	7.13	2.0	2.0	2.0	2.0
	1†	0.38	7.58	35.98	7.58	7.58				
Structural deficiency	2*	2.53	14.26	44.88	14.26	14.26	13.5	27.0	27.0	27.0
	2†	2.69	15.16	47.73	15.16	15.16				
Degraded	**5***	**14.05**	**35.65**	**74.97**	**35.65**	**35.65**	**6.1**	**4.0**	**7.6**	**14.0**
	5†	**14.94**	**37.91**	**79.73**	**37.91**	**37.91**				
Noise	2*	2.53	14.26	44.88	14.26	14.26	3.5	4.0	5.0	6.0
	2†	2.69	15.16	47.73	15.16	15.16				
Structural deficiency	3*	5.85	21.39	55.29	21.39	21.39	7.8	5.0	9.3	14.0
	3†	6.22	22.75	58.80	22.75	22.75				
Incipient	**4***	**9.73**	**28.52**	**65.27**	**28.52**	**28.52**	**1.9**	**1.0**	**2.8**	**7.0**
	4†	**10.35**	**30.33**	**69.41**	**30.33**	**30.33**				
Abnormal instrument reading	3*	5.85	21.39	55.29	21.39	21.39	1.3	1.0	1.3	2.0
	3†	6.22	22.75	58.80	22.75	22.75				
Minor in-service problems	1*	0.36	7.13	33.83	7.13	7.13	3.5	7.0	7.0	7.0
	1†	0.38	7.58	35.98	7.58	7.58				
All modes	**12***	**49.37**	**85.56**	**138.60**	**85.56**	**85.56**	**4.9**	**1.0**	**7.1**	**27.0**
	12†	**52.51**	**90.99**	**147.40**	**90.99**	**90.99**				

Comments

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Taxonomy no	Item
2.2.2.8	Electric Equipment Electric motors Pump Gas production

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0365	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.03	8.21	31.52	11.61	0.00	-	-	-	-
	0†	0.04	10.94	42.00	15.47	0.00				

Comments

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Taxonomy no	Item
2.2.2.9	Electric Equipment Electric motors Pump Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0701	0.0227	11

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	6.12	23.49	8.65	0.00	-	-	-	-
	0†	0.06	15.69	60.23	22.18	0.00				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = 0.0· 10^0

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Taxonomy no	Item
2.2.2.10	Electric Equipment Electric motors Pump Heating medium

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	4	0.2208	0.1619	12

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**3.24**	**22.39**	**55.91**	**17.20**	**22.64**	**10.9**	**2.0**	**29.0**	**60.0**
	5†	**6.97**	**30.11**	**66.55**	**18.99**	**30.88**				
Breakdown	2*	0.02	9.73	39.41	14.86	9.06	17.0	34.0	34.0	34.0
	2†	0.14	12.10	39.26	14.27	12.35				
Noise	2*	0.15	8.78	27.49	9.80	9.06	7.5	15.0	37.5	60.0
	2†	0.06	12.69	47.47	17.52	12.35				
Spurious stop	1*	0.00	4.13	18.18	7.13	4.53	2.0	2.0	2.0	2.0
	1†	0.02	5.47	20.76	7.65	6.18				
Incipient	**2***	**0.11**	**8.88**	**28.50**	**10.31**	**9.06**	**3.0**	**6.0**	**6.0**	**6.0**
	2†	**0.02**	**13.47**	**55.20**	**20.91**	**12.35**				
Abnormal instrument reading	1*	0.00	4.13	18.18	7.13	4.53	3.0	6.0	6.0	6.0
	1†	0.02	5.47	20.76	7.65	6.18				
Other	1*	0.28	4.65	13.65	4.53	4.53	-	-	-	-
	1†	0.01	8.44	34.61	13.12	6.18				
All modes	**7***	**13.78**	**31.46**	**55.00**	**12.78**	**31.70**	**9.3**	**2.0**	**25.2**	**60.0**
	7†	**20.13**	**43.05**	**72.95**	**16.34**	**43.23**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $0.0 \cdot 10^0$

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Taxonomy no	Item
2.2.2.11	Electric Equipment Electric motors Pump Oil export

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**	**165.0**	**13.0**	**165.0**	**317.0**
	2†	**6.93**	**39.05**	**122.91**	**39.05**	**39.05**				
Fail to start on demand	1*	0.95	19.03	90.28	19.03	19.03	13.0	13.0	13.0	13.0
	1†	0.98	19.53	92.65	19.53	19.53				
Spurious stop	1*	0.95	19.03	90.28	19.03	19.03	317.0	317.0	317.0	317.0
	1†	0.98	19.53	92.65	19.53	19.53				
Incipient	**2***	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**	**3.0**	**2.0**	**3.0**	**4.0**
	2†	**6.93**	**39.05**	**122.91**	**39.05**	**39.05**				
Abnormal instrument reading	2*	6.75	38.05	119.77	38.05	38.05	3.0	2.0	3.0	4.0
	2†	6.93	39.05	122.91	39.05	39.05				
All modes	**4***	**25.97**	**76.10**	**174.18**	**76.10**	**76.10**	**84.0**	**2.0**	**84.0**	**317.0**
	4†	**26.65**	**78.10**	**178.75**	**78.10**	**78.10**				

Comments

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Taxonomy no	Item
2.2.2.12	Electric Equipment Electric motors Pump Oil processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	2	0.2530	0.1948	960

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**20***	**0.39**	**94.49**	**358.06**	**132.03**	**79.05**	**9.5**	**1.0**	**16.5**	**146.0**
	20†	**0.49**	**116.63**	**440.54**	**162.48**	**102.65**				
Breakdown	3*	0.09	13.69	47.73	17.61	11.86	7.3	4.0	8.3	15.0
	3†	0.12	17.01	58.10	21.39	15.40				
Fail to start on demand	3*	0.09	13.69	47.73	17.61	11.86	2.0	1.0	2.0	3.0
	3†	0.12	17.01	58.10	21.39	15.40				
Low output	2*	0.08	8.94	29.51	10.79	7.90	1.5	1.0	1.5	2.0
	2†	0.14	11.15	35.79	12.95	10.26				
Noise	1*	0.31	4.21	12.03	3.95	3.95	5.0	5.0	5.0	5.0
	1†	0.36	5.37	15.54	5.13	5.13				
Parameter deviation	1*	0.31	4.21	12.03	3.95	3.95	3.5	7.0	7.0	7.0
	1†	0.36	5.37	15.54	5.13	5.13				
Spurious stop	4*	0.10	18.44	65.98	24.38	15.81	3.8	1.0	3.8	10.0
	4†	0.14	22.87	80.55	29.75	20.53				
Structural deficiency	4*	0.10	18.44	65.98	24.38	15.81	28.8	25.0	57.5	146.0
	4†	0.14	22.87	80.55	29.75	20.53				
Vibration	2*	0.08	8.94	29.51	10.79	7.90	11.0	22.0	22.0	22.0
	2†	0.14	11.15	35.79	12.95	10.26				
Degraded	**7***	**0.15**	**32.70**	**120.76**	**44.60**	**27.67**	**6.5**	**3.0**	**9.4**	**29.0**
	7†	**0.20**	**40.45**	**148.02**	**54.69**	**35.93**				
Parameter deviation	2*	0.08	8.94	29.51	10.79	7.90	4.0	4.0	4.0	4.0
	2†	0.14	11.15	35.79	12.95	10.26				
Structural deficiency	5*	0.12	23.20	84.24	31.13	19.76	7.1	3.0	10.8	29.0
	5†	0.15	28.73	103.03	38.07	25.66				
Incipient	**6***	**1.75**	**26.35**	**76.41**	**25.26**	**23.71**	**3.0**	**1.0**	**3.8**	**8.0**
	6†	**2.81**	**33.06**	**92.24**	**30.04**	**30.79**				
Abnormal instrument reading	1*	0.31	4.21	12.03	3.95	3.95	4.0	4.0	4.0	4.0
	1†	0.36	5.37	15.54	5.13	5.13				
Minor in-service problems	4*	0.10	18.44	65.98	24.38	15.81	3.3	2.0	4.7	8.0
	4†	0.14	22.87	80.55	29.75	20.53				
Other	1*	0.02	3.72	12.96	4.78	3.95	1.0	1.0	1.0	1.0
	1†	0.03	4.88	17.48	6.46	5.13				
All modes	**33***	**0.78**	**154.88**	**562.35**	**207.78**	**130.43**	**7.9**	**1.0**	**13.1**	**146.0**
	33†	**1.00**	**191.48**	**690.91**	**255.30**	**169.37**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $3.1 \cdot 10^{-3}$

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Taxonomy no	Item
2.2.2.13	Electric Equipment Electric motors Pump Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	1	0.3039	0.2406	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**15***	**30.42**	**49.36**	**76.00**	**49.36**	**49.36**	**9.8**	**3.0**	**18.3**	**39.0**
	15†	**38.42**	**62.34**	**95.99**	**62.34**	**62.34**				
Breakdown	3*	2.70	9.87	25.52	9.87	9.87	11.2	8.0	19.7	27.0
	3†	3.41	12.47	32.23	12.47	12.47				
Fail to start on demand	3*	2.70	9.87	25.52	9.87	9.87	8.2	3.0	14.3	37.0
	3†	3.41	12.47	32.23	12.47	12.47				
Spurious stop	2*	1.17	6.58	20.72	6.58	6.58	4.0	5.0	5.5	6.0
	2†	1.48	8.31	26.16	8.31	8.31				
Structural deficiency	3*	2.70	9.87	25.52	9.87	9.87	10.8	4.0	21.7	39.0
	3†	3.41	12.47	32.23	12.47	12.47				
Vibration	4*	4.49	13.16	30.13	13.16	13.16	12.0	7.0	24.0	38.0
	4†	5.67	16.62	38.05	16.62	16.62				
Degraded	**10***	**17.85**	**32.91**	**55.81**	**32.91**	**32.91**	**6.4**	**3.0**	**11.9**	**32.0**
	10†	**22.55**	**41.56**	**70.49**	**41.56**	**41.56**				
Overheating	1*	0.16	3.29	15.62	3.29	3.29	3.0	6.0	6.0	6.0
	1†	0.21	4.16	19.72	4.16	4.16				
Structural deficiency	5*	6.48	16.45	34.60	16.45	16.45	7.4	3.0	13.4	32.0
	5†	8.19	20.78	43.70	20.78	20.78				
Vibration	4*	4.49	13.16	30.13	13.16	13.16	5.5	10.0	11.0	12.0
	4†	5.67	16.62	38.05	16.62	16.62				
Incipient	**3***	**2.70**	**9.87**	**25.52**	**9.87**	**9.87**	**2.0**	**2.0**	**2.0**	**2.0**
	3†	**3.41**	**12.47**	**32.23**	**12.47**	**12.47**				
Minor in-service problems	3*	2.70	9.87	25.52	9.87	9.87	2.0	2.0	2.0	2.0
	3†	3.41	12.47	32.23	12.47	12.47				
Unknown	**1***	**0.16**	**3.29**	**15.62**	**3.29**	**3.29**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**0.21**	**4.16**	**19.72**	**4.16**	**4.16**				
Unknown	1*	0.16	3.29	15.62	3.29	3.29	4.0	4.0	4.0	4.0
	1†	0.21	4.16	19.72	4.16	4.16				
All modes	**29***	**68.27**	**95.44**	**130.12**	**95.44**	**95.44**	**7.9**	**2.0**	**14.5**	**39.0**
	29†	**86.22**	**120.53**	**164.34**	**120.53**	**120.53**				

Comments

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Taxonomy no	Item
2.2.2.14	Electric Equipment Electric motors Pump Sea water lift

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
18	4	0.4753	0.3662	528

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**2.18**	**14.73**	**36.61**	**11.23**	**14.73**	**94.9**	**6.0**	**110.3**	**426.0**
	7†	**4.09**	**18.67**	**41.97**	**12.12**	**19.11**				
Fail to start on demand	3*	0.74	6.35	16.55	5.19	6.31	48.5	15.0	61.7	146.0
	3†	1.43	8.17	19.48	5.82	8.19				
Parameter deviation	1*	0.00	1.99	8.98	3.56	2.10	13.0	26.0	26.0	26.0
	1†	0.00	2.43	10.11	3.85	2.73				
Spurious stop	3*	0.74	6.35	16.55	5.19	6.31	182.3	6.0	187.0	426.0
	3†	1.43	8.17	19.48	5.82	8.19				
Degraded	**8***	**3.44**	**17.98**	**41.89**	**12.37**	**16.83**	**95.2**	**3.0**	**126.6**	**484.0**
	8†	**10.64**	**21.59**	**35.67**	**7.72**	**21.84**				
Other	3*	0.00	8.76	38.09	14.80	6.31	161.0	19.0	174.0	484.0
	3†	0.00	9.39	40.87	15.90	8.19				
Parameter deviation	2*	0.04	4.30	14.08	5.14	4.21	3.0	3.0	3.0	3.0
	2†	0.04	5.38	18.10	6.65	5.46				
Structural deficiency	3*	0.01	5.81	23.22	8.69	6.31	60.2	94.0	120.3	173.0
	3†	0.05	6.98	23.58	8.67	8.19				
Incipient	**4***	**1.43**	**8.74**	**21.19**	**6.41**	**8.42**	**6.8**	**3.0**	**6.8**	**18.0**
	4†	**2.28**	**10.76**	**24.41**	**7.09**	**10.92**				
Abnormal instrument reading	4*	1.43	8.74	21.19	6.41	8.42	6.8	3.0	6.8	18.0
	4†	2.28	10.76	24.41	7.09	10.92				
All modes	**19***	**10.79**	**42.03**	**90.05**	**25.18**	**39.97**	**73.0**	**3.0**	**93.6**	**484.0**
	19†	**30.52**	**51.15**	**76.08**	**13.98**	**51.88**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.9 \cdot 10^{-3}$

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Taxonomy no	Item
2.2.2.15	Electric Equipment Electric motors Pump Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
24	6	0.7757	0.6448	1590

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**16***	**2.89**	**24.00**	**62.14**	**19.44**	**20.63**	**52.2**	**1.0**	**127.9**	**1140.0**
	16†	**3.66**	**27.59**	**70.15**	**21.78**	**24.81**				
Fail to start on demand	3*	0.02	4.46	16.27	6.01	3.87	3.7	3.0	5.0	8.0
	3†	0.03	5.18	18.70	6.91	4.65				
Other	5*	0.00	5.09	24.61	10.16	6.45	15.5	3.0	30.6	37.5
	5†	0.00	6.07	29.20	12.04	7.75				
Overheating	1*	0.00	1.81	8.22	3.27	1.29	2.0	2.0	2.0	2.0
	1†	0.00	2.12	9.54	3.79	1.55				
Spurious stop	5*	0.52	8.37	24.48	8.12	6.45	136.8	1.0	363.2	1140.0
	5†	0.75	9.38	26.47	8.66	7.75				
Vibration	2*	0.15	3.06	9.17	3.06	2.58	30.5	4.0	30.5	57.0
	2†	0.33	3.45	9.40	3.03	3.10				
Degraded	**6***	**0.60**	**11.89**	**35.60**	**11.89**	**7.74**	**3.6**	**3.0**	**5.5**	**12.0**
	6†	**0.57**	**14.20**	**42.78**	**14.51**	**9.31**				
Erratic output	2*	0.00	5.29	24.32	9.76	2.58	-	5.0	8.5	12.0
	2†	0.00	7.11	32.04	12.72	3.10				
External leakage - Utility medium	1*	0.00	1.81	8.22	3.27	1.29	1.5	3.0	3.0	3.0
	1†	0.00	2.12	9.54	3.79	1.55				
Overheating	2*	0.00	3.12	14.32	5.73	2.58	4.0	4.0	4.0	4.0
	2†	0.00	3.39	14.87	5.82	3.10				
Parameter deviation	1*	0.00	1.81	8.22	3.27	1.29	5.0	5.0	5.0	5.0
	1†	0.00	2.12	9.54	3.79	1.55				
Incipient	**16***	**0.21**	**26.26**	**88.78**	**32.63**	**20.63**	**16.7**	**2.0**	**29.9**	**77.5**
	16†	**0.25**	**30.77**	**103.67**	**38.08**	**24.81**				
Abnormal instrument reading	3*	0.00	6.55	30.93	12.64	3.87	8.7	3.0	8.7	17.0
	3†	0.00	7.67	36.26	14.83	4.65				
Minor in-service problems	9*	0.11	15.66	53.97	19.90	11.60	8.5	2.0	14.1	57.0
	9†	0.13	18.28	62.73	23.11	13.96				
Structural deficiency	4*	0.00	4.23	19.11	7.59	5.16	39.0	77.5	77.5	77.5
	4†	0.00	5.04	22.66	8.98	6.20				
All modes	**38***	**5.02**	**64.59**	**182.89**	**59.93**	**48.99**	**31.4**	**1.0**	**68.4**	**1140.0**
	38†	**6.06**	**75.36**	**212.21**	**69.38**	**58.94**				

Comments

On demand probability for consequence class: Critical and failure mode: Fail to start on demand = $1.3 \cdot 10^{-3}$

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MECHANICAL EQUIPMENT

Heat Exchangers

Inventory description

The boundary definition is shown in Figure 17 and corresponding subdivision in Maintainable Items in Table 12.

Inlet, outlet, pressure relief and drain valves are specifically excluded. The only valves are calibration valves and instrument valves that form a pressure boundary (e.g. block valves, control valves, calibration valves, local indicators/gauges).

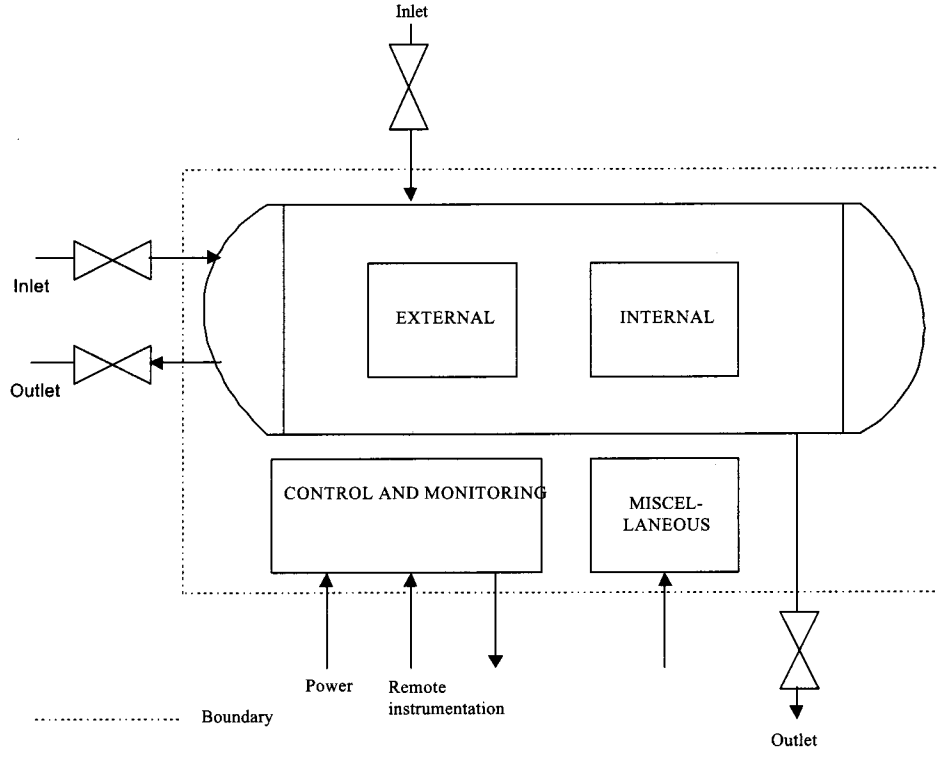

Figure 17 Heat Exchangers, Boundary Definition

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Table 12 Heat Exchangers, Subdivision in Maintainable Items

HEAT EXCHANGERS			
External	Internal	Control and Monitoring	Miscellaneous
• Support • Body/Shell • Valves & piping • Instruments	• Body/shell • Instruments • Plates • Seals (gaskets) • Tubes	• Actuating device • Cabling & junction boxes • Control unit • Instruments • Monitoring • Internal power supply • Valves	• Fan w/motor

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR Abnormal instrument reading
ELP External leakage - Process medium
ELU External leakage - Utility medium
IHT Insufficient heat transfer
INL Internal leakage
SER Minor in-service problems
OTH Other
PDE Parameter deviation
PLU Plugged/Choked
STD Structural deficiency
UNK Unknown

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Taxonomy no	Item
3.1	Mechanical Equipment Heat Exchangers

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
68	12	2.1078	1.6357	97740

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**29***	**0.06**	**13.64**	**50.42**	**18.62**	**13.76**	**23.5**	**2.0**	**45.5**	**311.0**
	29†	**0.17**	**16.50**	**53.93**	**19.66**	**17.73**				
Abnormal instrument reading	1*	0.01	0.53	1.69	0.61	0.47	-	12.0	12.0	12.0
	1†	0.00	0.70	3.86	1.93	0.61				
External leakage - Process medium	7*	0.01	4.30	17.10	6.39	3.32	12.3	6.0	24.5	60.0
	7†	0.03	5.14	18.30	6.76	4.28				
External leakage - Utility medium	2*	0.00	1.33	6.90	3.04	0.95	34.8	30.0	69.5	109.0
	2†	0.00	1.49	7.37	3.13	1.22				
Insufficient heat transfer	2*	0.02	0.78	2.41	0.85	0.95	5.0	4.0	8.0	12.0
	2†	0.00	1.00	4.16	1.58	1.22				
Minor in-service problems	1*	0.01	0.42	1.32	0.47	0.47	2.0	2.0	2.0	2.0
	1†	0.00	0.54	2.13	0.79	0.61				
Other	1*	0.01	0.42	1.32	0.47	0.47	6.0	14.0	14.0	14.0
	1†	0.00	0.54	2.13	0.79	0.61				
Parameter deviation	4*	0.19	1.97	5.37	1.73	1.90	12.9	4.0	24.8	60.0
	4†	0.00	2.39	10.83	4.31	2.45				
Plugged/Choked	1*	0.00	0.58	2.38	0.90	0.47	26.5	53.0	53.0	53.0
	1†	0.04	0.64	1.85	0.61	0.61				
Structural deficiency	10*	0.00	4.17	22.95	10.88	4.74	37.3	18.0	74.9	311.0
	10†	0.00	4.75	25.38	11.68	6.11				
Degraded	**69***	**0.07**	**22.17**	**86.33**	**32.00**	**32.73**	**4.4**	**1.0**	**5.2**	**24.0**
	69†	**0.01**	**31.69**	**138.72**	**54.20**	**42.18**				
External leakage - Process medium	2*	0.00	1.59	6.69	2.57	0.95	15.0	10.0	15.0	20.0
	2†	0.00	1.74	6.99	2.62	1.22				
External leakage - Utility medium	4*	0.00	2.54	11.39	4.51	1.90	1.0	1.0	2.8	6.0
	4†	0.00	3.59	16.68	6.75	2.45				
Insufficient heat transfer	26*	0.00	4.37	22.63	17.58	12.33	3.8	1.0	4.3	9.0
	26†	0.00	7.59	39.25	29.97	15.90				
Internal leakage	2*	0.20	1.00	2.29	0.67	0.95	7.0	10.0	17.0	24.0
	2†	0.00	1.29	6.61	2.86	1.22				
Minor in-service problems	11*	0.00	2.50	13.23	6.04	5.22	3.0	1.0	3.0	6.0
	11†	0.00	3.70	21.20	11.42	6.72				
Other	9*	0.00	2.30	10.83	4.42	4.27	5.9	3.0	6.5	17.0
	9†	0.00	3.18	17.59	8.91	5.50				
Parameter deviation	6*	0.30	2.96	7.97	2.55	2.85	4.5	4.0	7.7	16.0
	6†	0.27	3.92	11.34	3.75	3.67				
Plugged/Choked	9*	0.00	6.16	34.10	17.39	4.27	3.7	2.0	3.7	6.0
	9†	0.00	7.31	40.29	20.14	5.50				
Incipient	**111***	**8.34**	**50.46**	**122.05**	**36.85**	**52.66**	**18.0**	**1.0**	**21.1**	**279.0**
	111†	**6.33**	**68.74**	**188.92**	**61.10**	**67.86**				
Abnormal instrument reading	28*	1.13	14.40	40.69	13.32	13.28	2.9	1.0	5.1	24.0
	28†	0.83	19.94	59.97	20.27	17.12				

Comments

(cont.)

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Taxonomy no	Item
3.1	Mechanical Equipment Heat Exchangers

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
68	12	2.1078	1.6357	97740

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	8*	0.00	4.72	26.39	13.79	3.80	-	2.0	2.4	4.0
	8†	0.00	5.37	29.87	15.42	4.89				
External leakage - Utility medium	5*	0.00	4.15	17.88	6.93	2.37	58.0	2.0	26.4	96.0
	5†	0.00	5.58	23.42	8.97	3.06				
Insufficient heat transfer	1*	0.01	0.42	1.32	0.47	0.47	-	4.0	4.0	4.0
	1†	0.00	0.54	2.13	0.79	0.61				
Internal leakage	1*	0.00	0.46	2.16	0.88	0.47	2.0	6.0	6.0	6.0
	1†	0.00	0.56	2.42	0.94	0.61				
Minor in-service problems	33*	0.06	12.07	43.29	16.00	15.66	4.1	1.0	8.1	76.0
	33†	0.04	18.27	73.30	27.50	20.17				
Other	12*	0.11	4.99	15.36	5.40	5.69	9.0	2.0	15.3	65.0
	12†	0.21	6.47	19.61	6.74	7.34				
Parameter deviation	11*	0.67	4.55	11.31	3.47	5.22	31.2	4.0	55.9	146.0
	11†	0.93	5.93	14.53	4.42	6.72				
Plugged/Choked	1*	0.01	0.53	1.69	0.61	0.47	-	5.0	5.0	5.0
	1†	0.00	0.78	3.64	1.47	0.61				
Structural deficiency	10*	0.00	4.71	21.96	8.90	4.74	58.1	2.0	78.7	279.0
	10†	0.00	6.02	26.63	10.47	6.11				
Unknown	1*	0.00	1.05	5.49	2.46	0.47	200.0	200.0	200.0	200.0
	1†	0.00	1.15	5.96	2.64	0.61				
Unknown	**3***	**0.00**	**2.99**	**13.68**	**5.46**	**1.42**	**29.5**	**9.0**	**31.0**	**60.0**
	3†	**0.00**	**3.31**	**15.04**	**5.99**	**1.83**				
Other	2*	0.00	2.46	12.66	5.49	0.95	42.0	24.0	42.0	60.0
	2†	0.00	2.75	14.14	6.13	1.22				
Unknown	1*	0.00	0.58	2.38	0.90	0.47	4.5	9.0	9.0	9.0
	1†	0.04	0.64	1.85	0.61	0.61				
All modes	**212***	**19.89**	**88.98**	**198.74**	**57.14**	**100.58**	**13.7**	**1.0**	**19.0**	**311.0**
	212†	**11.30**	**118.98**	**324.89**	**104.74**	**129.61**				

Comments

On demand probability for consequence class: Critical and failure mode: *** = 0.0 10^0

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Maintainable item versus failure mode, to be continued
Item: Heat Exchangers

	AIR	ELP	ELU	IHT	INL	OTH
Actuating device	0.00	0.00	0.00	0.00	0.00	0.47
Body/shell	0.00	0.47	0.00	0.00	0.00	2.36
Cabling & junction boxes	0.47	0.00	0.00	0.00	0.00	0.00
Control unit	0.47	0.00	0.00	0.94	0.00	0.00
Fan w/motor	0.47	0.00	0.00	12.74	0.00	4.25
Instrument, flow	2.36	0.00	0.00	0.00	0.00	0.00
Instrument, general	2.83	0.00	0.00	0.00	0.00	0.47
Instrument, level	0.47	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.42	0.00	0.47	0.00	0.00	0.00
Instrument, temperature	3.77	0.00	0.47	0.00	0.00	0.00
Monitoring	0.47	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.47	0.00	0.00	0.47
Piping	0.00	0.94	0.00	0.00	0.47	0.00
Plates	0.00	0.94	0.47	0.00	0.47	0.47
Seals (gaskets)	0.00	0.47	0.94	0.00	0.00	0.47
Subunit	0.00	0.47	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tubes	0.00	0.00	0.47	0.00	0.00	0.00
Unknown	0.00	0.94	0.47	0.00	0.00	2.36
Valves	0.94	3.77	1.42	0.00	0.47	0.00
Total	13.68	8.02	5.19	13.68	1.42	11.32

Maintainable item versus failure mode, continued
Item: Heat Exchangers

	PDE	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.47
Body/shell	0.94	0.00	0.94	2.83	0.00	7.55
Cabling & junction boxes	0.47	0.00	0.00	0.00	0.00	0.94
Control unit	0.00	0.00	3.77	0.00	0.00	5.19
Fan w/motor	2.83	0.00	11.32	0.00	0.00	31.60
Instrument, flow	0.47	0.00	0.47	0.00	0.00	3.30
Instrument, general	0.00	0.00	0.00	0.00	0.00	3.30
Instrument, level	0.00	0.00	0.00	0.00	0.00	0.47
Instrument, pressure	0.00	0.00	0.47	0.94	0.00	3.30
Instrument, temperature	0.24	0.00	0.47	0.00	0.00	4.95
Monitoring	0.00	0.00	0.00	0.00	0.00	0.47
Other	0.00	0.00	1.42	0.00	0.00	2.36
Piping	0.47	0.00	0.00	4.25	0.00	6.13
Plates	0.00	0.00	0.00	0.47	0.47	3.30
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	1.89
Subunit	0.00	2.36	0.00	0.00	0.00	2.83
Support	0.00	0.47	0.94	0.00	0.00	1.42
Tubes	2.36	0.47	0.00	0.00	0.00	3.30
Unknown	0.00	1.42	1.42	0.00	0.47	7.08
Valves	2.12	0.47	0.00	0.94	0.00	10.14
Total	9.91	5.19	21.23	9.43	0.94	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heat Exchangers

	AIR	ELP	ELU	IHT	INL	OTH
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.47	0.00	0.47	0.47	0.00	0.94
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.47	0.00	0.00
Control failure	0.47	0.00	0.00	0.00	0.00	0.00
Corrosion	0.94	0.47	0.47	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.94	0.00	0.00
Electrical failure - general	0.47	0.00	0.00	1.42	0.00	0.94
Erosion	0.00	0.00	0.00	0.00	0.47	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	3.30	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.30	0.00	0.94	0.00	0.00	0.47
Leakage	0.00	6.13	1.89	0.00	0.47	0.94
Looseness	0.00	0.00	0.47	1.89	0.00	0.94
Material failure - general	0.00	0.94	0.47	0.47	0.00	0.47
Mechanical Failure - general	0.47	0.00	0.00	1.89	0.00	1.42
Misc. external influences	0.00	0.00	0.00	0.00	0.00	1.89
Miscellaneous - general	0.00	0.00	0.00	1.42	0.47	0.00
No signal/indication/alarm	0.94	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	0.94	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.47
Out of adjustment	2.36	0.00	0.47	0.47	0.00	0.00
Sticking	0.47	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.47
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.47	0.47	0.00	3.30	0.00	2.36
Total	13.68	8.02	5.19	13.68	1.42	11.32

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Heat Exchangers

	PDE	PLU	SER	STD	UNK	Sum
Blockage/plugged	0.94	0.00	0.00	0.94	0.00	1.89
Breakage	0.00	0.00	0.94	0.94	0.00	4.25
Cavitation	0.00	0.00	0.00	0.94	0.00	0.94
Clearance/ alignment failure	0.00	0.00	1.89	0.00	0.00	2.36
Control failure	0.47	0.00	0.00	0.00	0.00	0.94
Corrosion	0.47	0.00	1.89	3.30	0.00	7.55
Deformation	0.00	0.00	0.47	0.00	0.00	0.47
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.94
Electrical failure - general	0.94	0.00	0.47	0.00	0.00	4.25
Erosion	0.00	0.00	0.00	0.00	0.00	0.47
External influence - general	1.42	0.00	0.00	1.42	0.00	2.83
Faulty signal/indication/alarm	0.47	0.00	0.00	0.00	0.00	3.77
Instrument failure - general	0.47	0.00	0.00	0.00	0.47	5.66
Leakage	0.00	0.00	0.94	0.00	0.00	10.38
Looseness	0.00	0.00	5.19	0.00	0.00	8.49
Material failure - general	0.00	0.00	0.47	0.00	0.00	2.83
Mechanical Failure - general	1.89	0.00	2.83	0.47	0.00	8.96
Misc. external influences	0.94	0.47	0.00	0.00	0.00	3.30
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	1.89
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.94
Open circuit	0.00	0.00	0.00	0.00	0.00	0.94
Other	0.00	0.00	0.00	0.47	0.00	0.94
Out of adjustment	0.00	0.00	0.00	0.00	0.00	3.30
Sticking	0.47	0.47	0.00	0.00	0.00	1.42
Unknown	0.00	0.00	0.00	0.00	0.47	0.94
Vibration	0.94	0.00	0.94	0.94	0.00	2.83
Wear	0.47	4.25	5.19	0.00	0.00	16.51
Total	9.91	5.19	21.23	9.43	0.94	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.1.1	Mechanical Equipment Heat Exchangers Fin fan

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	2	0.6134	0.2921	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.88**	**8.56**	**22.96**	**7.34**	**9.78**	**4.2**	**2.0**	**7.0**	**14.0**
	6†	**3.63**	**20.52**	**48.72**	**14.53**	**20.54**				
External leakage - Process medium	1*	0.05	1.56	4.73	1.63	1.63	3.0	6.0	6.0	6.0
	1†	0.17	3.42	10.25	3.42	3.42				
Insufficient heat transfer	2*	0.41	3.09	7.88	2.45	3.26	5.0	4.0	8.0	12.0
	2†	1.21	6.84	16.24	4.84	6.85				
Minor in-service problems	1*	0.05	1.56	4.73	1.63	1.63	2.0	2.0	2.0	2.0
	1†	0.17	3.42	10.25	3.42	3.42				
Other	1*	0.05	1.56	4.73	1.63	1.63	6.0	14.0	14.0	14.0
	1†	0.17	3.42	10.25	3.42	3.42				
Parameter deviation	1*	0.05	1.56	4.73	1.63	1.63	4.0	4.0	4.0	4.0
	1†	0.17	3.42	10.25	3.42	3.42				
Degraded	**48***	**5.17**	**54.12**	**147.61**	**47.56**	**78.25**	**4.1**	**1.0**	**4.5**	**17.0**
	48†	**28.39**	**162.93**	**388.55**	**116.22**	**164.31**				
Insufficient heat transfer	26*	10.49	35.10	71.50	19.24	42.39	3.8	1.0	4.3	9.0
	26†	15.56	88.59	210.79	62.95	89.00				
Minor in-service problems	11*	1.16	14.56	41.10	13.45	17.93	3.0	1.0	3.0	6.0
	11†	6.64	37.58	89.28	26.63	37.65				
Other	9*	1.08	12.24	33.90	11.00	14.67	5.9	3.0	6.5	17.0
	9†	5.44	30.76	73.06	21.79	30.81				
Parameter deviation	2*	0.41	3.09	7.88	2.45	3.26	6.8	5.0	6.5	8.0
	2†	1.21	6.84	16.24	4.84	6.85				
Incipient	**45***	**5.43**	**51.53**	**137.53**	**43.80**	**73.36**	**4.0**	**1.0**	**4.7**	**24.0**
	45†	**26.66**	**152.82**	**364.34**	**108.96**	**154.04**				
Abnormal instrument reading	10*	1.12	13.41	37.51	12.23	16.30	3.5	1.0	4.9	24.0
	10†	6.04	34.17	81.17	24.21	34.23				
Insufficient heat transfer	1*	0.05	1.56	4.73	1.63	1.63	-	4.0	4.0	4.0
	1†	0.17	3.42	10.25	3.42	3.42				
Minor in-service problems	23*	12.38	32.51	60.39	14.97	37.50	3.7	1.0	3.8	14.0
	23†	13.79	78.41	186.51	55.69	78.73				
Other	6*	0.88	8.56	22.96	7.34	9.78	3.7	2.0	3.7	4.0
	6†	3.63	20.52	48.72	14.53	20.54				
Parameter deviation	5*	0.79	7.26	19.26	6.11	8.15	6.4	5.0	10.2	14.0
	5†	3.03	17.10	40.60	12.11	17.12				
All modes	**99***	**1.59**	**98.21**	**308.95**	**110.52**	**161.40**	**4.1**	**1.0**	**4.7**	**24.0**
	99†	**56.96**	**333.11**	**798.54**	**239.71**	**338.88**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heat Exchangers - Fin fan

	AIR	ELP	ELU	IHT	INL	OTH
Actuating device	0.00	0.00	0.00	0.00	0.00	1.01
Body/shell	0.00	1.01	0.00	0.00	0.00	4.04
Cabling & junction boxes	1.01	0.00	0.00	0.00	0.00	0.00
Control unit	1.01	0.00	0.00	2.02	0.00	0.00
Fan w/motor	1.01	0.00	0.00	27.27	0.00	9.09
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	6.06	0.00	0.00	0.00	0.00	1.01
Monitoring	1.01	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	1.01
Total	10.10	1.01	0.00	29.29	0.00	16.16

Maintainable item versus failure mode, continued
Item: Heat Exchangers - Fin fan

	PDE	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	1.01
Body/shell	0.00	0.00	1.01	0.00	0.00	6.06
Cabling & junction boxes	1.01	0.00	0.00	0.00	0.00	2.02
Control unit	0.00	0.00	8.08	0.00	0.00	11.11
Fan w/motor	6.06	0.00	24.24	0.00	0.00	67.68
Instrument, flow	1.01	0.00	0.00	0.00	0.00	1.01
Instrument, general	0.00	0.00	0.00	0.00	0.00	7.07
Monitoring	0.00	0.00	0.00	0.00	0.00	1.01
Other	0.00	0.00	2.02	0.00	0.00	3.03
Total	8.08	0.00	35.35	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heat Exchangers - Fin fan

	AIR	ELP	ELU	IHT	INL	OTH
Breakage	0.00	0.00	0.00	1.01	0.00	2.02
Clearance/ alignment failure	0.00	0.00	0.00	1.01	0.00	0.00
Control failure	1.01	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	2.02	0.00	0.00
Electrical failure - general	1.01	0.00	0.00	3.03	0.00	2.02
Faulty signal/indication/alarm	6.06	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.02	0.00	0.00	0.00	0.00	1.01
Leakage	0.00	1.01	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	4.04	0.00	2.02
Material failure - general	0.00	0.00	0.00	1.01	0.00	1.01
Mechanical Failure - general	0.00	0.00	0.00	4.04	0.00	3.03
Miscellaneous - general	0.00	0.00	0.00	3.03	0.00	0.00
Open circuit	0.00	0.00	0.00	2.02	0.00	0.00
Out of adjustment	0.00	0.00	0.00	1.01	0.00	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	7.07	0.00	5.05
Total	10.10	1.01	0.00	29.29	0.00	16.16

Failure descriptior versus failure mode, continued
Item: Heat Exchangers - Fin fan

	PDE	PLU	SER	STD	UNK	Sum
Breakage	0.00	0.00	2.02	0.00	0.00	5.05
Clearance/ alignment failure	0.00	0.00	4.04	0.00	0.00	5.05
Control failure	1.01	0.00	0.00	0.00	0.00	2.02
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	2.02
Electrical failure - general	2.02	0.00	1.01	0.00	0.00	9.09
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	6.06
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	3.03
Leakage	0.00	0.00	0.00	0.00	0.00	1.01
Looseness	0.00	0.00	11.11	0.00	0.00	17.17
Material failure - general	0.00	0.00	1.01	0.00	0.00	3.03
Mechanical Failure - general	2.02	0.00	3.03	0.00	0.00	12.12
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	3.03
Open circuit	0.00	0.00	0.00	0.00	0.00	2.02
Out of adjustment	0.00	0.00	0.00	0.00	0.00	1.01
Vibration	2.02	0.00	2.02	0.00	0.00	4.04
Wear	1.01	0.00	11.11	0.00	0.00	24.24
Total	8.08	0.00	35.35	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.1.1.1	Mechanical Equipment Heat Exchangers Fin fan Air->Sea Water

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0351	0.0001	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.05	12.44	47.79	17.60	0.00	-	-	-	-
	0†	1.21	311.53	1196.27	440.57	0.00				

Comments

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Taxonomy no	Item
3.1.1.2	Mechanical Equipment Heat Exchangers Fin fan Gas->Air

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.5783	0.2920	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**4.52**	**10.38**	**20.47**	**10.38**	**10.38**	**4.2**	**2.0**	**7.0**	**14.0**
	6†	**8.95**	**20.55**	**40.54**	**20.55**	**20.55**				
External leakage - Process medium	1*	0.09	1.73	8.21	1.73	1.73	3.0	6.0	6.0	6.0
	1†	0.17	3.42	16.25	3.42	3.42				
Insufficient heat transfer	2*	0.61	3.46	10.89	3.46	3.46	5.0	4.0	8.0	12.0
	2†	1.22	6.85	21.56	6.85	6.85				
Minor in-service problems	1*	0.09	1.73	8.21	1.73	1.73	2.0	2.0	2.0	2.0
	1†	0.17	3.42	16.25	3.42	3.42				
Other	1*	0.09	1.73	8.21	1.73	1.73	6.0	14.0	14.0	14.0
	1†	0.17	3.42	16.25	3.42	3.42				
Parameter deviation	1*	0.09	1.73	8.21	1.73	1.73	4.0	4.0	4.0	4.0
	1†	0.17	3.42	16.25	3.42	3.42				
Degraded	**48***	**64.33**	**83.00**	**105.57**	**83.00**	**83.00**	**4.1**	**1.0**	**4.5**	**17.0**
	48†	**127.38**	**164.37**	**209.07**	**164.37**	**164.37**				
Insufficient heat transfer	26*	31.50	44.96	62.38	44.96	44.96	3.8	1.0	4.3	9.0
	26†	62.38	89.03	123.53	89.03	89.03				
Minor in-service problems	11*	10.67	19.02	31.49	19.02	19.02	3.0	1.0	3.0	6.0
	11†	21.13	37.67	62.36	37.67	37.67				
Other	9*	8.12	15.56	27.16	15.56	15.56	5.9	3.0	6.5	17.0
	9†	16.08	30.82	53.78	30.82	30.82				
Parameter deviation	2*	0.61	3.46	10.89	3.46	3.46	6.8	5.0	6.5	8.0
	2†	1.22	6.85	21.56	6.85	6.85				
Incipient	**45***	**59.76**	**77.81**	**99.77**	**77.81**	**77.81**	**4.0**	**1.0**	**4.7**	**24.0**
	45†	**118.35**	**154.09**	**197.56**	**154.09**	**154.09**				
Abnormal instrument reading	10*	9.38	17.29	29.33	17.29	17.29	3.5	1.0	4.9	24.0
	10†	18.58	34.24	58.08	34.24	34.24				
Insufficient heat transfer	1*	0.09	1.73	8.21	1.73	1.73	-	4.0	4.0	4.0
	1†	0.17	3.42	16.25	3.42	3.42				
Minor in-service problems	23*	27.18	39.77	56.34	39.77	39.77	3.7	1.0	3.8	14.0
	23†	53.82	78.76	111.58	78.76	78.76				
Other	6*	4.52	10.38	20.47	10.38	10.38	3.7	2.0	3.7	4.0
	6†	8.95	20.55	40.54	20.55	20.55				
Parameter deviation	5*	3.41	8.65	18.18	8.65	8.65	6.4	5.0	10.2	14.0
	5†	6.75	17.12	36.01	17.12	17.12				
All modes	**99***	**143.90**	**171.19**	**202.31**	**171.19**	**171.19**	**4.1**	**1.0**	**4.7**	**24.0**
	99†	**284.97**	**339.00**	**400.63**	**339.00**	**339.00**				

Comments

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Taxonomy no		Item									
3.1.2		Mechanical Equipment Heat Exchangers Plate - compact									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
1	1	**Calendar time** * 0.0088		**Operational time** † 0.0088							
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
All modes		**0***	**0.14**	**34.77**	**133.52**	**49.18**	**0.00**	-	-	-	-
		0†	**0.15**	**38.57**	**148.12**	**54.55**	**0.00**				
Comments											

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Taxonomy no	Item
3.1.2.1	Mechanical Equipment Heat Exchangers Plate - compact Gas->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0088	0.0088	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.08	21.61	82.98	30.56	0.00	-	-	-	-
	0†	0.09	23.02	88.39	32.55	0.00				

Comments

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Taxonomy no		Item									
3.1.3		Mechanical Equipment Heat Exchangers Plate - conventional									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
14	4	**Calendar time *** 0.4823			**Operational time †** 0.4497						
Failure mode		**No of**	**Failure rate (per 10^6 hours).**					**Active**	**Repair (manhours)**		
		failures	**Lower**	**Mean**	**Upper**	**SD**	**n/τ**	**rep.hrs**	**Min**	**Mean**	**Max**
Critical		**11***	**0.01**	**20.89**	**88.56**	**34.09**	**22.81**	**18.7**	**8.0**	**37.4**	**109.0**
		11†	**0.01**	**21.75**	**92.05**	**35.41**	**24.46**				
External leakage - Process medium		5*	0.26	10.15	31.06	10.82	10.37	15.3	8.0	30.7	60.0
		5†	0.38	10.65	32.16	10.98	11.12				
External leakage - Utility medium		2*	0.05	4.02	13.04	4.74	4.15	34.8	30.0	69.5	109.0
		2†	0.07	4.25	13.35	4.77	4.45				
Parameter deviation		2*	0.05	4.02	13.04	4.74	4.15	8.8	11.0	17.5	24.0
		2†	0.07	4.25	13.35	4.77	4.45				
Plugged/Choked		1*	0.00	2.00	8.99	3.56	2.07	26.5	53.0	53.0	53.0
		1†	0.00	2.11	9.39	3.71	2.22				
Structural deficiency		1*	0.00	2.00	8.99	3.56	2.07	9.0	18.0	18.0	18.0
		1†	0.00	2.11	9.39	3.71	2.22				
Degraded		**6***	**3.76**	**12.70**	**25.93**	**6.99**	**12.44**	**6.6**	**1.0**	**10.7**	**24.0**
		6†	**4.25**	**13.48**	**26.94**	**7.13**	**13.34**				
External leakage - Process medium		1*	0.00	2.98	12.54	4.80	2.07	20.0	20.0	20.0	20.0
		1†	0.00	3.14	13.18	5.04	2.22				
External leakage - Utility medium		1*	0.00	2.00	8.99	3.56	2.07	1.0	1.0	1.0	1.0
		1†	0.00	2.11	9.39	3.71	2.22				
Internal leakage		2*	0.06	4.07	12.93	4.65	4.15	7.0	10.0	17.0	24.0
		2†	0.08	4.36	13.62	4.85	4.45				
Parameter deviation		2*	0.05	4.02	13.04	4.74	4.15	2.3	4.0	4.5	5.0
		2†	0.07	4.25	13.35	4.77	4.45				
Incipient		**12***	**4.34**	**27.00**	**65.78**	**19.95**	**24.88**	**40.6**	**2.0**	**42.0**	**200.0**
		12†	**4.93**	**28.37**	**67.70**	**20.26**	**26.68**				
Abnormal instrument reading		4*	1.00	8.28	21.44	6.71	8.29	1.8	2.0	3.5	6.0
		4†	1.34	8.74	21.54	6.58	8.89				
External leakage - Utility medium		2*	0.00	6.94	29.41	11.32	4.15	58.0	20.0	58.0	96.0
		2†	0.00	7.31	31.01	11.95	4.45				
Internal leakage		1*	0.00	1.86	7.55	2.85	2.07	2.0	6.0	6.0	6.0
		1†	0.00	2.02	8.52	3.27	2.22				
Other		4*	0.00	7.67	32.86	12.71	8.29	-	-	-	-
		4†	0.00	8.03	34.13	13.15	8.89				
Unknown		1*	0.00	2.98	12.54	4.80	2.07	200.0	200.0	200.0	200.0
		1†	0.00	3.14	13.18	5.04	2.22				
Unknown		**3***	**0.08**	**8.27**	**27.44**	**10.05**	**6.22**	**29.5**	**9.0**	**31.0**	**60.0**
		3†	**0.08**	**8.69**	**28.78**	**10.53**	**6.67**				
Other		2*	0.00	6.94	29.41	11.32	4.15	42.0	24.0	42.0	60.0
		2†	0.00	7.31	31.01	11.95	4.45				
Unknown		1*	0.00	2.00	8.99	3.56	2.07	4.5	9.0	9.0	9.0
		1†	0.00	2.11	9.39	3.71	2.22				
Comments											

(cont.)

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Taxonomy no	Item
3.1.3	Mechanical Equipment Heat Exchangers Plate - conventional

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
14	4	0.4823	0.4497	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	32* 32†	5.50 6.18	71.15 74.50	201.72 208.68	66.13 68.07	66.35 71.15	23.9	1.0	31.9	200.0

Comments

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Maintainable item versus failure mode, to be continued
Item: Heat Exchangers - Plate - conventional

	AIR	ELP	ELU	IHT	INL	OTH
Instrument, flow	6.25	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	6.25	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	3.13	0.00	0.00	0.00
Piping	0.00	6.25	0.00	0.00	3.13	0.00
Plates	0.00	6.25	3.13	0.00	3.13	3.13
Seals (gaskets)	0.00	3.13	3.13	0.00	0.00	3.13
Tubes	0.00	0.00	3.13	0.00	0.00	0.00
Unknown	0.00	3.13	3.13	0.00	0.00	12.50
Valves	0.00	0.00	0.00	0.00	3.13	0.00
Total	12.50	18.75	15.63	0.00	9.38	18.75

Maintainable item versus failure mode, continued
Item: Heat Exchangers - Plate - conventional

	PDE	PLU	SER	STD	UNK	Sum
Instrument, flow	0.00	0.00	0.00	0.00	0.00	6.25
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	6.25
Other	0.00	0.00	0.00	0.00	0.00	3.13
Piping	0.00	0.00	0.00	0.00	0.00	9.38
Plates	0.00	0.00	0.00	3.13	3.13	21.88
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	9.38
Tubes	6.25	3.13	0.00	0.00	0.00	12.50
Unknown	0.00	0.00	0.00	0.00	3.13	21.88
Valves	6.25	0.00	0.00	0.00	0.00	9.38
Total	12.50	3.13	0.00	3.13	6.25	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heat Exchangers - Plate - conventional

	AIR	ELP	ELU	IHT	INL	OTH
Corrosion	0.00	0.00	3.13	0.00	0.00	0.00
Erosion	0.00	0.00	0.00	0.00	3.13	0.00
Instrument failure - general	6.25	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	12.50	12.50	0.00	3.13	6.25
Material failure - general	0.00	6.25	0.00	0.00	0.00	0.00
Mechanical Failure - general	3.13	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	12.50
Miscellaneous - general	0.00	0.00	0.00	0.00	3.13	0.00
Out of adjustment	3.13	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	12.50	18.75	15.63	0.00	9.38	18.75

Failure descriptior versus failure mode, continued
Item: Heat Exchangers - Plate - conventional

	PDE	PLU	SER	STD	UNK	Sum
Corrosion	0.00	0.00	0.00	0.00	0.00	3.13
Erosion	0.00	0.00	0.00	0.00	0.00	3.13
Instrument failure - general	0.00	0.00	0.00	0.00	3.13	9.38
Leakage	0.00	0.00	0.00	0.00	0.00	34.38
Material failure - general	0.00	0.00	0.00	0.00	0.00	6.25
Mechanical Failure - general	6.25	0.00	0.00	3.13	0.00	12.50
Misc. external influences	6.25	3.13	0.00	0.00	0.00	21.88
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	3.13
Out of adjustment	0.00	0.00	0.00	0.00	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	3.13	3.13
Total	12.50	3.13	0.00	3.13	6.25	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.1.3.1	Mechanical Equipment Heat Exchangers Plate - conventional Crude Oil->Sea Water

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0613	0.0582	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.82**	**16.30**	**77.35**	**16.30**	**16.30**	**20.0**	**20.0**	**20.0**	**20.0**
	1†	**0.86**	**17.18**	**81.53**	**17.18**	**17.18**				
External leakage - Process medium	1*	0.82	16.30	77.35	16.30	16.30	20.0	20.0	20.0	20.0
	1†	0.86	17.18	81.53	17.18	17.18				
Incipient	**3***	**13.37**	**48.90**	**126.42**	**48.90**	**48.90**	**105.3**	**20.0**	**105.3**	**200.0**
	3†	**14.09**	**51.55**	**133.25**	**51.55**	**51.55**				
External leakage - Utility medium	2*	5.79	32.60	102.62	32.60	32.60	58.0	20.0	58.0	96.0
	2†	6.10	34.36	108.16	34.36	34.36				
Unknown	1*	0.82	16.30	77.35	16.30	16.30	200.0	200.0	200.0	200.0
	1†	0.86	17.18	81.53	17.18	17.18				
Unknown	**2***	**5.79**	**32.60**	**102.62**	**32.60**	**32.60**	**42.0**	**24.0**	**42.0**	**60.0**
	2†	**6.10**	**34.36**	**108.16**	**34.36**	**34.36**				
Other	2*	5.79	32.60	102.62	32.60	32.60	42.0	24.0	42.0	60.0
	2†	6.10	34.36	108.16	34.36	34.36				
All modes	**6***	**42.63**	**97.81**	**193.01**	**97.81**	**97.81**	**70.0**	**20.0**	**70.0**	**200.0**
	6†	**44.93**	**103.09**	**203.44**	**103.09**	**103.09**				

Comments

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Taxonomy no	Item
3.1.3.2	Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Crude Oil

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0701	0.0672	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**37.29**	**85.56**	**168.83**	**85.56**	**85.56**	**16.1**	**8.0**	**32.2**	**60.0**
	6†	**38.89**	**89.24**	**176.10**	**89.24**	**89.24**				
External leakage - Process medium	2*	5.06	28.52	89.76	28.52	28.52	17.0	8.0	34.0	60.0
	2†	5.28	29.75	93.63	29.75	29.75				
External leakage - Utility medium	1*	0.71	14.26	67.66	14.26	14.26	15.0	30.0	30.0	30.0
	1†	0.74	14.87	70.57	14.87	14.87				
Parameter deviation	1*	0.71	14.26	67.66	14.26	14.26	12.0	24.0	24.0	24.0
	1†	0.74	14.87	70.57	14.87	14.87				
Plugged/Choked	1*	0.71	14.26	67.66	14.26	14.26	26.5	53.0	53.0	53.0
	1†	0.74	14.87	70.57	14.87	14.87				
Structural deficiency	1*	0.71	14.26	67.66	14.26	14.26	9.0	18.0	18.0	18.0
	1†	0.74	14.87	70.57	14.87	14.87				
Degraded	**3***	**11.69**	**42.78**	**110.58**	**42.78**	**42.78**	**1.8**	**1.0**	**3.3**	**5.0**
	3†	**12.20**	**44.62**	**115.34**	**44.62**	**44.62**				
External leakage - Utility medium	1*	0.71	14.26	67.66	14.26	14.26	1.0	1.0	1.0	1.0
	1†	0.74	14.87	70.57	14.87	14.87				
Parameter deviation	2*	5.06	28.52	89.76	28.52	28.52	2.3	4.0	4.5	5.0
	2†	5.28	29.75	93.63	29.75	29.75				
Incipient	**5***	**28.09**	**71.30**	**149.94**	**71.30**	**71.30**	**1.7**	**2.0**	**3.3**	**6.0**
	5†	**29.30**	**74.36**	**156.39**	**74.36**	**74.36**				
Abnormal instrument reading	3*	11.69	42.78	110.58	42.78	42.78	1.7	2.0	3.3	6.0
	3†	12.20	44.62	115.34	44.62	44.62				
Other	2*	5.06	28.52	89.76	28.52	28.52	-	-	-	-
	2†	5.28	29.75	93.63	29.75	29.75				
All modes	**14***	**120.67**	**199.63**	**312.06**	**199.63**	**199.63**	**8.9**	**1.0**	**17.8**	**60.0**
	14†	**125.86**	**208.22**	**325.48**	**208.22**	**208.22**				

Comments

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Taxonomy no	Item
3.1.3.3	Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Sea Water

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	3	0.2807	0.2553	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**0.02**	**19.21**	**80.73**	**30.93**	**14.25**	**30.0**	**11.0**	**60.0**	**109.0**
	4†	**0.02**	**19.94**	**83.26**	**31.79**	**15.67**				
External leakage - Process medium	2*	0.03	9.49	37.21	13.83	7.13	-	-	-	-
	2†	0.04	9.86	38.03	14.04	7.83				
External leakage - Utility medium	1*	0.07	4.34	13.67	4.89	3.56	54.5	109.0	109.0	109.0
	1†	0.17	4.51	13.61	4.63	3.92				
Parameter deviation	1*	0.07	4.34	13.67	4.89	3.56	5.5	11.0	11.0	11.0
	1†	0.17	4.51	13.61	4.63	3.92				
Degraded	**1***	**0.05**	**3.15**	**9.94**	**3.56**	**3.56**	**2.0**	**10.0**	**10.0**	**10.0**
	1†	**0.06**	**3.48**	**10.95**	**3.92**	**3.92**				
Internal leakage	1*	0.05	3.15	9.94	3.56	3.56	2.0	10.0	10.0	10.0
	1†	0.06	3.48	10.95	3.92	3.92				
Incipient	**3***	**2.25**	**11.56**	**26.81**	**7.90**	**10.69**	**2.0**	**6.0**	**6.0**	**6.0**
	3†	**3.47**	**12.30**	**25.56**	**6.98**	**11.75**				
Internal leakage	1*	0.05	3.15	9.94	3.56	3.56	2.0	6.0	6.0	6.0
	1†	0.06	3.48	10.95	3.92	3.92				
Other	2*	0.03	9.49	37.21	13.83	7.13	-	-	-	-
	2†	0.04	9.86	38.03	14.04	7.83				
Unknown	**1***	**0.07**	**4.34**	**13.67**	**4.89**	**3.56**	**4.5**	**9.0**	**9.0**	**9.0**
	1†	**0.17**	**4.51**	**13.61**	**4.63**	**3.92**				
Unknown	1*	0.07	4.34	13.67	4.89	3.56	4.5	9.0	9.0	9.0
	1†	0.17	4.51	13.61	4.63	3.92				
All modes	**9***	**0.21**	**37.86**	**134.63**	**49.74**	**32.07**	**13.7**	**6.0**	**29.0**	**109.0**
	9†	**0.27**	**39.75**	**137.51**	**50.71**	**35.25**				

Comments

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Taxonomy no	Item
3.1.3.4	Mechanical Equipment Heat Exchangers Plate - conventional Water/glycol->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0702	0.0690	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.71**	**14.25**	**67.62**	**14.25**	**14.25**	**12.0**	**24.0**	**24.0**	**24.0**
	1†	**0.72**	**14.49**	**68.77**	**14.49**	**14.49**				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
Degraded	**1***	**0.71**	**14.25**	**67.62**	**14.25**	**14.25**	**12.0**	**24.0**	**24.0**	**24.0**
	1†	**0.72**	**14.49**	**68.77**	**14.49**	**14.49**				
Internal leakage	1*	0.71	14.25	67.62	14.25	14.25	12.0	24.0	24.0	24.0
	1†	0.72	14.49	68.77	14.49	14.49				
Incipient	**1***	**0.71**	**14.25**	**67.62**	**14.25**	**14.25**	**2.0**	**4.0**	**4.0**	**4.0**
	1†	**0.72**	**14.49**	**68.77**	**14.49**	**14.49**				
Abnormal instrument reading	1*	0.71	14.25	67.62	14.25	14.25	2.0	4.0	4.0	4.0
	1†	0.72	14.49	68.77	14.49	14.49				
All modes	**3***	**11.68**	**42.75**	**110.51**	**42.75**	**42.75**	**8.7**	**4.0**	**17.3**	**24.0**
	3†	**11.88**	**43.48**	**112.39**	**43.48**	**43.48**				

Comments

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Taxonomy no	Item
3.1.4	Mechanical Equipment Heat Exchangers Printed circuit

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0165	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**9***	**178.65**	**342.47**	**597.60**	**342.47**	**342.47**	**3.7**	**2.0**	**3.7**	**6.0**
	9†	**283.99**	**544.40**	**949.98**	**544.40**	**544.40**				
Plugged/Choked	9*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
	9†	283.99	544.40	949.98	544.40	544.40				
All modes	**9***	**178.65**	**342.47**	**597.60**	**342.47**	**342.47**	**3.7**	**2.0**	**3.7**	**6.0**
	9†	**283.99**	**544.40**	**949.98**	**544.40**	**544.40**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heat Exchangers - Printed circuit

	AIR	ELP	ELU	IHT	INL	OTH
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Heat Exchangers - Printed circuit

	PDE	PLU	SER	STD	UNK	Sum
Subunit	0.00	55.56	0.00	0.00	0.00	55.56
Support	0.00	11.11	0.00	0.00	0.00	11.11
Unknown	0.00	33.33	0.00	0.00	0.00	33.33
Total	0.00	100.0	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Heat Exchangers - Printed circuit

	AIR	ELP	ELU	IHT	INL	OTH
Wear	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Heat Exchangers - Printed circuit

	PDE	PLU	SER	STD	UNK	Sum
Wear	0.00	100.0	0.00	0.00	0.00	100.0
Total	0.00	100.0	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.1.4.1	Mechanical Equipment Heat Exchangers Printed circuit Gas->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0165	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**9***	**178.65**	**342.47**	**597.60**	**342.47**	**342.47**	**3.7**	**2.0**	**3.7**	**6.0**
	9†	**283.99**	**544.40**	**949.98**	**544.40**	**544.40**				
Plugged/Choked	9*	178.65	342.47	597.60	342.47	342.47	3.7	2.0	3.7	6.0
	9†	283.99	544.40	949.98	544.40	544.40				
All modes	**9***	**178.65**	**342.47**	**597.60**	**342.47**	**342.47**	**3.7**	**2.0**	**3.7**	**6.0**
	9†	**283.99**	**544.40**	**949.98**	**544.40**	**544.40**				

Comments

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Taxonomy no	Item
3.1.5	Mechanical Equipment Heat Exchangers Shell and tube

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
42	7	0.9771	0.8685	97740

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**12***	**0.00**	**8.58**	**36.72**	**14.20**	**12.28**	**39.5**	**12.0**	**73.0**	**311.0**
	12†	**0.02**	**9.70**	**39.25**	**14.78**	**13.82**				
Abnormal instrument reading	1*	0.00	1.03	5.36	2.40	1.02	-	12.0	12.0	12.0
	1†	0.00	1.14	5.83	2.52	1.15				
External leakage - Process medium	1*	0.00	1.03	5.36	2.40	1.02	-	-	-	-
	1†	0.01	1.29	4.90	1.81	1.15				
Parameter deviation	1*	0.00	0.89	3.68	1.40	1.02	30.0	60.0	60.0	60.0
	1†	0.00	1.00	3.93	1.46	1.15				
Structural deficiency	9*	0.00	5.72	30.70	14.19	9.21	40.5	28.0	81.2	311.0
	9†	0.00	6.17	32.68	14.92	10.36				
Degraded	**6***	**0.00**	**6.27**	**27.61**	**10.83**	**6.14**	**10.0**	**1.0**	**7.3**	**16.0**
	6†	**0.00**	**8.82**	**40.50**	**16.22**	**6.91**				
External leakage - Process medium	1*	0.00	1.15	4.58	1.71	1.02	10.0	10.0	10.0	10.0
	1†	0.01	1.25	4.22	1.55	1.15				
External leakage - Utility medium	3*	0.00	3.03	14.64	6.05	3.07	-	1.0	3.3	6.0
	3†	0.00	4.41	22.00	9.38	3.45				
Parameter deviation	2*	0.00	2.06	8.70	3.34	2.05	-	8.0	12.0	16.0
	2†	0.00	2.88	13.85	5.71	2.30				
Incipient	**54***	**5.54**	**55.58**	**150.24**	**48.19**	**55.26**	**46.1**	**1.5**	**32.1**	**279.0**
	54†	**3.42**	**70.04**	**209.89**	**70.20**	**62.17**				
Abnormal instrument reading	14*	0.31	17.39	54.31	19.33	14.33	1.5	1.5	5.8	23.0
	14†	0.24	22.99	75.06	27.34	16.12				
External leakage - Process medium	8*	0.00	7.67	41.17	19.02	8.19	-	2.0	2.4	4.0
	8†	0.00	8.19	44.23	20.53	9.21				
External leakage - Utility medium	3*	0.00	3.03	14.64	6.05	3.07	-	2.0	5.3	8.0
	3†	0.00	4.41	22.00	9.38	3.45				
Minor in-service problems	10*	0.16	13.29	42.86	15.55	10.23	12.0	2.0	18.1	76.0
	10†	0.15	17.31	57.93	21.25	11.51				
Other	2*	0.00	1.63	7.16	2.80	2.05	25.0	35.0	50.0	65.0
	2†	0.00	1.82	7.64	2.92	2.30				
Parameter deviation	6*	0.07	4.94	15.62	5.61	6.14	56.0	4.0	94.0	146.0
	6†	0.23	5.70	17.18	5.83	6.91				
Plugged/Choked	1*	0.00	1.03	5.36	2.40	1.02	-	5.0	5.0	5.0
	1†	0.01	1.29	4.90	1.81	1.15				
Structural deficiency	10*	0.08	8.07	26.45	9.65	10.23	58.1	2.0	78.7	279.0
	10†	0.08	9.53	32.10	11.79	11.51				
All modes	**72***	**6.93**	**69.62**	**188.25**	**60.39**	**73.69**	**42.2**	**1.0**	**36.5**	**311.0**
	72†	**3.92**	**87.48**	**262.63**	**88.37**	**82.90**				

Comments

On demand probability for consequence class: Critical and failure mode: *** = $0.0 \cdot 10^0$

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Maintainable item versus failure mode, to be continued
Item: Heat Exchangers - Shell and tube

	AIR	ELP	ELU	IHT	INL	OTH
Body/shell	0.00	0.00	0.00	0.00	0.00	1.39
Instrument, flow	4.17	0.00	0.00	0.00	0.00	0.00
Instrument, level	1.39	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	4.17	0.00	1.39	0.00	0.00	0.00
Instrument, temperature	8.33	0.00	1.39	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	1.39	0.00	0.00	0.00
Subunit	0.00	1.39	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tubes	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	1.39	0.00	0.00	0.00	1.39
Valves	2.78	11.11	4.17	0.00	0.00	0.00
Total	20.83	13.89	8.33	0.00	0.00	2.78

Maintainable item versus failure mode, continued
Item: Heat Exchangers - Shell and tube

	PDE	PLU	SER	STD	UNK	Sum
Body/shell	2.78	0.00	1.39	8.33	0.00	13.89
Instrument, flow	0.00	0.00	1.39	0.00	0.00	5.56
Instrument, level	0.00	0.00	0.00	0.00	0.00	1.39
Instrument, pressure	0.00	0.00	1.39	2.78	0.00	9.72
Instrument, temperature	0.69	0.00	1.39	0.00	0.00	11.81
Other	0.00	0.00	1.39	0.00	0.00	1.39
Piping	1.39	0.00	0.00	12.50	0.00	13.89
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	1.39
Subunit	0.00	0.00	0.00	0.00	0.00	1.39
Support	0.00	0.00	2.78	0.00	0.00	2.78
Tubes	4.17	0.00	0.00	0.00	0.00	4.17
Unknown	0.00	0.00	4.17	0.00	0.00	6.94
Valves	3.47	1.39	0.00	2.78	0.00	25.69
Total	12.50	1.39	13.89	26.39	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heat Exchangers - Shell and tube

	AIR	ELP	ELU	IHT	INL	OTH
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	1.39	0.00	1.39	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	2.78	1.39	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.39	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.17	0.00	2.78	0.00	0.00	0.00
Leakage	0.00	11.11	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	1.39	0.00	0.00	0.00
Material failure - general	0.00	0.00	1.39	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.78	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	1.39
Out of adjustment	5.56	0.00	1.39	0.00	0.00	0.00
Sticking	1.39	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	1.39
Vibration	0.00	0.00	0.00	0.00	0.00	0.00
Wear	1.39	1.39	0.00	0.00	0.00	0.00
Total	20.83	13.89	8.33	0.00	0.00	2.78

Failure descriptior versus failure mode, continued
Item: Heat Exchangers - Shell and tube

	PDE	PLU	SER	STD	UNK	Sum
Blockage/plugged	2.78	0.00	0.00	2.78	0.00	5.56
Breakage	0.00	0.00	0.00	2.78	0.00	5.56
Cavitation	0.00	0.00	0.00	2.78	0.00	2.78
Corrosion	1.39	0.00	5.56	9.72	0.00	20.83
Deformation	0.00	0.00	1.39	0.00	0.00	1.39
External influence - general	4.17	0.00	0.00	4.17	0.00	8.33
Faulty signal/indication/alarm	1.39	0.00	0.00	0.00	0.00	2.78
Instrument failure - general	1.39	0.00	0.00	0.00	0.00	8.33
Leakage	0.00	0.00	2.78	0.00	0.00	13.89
Looseness	0.00	0.00	0.00	0.00	0.00	1.39
Material failure - general	0.00	0.00	0.00	0.00	0.00	1.39
Mechanical Failure - general	0.00	0.00	4.17	0.00	0.00	4.17
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	2.78
Other	0.00	0.00	0.00	1.39	0.00	2.78
Out of adjustment	0.00	0.00	0.00	0.00	0.00	6.94
Sticking	1.39	1.39	0.00	0.00	0.00	4.17
Unknown	0.00	0.00	0.00	0.00	0.00	1.39
Vibration	0.00	0.00	0.00	2.78	0.00	2.78
Wear	0.00	0.00	0.00	0.00	0.00	2.78
Total	12.50	1.39	13.89	26.39	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.1.5.1	Mechanical Equipment Heat Exchangers Shell and tube Condensate->Gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0365	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**1.01**	**20.30**	**96.30**	**20.30**	**20.30**	**1.5**	**1.5**	**1.5**	**1.5**
	1†	**1.37**	**27.39**	**129.99**	**27.39**	**27.39**				
Abnormal instrument reading	1*	1.01	20.30	96.30	20.30	20.30	1.5	1.5	1.5	1.5
	1†	1.37	27.39	129.99	27.39	27.39				
All modes	**1***	**1.01**	**20.30**	**96.30**	**20.30**	**20.30**	**1.5**	**1.5**	**1.5**	**1.5**
	1†	**1.37**	**27.39**	**129.99**	**27.39**	**27.39**				

Comments

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Taxonomy no	Item
3.1.5.2	Mechanical Equipment Heat Exchangers Shell and tube Crude Oil->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.05	13.22	50.75	18.69	0.00	-	-	-	-
	0†	0.05	13.76	52.83	19.46	0.00				

Comments

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Taxonomy no	Item
3.1.5.3	Mechanical Equipment Heat Exchangers Shell and tube Flare Gas->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1226	0.1225	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	3.85	14.79	5.45	0.00	-	-	-	-
	0†	0.02	3.90	14.98	5.52	0.00				

Comments

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Taxonomy no	Item
3.1.5.4	Mechanical Equipment Heat Exchangers Shell and tube Gas->Condensate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**2***	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**	-	**5.0**	**5.0**	**5.0**
	2†	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**				
Abnormal instrument reading	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0
	1†	2.85	57.08	270.83	57.08	57.08				
Structural deficiency	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	**2***	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**	-	**5.0**	**5.0**	**5.0**
	2†	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**				

Comments

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Taxonomy no	Item
3.1.5.5	Mechanical Equipment Heat Exchangers Shell and tube Gas->Freshwater

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	2	0.1051	0.0701	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**2.56**	**17.56**	**43.78**	**13.45**	**19.03**	-	**1.0**	**8.5**	**16.0**
	2†	**1.43**	**28.52**	**85.40**	**28.51**	**28.53**				
External leakage - Utility medium	1*	0.11	8.72	27.92	10.09	9.51	-	1.0	1.0	1.0
	1†	0.06	14.26	54.76	20.17	14.26				
Parameter deviation	1*	0.11	8.72	27.92	10.09	9.51	-	16.0	16.0	16.0
	1†	0.06	14.26	54.76	20.17	14.26				
Incipient	**19***	**113.41**	**175.62**	**248.91**	**41.47**	**180.75**	-	**2.0**	**7.6**	**27.0**
	19†	**41.72**	**270.98**	**667.11**	**203.60**	**271.03**				
Abnormal instrument reading	7*	30.60	65.86	111.94	25.17	66.59	-	2.0	6.8	23.0
	7†	46.85	99.85	168.89	37.74	99.85				
External leakage - Utility medium	3*	5.38	26.16	59.84	17.48	28.54	-	2.0	5.3	8.0
	3†	0.56	42.78	136.77	49.39	42.79				
Minor in-service problems	5*	19.37	48.30	87.76	21.27	47.56	-	2.0	13.0	27.0
	5†	28.10	71.32	130.59	31.90	71.32				
Parameter deviation	1*	0.11	8.72	27.92	10.09	9.51	-	4.0	4.0	4.0
	1†	0.06	14.26	54.76	20.17	14.26				
Plugged/Choked	1*	0.11	8.72	27.92	10.09	9.51	-	5.0	5.0	5.0
	1†	0.06	14.26	54.76	20.17	14.26				
Structural deficiency	2*	2.56	17.56	43.78	13.45	19.03	-	3.0	3.0	3.0
	2†	1.43	28.52	85.40	28.51	28.53				
All modes	**21***	**99.02**	**189.47**	**303.60**	**63.01**	**199.77**	-	**1.0**	**7.7**	**27.0**
	21†	**34.71**	**299.50**	**781.08**	**245.26**	**299.55**				

Comments

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Taxonomy no	Item
3.1.5.6	Mechanical Equipment Heat Exchangers Shell and tube Gas->Gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0350	0.0333	21720

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.05	11.84	45.47	16.75	0.00	-	-	-	-
	0†	0.05	12.82	49.24	18.13	0.00				

Comments

On demand probability for consequence class: Critical and failure mode: *** = $0.0 \cdot 10^0$

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Taxonomy no	Item
3.1.5.7	Mechanical Equipment Heat Exchangers Shell and tube Gas->Gas/condensate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**5.0**	**5.0**	**5.0**
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
Minor in-service problems	1*	2.85	57.08	270.83	57.08	57.08	-	5.0	5.0	5.0
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**5.0**	**5.0**	**5.0**
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				

Comments

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Taxonomy no	Item
3.1.5.8	Mechanical Equipment Heat Exchangers Shell and tube Gas->Sea Water

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.1717	0.1647	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**10***	**31.60**	**58.24**	**98.78**	**58.24**	**58.24**	**39.5**	**28.0**	**79.1**	**311.0**
	10†	**32.94**	**60.72**	**102.98**	**60.72**	**60.72**				
Parameter deviation	1*	0.29	5.82	27.64	5.82	5.82	30.0	60.0	60.0	60.0
	1†	0.30	6.07	28.81	6.07	6.07				
Structural deficiency	9*	27.34	52.42	91.47	52.42	52.42	40.5	28.0	81.2	311.0
	9†	28.51	54.65	95.36	54.65	54.65				
Incipient	**13***	**44.78**	**75.72**	**120.36**	**75.72**	**75.72**	**55.1**	**2.0**	**110.2**	**279.0**
	13†	**46.68**	**78.94**	**125.49**	**78.94**	**78.94**				
Other	1*	0.29	5.82	27.64	5.82	5.82	32.5	65.0	65.0	65.0
	1†	0.30	6.07	28.81	6.07	6.07				
Parameter deviation	5*	11.47	29.12	61.24	29.12	29.12	56.0	96.0	112.0	146.0
	5†	11.96	30.36	63.85	30.36	30.36				
Structural deficiency	7*	19.13	40.77	76.59	40.77	40.77	58.1	2.0	116.2	279.0
	7†	19.95	42.50	79.85	42.50	42.50				
All modes	**23***	**91.55**	**133.96**	**189.78**	**133.96**	**133.96**	**48.0**	**2.0**	**96.0**	**311.0**
	23†	**95.44**	**139.66**	**197.85**	**139.66**	**139.66**				

Comments

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Taxonomy no	Item
3.1.5.9	Mechanical Equipment Heat Exchangers Shell and tube Gas->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	2	0.2278	0.2189	76020

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.02**	**4.25**	**15.61**	**5.77**	**4.39**	-	**12.0**	**12.0**	**12.0**
	1†	**0.02**	**4.44**	**16.44**	**6.07**	**4.57**				
Abnormal instrument reading	1*	0.02	4.25	15.61	5.77	4.39	-	12.0	12.0	12.0
	1†	0.02	4.44	16.44	6.07	4.57				
Degraded	**1***	**0.27**	**4.51**	**13.23**	**4.39**	**4.39**	**10.0**	**10.0**	**10.0**	**10.0**
	1†	**0.27**	**4.67**	**13.75**	**4.57**	**4.57**				
External leakage - Process medium	1*	0.27	4.51	13.23	4.39	4.39	10.0	10.0	10.0	10.0
	1†	0.27	4.67	13.75	4.57	4.57				
Incipient	**13***	**1.28**	**54.12**	**166.32**	**58.29**	**57.08**	**12.0**	**2.0**	**4.8**	**18.0**
	13†	**1.24**	**56.77**	**175.19**	**61.68**	**59.38**				
Abnormal instrument reading	3*	0.31	12.60	38.65	13.52	13.17	-	4.0	7.3	12.0
	3†	0.29	13.19	40.74	14.35	13.70				
External leakage - Process medium	8*	0.20	32.98	115.48	42.63	35.12	-	2.0	2.4	4.0
	8†	0.21	34.65	121.82	44.98	36.54				
Minor in-service problems	2*	1.57	8.80	20.85	6.21	8.78	12.0	3.0	10.5	18.0
	2†	1.63	9.15	21.69	6.46	9.14				
All modes	**15***	**5.60**	**63.03**	**174.38**	**56.57**	**65.86**	**11.0**	**2.0**	**5.6**	**18.0**
	15†	**5.56**	**66.00**	**184.41**	**60.09**	**68.52**				

Comments

On demand probability for consequence class: Critical and failure mode: *** = 0.0 10^0

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Taxonomy no	Item
3.1.5.10	Mechanical Equipment Heat Exchangers Shell and tube Hc-comb->Hc-comb

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0365	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.03	8.86	34.01	12.53	0.00	-	-	-	-
	0†	0.05	11.84	45.48	16.75	0.00				

Comments

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Taxonomy no	Item
3.1.5.11	Mechanical Equipment Heat Exchangers Shell and tube Oil->Fuel Gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0088	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**2.0**	**2.0**	**2.0**
	1†	**5.71**	**114.16**	**541.67**	**114.16**	**114.16**				
Abnormal instrument reading	1*	2.85	57.08	270.83	57.08	57.08	-	2.0	2.0	2.0
	1†	5.71	114.16	541.67	114.16	114.16				
All modes	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	**2.0**	**2.0**	**2.0**
	1†	**5.71**	**114.16**	**541.67**	**114.16**	**114.16**				

Comments

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Taxonomy no	Item
3.1.5.12	Mechanical Equipment Heat Exchangers Shell and tube Oil->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0350	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
External leakage - Process medium	1*	1.43	28.54	135.42	28.54	28.54	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
Degraded	**3***	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**	-	**3.0**	**5.7**	**8.0**
	3†	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**				
External leakage - Utility medium	2*	10.13	57.08	179.65	57.08	57.08	-	3.0	4.5	6.0
	2†	20.26	114.16	359.30	114.16	114.16				
Parameter deviation	1*	1.43	28.54	135.42	28.54	28.54	-	8.0	8.0	8.0
	1†	2.85	57.08	270.83	57.08	57.08				
Incipient	**3***	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**	-	**4.0**	**31.3**	**76.0**
	3†	**46.80**	**171.23**	**442.64**	**171.23**	**171.23**				
Abnormal instrument reading	1*	1.43	28.54	135.42	28.54	28.54	-	4.0	4.0	4.0
	1†	2.85	57.08	270.83	57.08	57.08				
Minor in-service problems	2*	10.13	57.08	179.65	57.08	57.08	-	14.0	45.0	76.0
	2†	20.26	114.16	359.30	114.16	114.16				
All modes	**7***	**93.75**	**199.77**	**375.29**	**199.77**	**199.77**	-	**3.0**	**18.5**	**76.0**
	7†	**187.50**	**399.54**	**750.57**	**399.54**	**399.54**				

Comments

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Taxonomy no	Item
3.1.5.13	Mechanical Equipment Heat Exchangers Shell and tube Water/glycol->Water/glycol

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0981	0.0941	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.51**	**10.19**	**48.36**	**10.19**	**10.19**	**17.5**	**35.0**	**35.0**	**35.0**
	1†	**0.53**	**10.63**	**50.43**	**10.63**	**10.63**				
Other	1*	0.51	10.19	48.36	10.19	10.19	17.5	35.0	35.0	35.0
	1†	0.53	10.63	50.43	10.63	10.63				
All modes	**1***	**0.51**	**10.19**	**48.36**	**10.19**	**10.19**	**17.5**	**35.0**	**35.0**	**35.0**
	1†	**0.53**	**10.63**	**50.43**	**10.63**	**10.63**				

Comments

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Vessels

Inventory description

Boundary definition is shown in Figure 18, and definition of Subunits and Maintainable Items is shown in Table 13.

Inlet, outlet, pressure relief and drain valves are specifically excluded. The only valves are calibration valves and instrument valves that form a pressure boundary (e.g. block valves, control valves, calibration valves, local indicators/gauges).

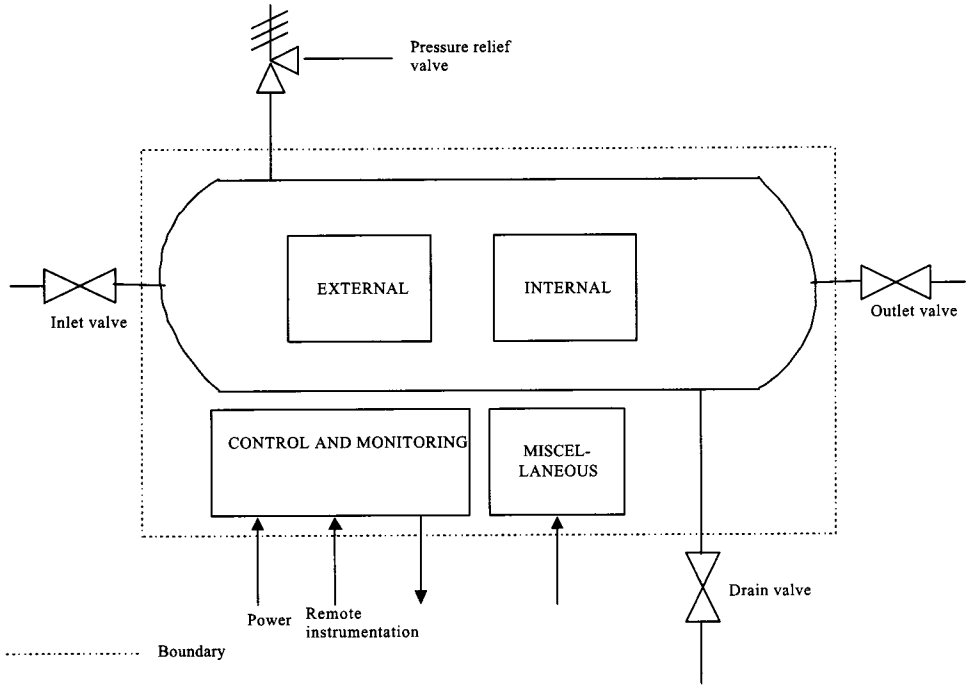

Figure 18 Vessels, Boundary Definition

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Table 13 Vessels, Subdivision in Maintainable Items

VESSELS			
External	Internal	Control and Monitoring	Miscellaneous
• Support • Body/Shell • Valves & piping • Instruments	• Body/shell • Corrosion protection • Heater • Instruments • Plates, trays, vanes, pads • Sand trap system	• Actuating device • Cabling & junction boxes • Control unit • Instruments • Monitoring • Internal power supply • Valves	• Others

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR Abnormal instrument reading
ELP External leakage - Process medium
ELU External leakage - Utility medium
SER Minor in-service problems
OTH Other
PDE Parameter deviation
PLU Plugged/Choked
STD Structural deficiency
UNK Unknown

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Taxonomy no	Item
3.2	Mechanical Equipment Vessels

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
199	20	7.9317	4.2609	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**124***	**0.16**	**24.45**	**84.75**	**31.26**	**15.63**	**8.7**	**1.0**	**18.3**	**264.0**
	124†	**0.17**	**28.93**	**102.54**	**37.87**	**29.10**				
Abnormal instrument reading	57*	0.00	9.83	46.87	19.25	7.19	6.2	1.0	10.7	74.0
	57†	0.00	10.45	54.06	23.76	13.38				
External leakage - Process medium	28*	0.00	2.87	16.51	9.17	3.53	9.3	1.0	28.6	264.0
	28†	0.00	4.40	24.19	11.60	6.57				
External leakage - Utility medium	2*	0.00	0.70	3.34	1.38	0.25	9.0	4.0	18.0	32.0
	2†	0.00	0.75	3.67	1.55	0.47				
Other	11*	0.00	2.86	13.37	5.43	1.39	6.4	1.0	12.1	45.0
	11†	0.00	3.10	15.54	6.65	2.58				
Parameter deviation	10*	0.16	1.33	3.43	1.07	1.26	26.4	1.0	42.7	155.0
	10†	0.00	2.66	10.70	4.02	2.35				
Plugged/Choked	5*	0.00	1.53	8.01	3.60	0.63	2.5	2.0	9.2	22.0
	5†	0.00	2.04	10.59	4.71	1.17				
Structural deficiency	10*	0.00	4.71	23.11	9.71	1.26	9.7	4.0	19.4	36.0
	10†	0.00	4.97	27.35	12.90	2.35				
Unknown	1*	0.00	0.32	1.78	0.91	0.13	-	-	-	-
	1†	0.00	0.35	1.94	0.99	0.23				
Degraded	**240***	**0.00**	**24.66**	**113.21**	**45.34**	**30.26**	**9.3**	**1.0**	**24.3**	**2228.9**
	240†	**0.14**	**46.92**	**183.48**	**68.13**	**56.33**				
Abnormal instrument reading	57*	0.00	4.35	17.71	20.39	7.19	6.3	1.0	9.5	64.0
	57†	0.00	5.58	26.32	25.49	13.38				
External leakage - Process medium	35*	0.01	4.77	19.14	7.18	4.41	5.8	1.0	7.3	25.0
	35†	0.06	8.11	27.92	10.29	8.21				
External leakage - Utility medium	12*	0.00	2.11	10.82	4.69	1.51	10.1	4.0	15.5	40.0
	12†	0.00	2.38	12.26	5.35	2.82				
Other	43*	0.01	6.56	26.49	9.97	5.42	11.7	1.0	15.9	249.0
	43†	0.06	9.46	33.14	12.23	10.09				
Parameter deviation	28*	0.00	2.44	13.82	7.38	3.53	13.0	1.0	24.1	199.0
	28†	0.00	5.25	25.34	10.46	6.57				
Plugged/Choked	50*	1.09	5.23	11.94	3.48	6.30	10.6	1.0	56.8	2228.9
	50†	0.00	15.21	69.25	27.59	11.73				
Structural deficiency	15*	0.00	2.14	11.15	4.97	1.89	10.4	1.0	43.3	380.0
	15†	0.00	2.43	12.63	5.61	3.52				
Incipient	**1105***	**0.00**	**132.17**	**628.36**	**257.74**	**139.32**	**6.3**	**0.5**	**9.4**	**594.0**
	1105†	**0.03**	**175.51**	**781.36**	**308.37**	**259.34**				
Abnormal instrument reading	755*	0.00	69.22	388.80	204.72	95.19	5.2	1.0	6.4	97.0
	755†	0.00	93.66	514.84	251.96	177.19				
External leakage - Process medium	60*	0.01	11.22	46.82	17.87	7.56	3.7	1.0	14.4	79.0
	60†	0.02	20.86	87.22	33.33	14.08				
External leakage - Utility medium	18*	0.01	4.64	18.54	6.94	2.27	11.2	2.0	15.8	54.0
	18†	0.00	5.15	21.76	8.36	4.22				

Comments

(cont.)

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Taxonomy no	Item
3.2	Mechanical Equipment Vessels

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
199	20	7.9317	4.2609	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Minor in-service problems	132*	0.00	16.20	83.05	35.97	16.64	7.4	1.0	11.2	217.0
	132†	0.00	17.44	92.97	42.69	30.98				
Other	46*	0.55	11.65	34.94	11.71	5.80	24.6	1.0	35.8	594.0
	46†	0.40	12.57	38.13	13.12	10.80				
Parameter deviation	32*	0.13	8.76	27.71	9.95	4.03	4.8	0.5	6.9	40.0
	32†	0.15	12.98	41.86	15.18	7.51				
Plugged/Choked	34*	0.00	3.03	16.78	8.61	4.29	7.3	1.0	11.1	104.0
	34†	0.00	5.80	28.84	12.27	7.98				
Structural deficiency	24*	0.01	5.55	22.16	8.29	3.03	18.4	1.0	32.0	179.0
	24†	0.00	5.98	25.62	9.91	5.63				
Unknown	4*	0.00	0.60	2.74	1.09	0.50	4.0	1.0	4.5	11.0
	4†	0.00	0.73	4.02	2.06	0.94				
Unknown	**24***	**0.00**	**3.94**	**18.74**	**7.69**	**3.03**	**10.3**	**1.0**	**20.1**	**84.0**
	24†	**0.00**	**4.68**	**22.29**	**9.15**	**5.63**				
Abnormal instrument reading	5*	0.00	0.65	2.85	1.11	0.63	15.2	6.0	33.5	49.0
	5†	0.00	0.89	3.59	1.35	1.17				
External leakage - Process medium	2*	0.00	0.36	2.00	0.97	0.25	-	9.0	9.5	10.0
	2†	0.00	0.47	2.05	0.80	0.47				
Other	3*	0.00	1.54	7.59	3.21	0.38	-	12.0	26.7	52.0
	3†	0.00	1.62	8.88	4.16	0.70				
Parameter deviation	1*	0.00	0.11	0.35	0.13	0.13	-	-	-	-
	1†	0.00	0.39	2.20	1.16	0.23				
Unknown	13*	0.00	1.66	9.11	4.29	1.64	8.6	1.0	15.4	84.0
	13†	0.00	1.91	10.28	4.75	3.05				
All modes	**1493***	**0.03**	**185.04**	**826.67**	**326.82**	**188.23**	**7.0**	**0.5**	**12.8**	**2228.9**
	1493†	**0.37**	**255.91**	**1042.69**	**394.06**	**350.40**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.20	0.03	0.07	0.20	0.13
Body/shell	0.00	0.07	0.13	0.27	0.13
Cabling & junction boxes	0.13	0.00	0.00	0.13	0.00
Control unit	0.80	0.00	0.00	0.27	0.07
Heater	0.03	0.13	0.07	0.27	0.80
Instrument, flow	4.19	0.00	0.00	0.00	0.33
Instrument, general	0.67	0.00	0.00	0.00	0.00
Instrument, level	42.03	0.80	0.27	0.64	2.24
Instrument, pressure	2.34	0.07	0.07	0.27	0.00
Instrument, temperature	1.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.07	0.07	0.00
Monitoring	0.27	0.00	0.00	0.13	0.00
Other	0.00	0.87	0.07	0.20	0.00
Piping	0.03	0.87	0.07	0.13	0.00
Plates, trays, vanes, pads	0.00	0.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.27	0.27	0.00	0.07	0.00
Support	0.00	0.00	0.00	0.07	0.00
Unknown	1.00	0.20	0.07	0.47	0.20
Valves	5.36	5.06	1.27	3.72	0.84
Total	58.54	8.37	2.14	6.90	4.76

Maintainable item versus failure mode, continued
Item: Vessels

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.64
Body/shell	0.00	0.27	0.87	0.00	1.74
Cabling & junction boxes	0.00	0.13	0.07	0.00	0.47
Control unit	0.07	0.00	0.00	0.00	1.21
Heater	0.00	0.27	0.00	0.07	1.64
Instrument, flow	0.00	0.20	0.00	0.00	4.72
Instrument, general	0.00	0.33	0.03	0.00	1.04
Instrument, level	0.13	1.34	0.00	0.27	47.72
Instrument, pressure	0.00	0.20	0.00	0.07	3.01
Instrument, temperature	0.00	0.00	0.07	0.00	1.07
Internal power supply	0.00	0.07	0.00	0.00	0.40
Monitoring	0.00	0.07	0.00	0.00	0.47
Other	0.13	0.47	0.07	0.00	1.81
Piping	0.07	1.14	0.90	0.00	3.22
Plates, trays, vanes, pads	0.00	0.13	0.00	0.00	0.13
Sand trap system	0.47	0.00	0.00	0.00	0.47
Subunit	2.21	0.47	0.13	0.00	3.42
Support	0.00	0.07	0.13	0.00	0.27
Unknown	0.20	0.54	0.20	0.27	3.15
Valves	2.68	3.15	0.80	0.54	23.41
Total	5.96	8.84	3.28	1.21	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	7.37	0.07	0.00	0.33	0.20
Breakage	0.40	0.07	0.20	0.27	0.20
Burst	0.00	0.00	0.00	0.00	0.00
Cavitation	0.13	0.00	0.07	0.07	0.00
Clearance/ alignment failure	0.13	0.00	0.07	0.07	0.00
Combined causes	0.07	0.07	0.00	0.00	0.07
Common mode failure	0.07	0.00	0.00	0.00	0.07
Contamination	0.13	0.00	0.00	0.00	0.00
Control failure	0.47	0.00	0.00	0.20	0.20
Corrosion	0.47	0.07	0.07	0.74	0.00
Deformation	0.07	0.00	0.00	0.13	0.00
Earth/isolation fault	0.47	0.00	0.00	0.00	0.07
Electrical failure - general	0.54	0.00	0.00	0.20	0.54
Erosion	0.00	1.47	0.00	0.00	0.13
External influence - general	0.07	0.00	0.00	0.07	0.00
Fatigue	0.00	0.07	0.00	0.00	0.00
Faulty signal/indication/alarm	4.82	0.07	0.00	0.07	0.13
Instrument failure - general	18.62	0.00	0.13	0.67	1.14
Leakage	0.27	3.48	0.74	0.47	0.00
Looseness	0.13	0.47	0.07	0.00	0.00
Material failure - general	0.00	0.33	0.07	0.40	0.13
Mechanical Failure - general	2.14	0.67	0.20	0.80	0.13
Misc. external influences	1.41	0.00	0.00	0.33	0.20
Miscellaneous - general	0.00	0.00	0.00	0.27	0.00
No cause found	0.07	0.07	0.07	0.07	0.07
No signal/indication/alarm	1.41	0.00	0.00	0.07	0.00
Open circuit	0.13	0.00	0.00	0.00	0.00
Other	0.00	0.07	0.00	0.13	0.00
Out of adjustment	18.35	0.00	0.07	0.67	1.21
Overheating	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.07	0.00	0.00	0.13	0.00
Sticking	0.20	0.00	0.07	0.07	0.00
Unknown	0.13	0.07	0.07	0.20	0.20
Vibration	0.20	0.00	0.00	0.00	0.00
Wear	0.20	1.34	0.27	0.47	0.07
Total	58.54	8.37	2.14	6.90	4.76

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Vessels

	PLU	SER	STD	UNK	Sum
Blockage/plugged	3.68	0.74	0.00	0.07	12.46
Breakage	0.07	0.13	0.00	0.00	1.34
Burst	0.00	0.13	0.00	0.00	0.13
Cavitation	0.00	0.00	0.67	0.00	0.94
Clearance/ alignment failure	0.20	0.07	0.00	0.00	0.54
Combined causes	0.27	0.00	0.00	0.00	0.47
Common mode failure	0.00	0.00	0.00	0.00	0.13
Contamination	0.07	0.07	0.00	0.00	0.27
Control failure	0.07	0.00	0.00	0.00	0.94
Corrosion	0.20	0.87	1.34	0.00	3.75
Deformation	0.00	0.00	0.07	0.00	0.27
Earth/isolation fault	0.00	0.13	0.00	0.00	0.67
Electrical failure - general	0.00	0.20	0.00	0.07	1.54
Erosion	0.00	0.00	0.00	0.00	1.61
External influence - general	0.07	0.47	0.00	0.00	0.67
Fatigue	0.00	0.00	0.00	0.00	0.07
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	5.09
Instrument failure - general	0.33	1.21	0.13	0.67	22.91
Leakage	0.00	0.20	0.27	0.00	5.43
Looseness	0.00	0.00	0.00	0.00	0.67
Material failure - general	0.00	0.87	0.07	0.00	1.88
Mechanical Failure - general	0.33	0.87	0.40	0.07	5.63
Misc. external influences	0.13	1.61	0.27	0.00	3.95
Miscellaneous - general	0.00	0.00	0.00	0.00	0.27
No cause found	0.00	0.00	0.00	0.00	0.33
No signal/indication/alarm	0.00	0.00	0.00	0.07	1.54
Open circuit	0.00	0.00	0.00	0.00	0.13
Other	0.00	0.27	0.00	0.07	0.54
Out of adjustment	0.07	0.27	0.00	0.07	20.70
Overheating	0.07	0.00	0.00	0.00	0.07
Short circuiting	0.00	0.00	0.00	0.00	0.20
Sticking	0.13	0.20	0.00	0.00	0.67
Unknown	0.13	0.20	0.00	0.13	1.14
Vibration	0.00	0.07	0.07	0.00	0.33
Wear	0.13	0.27	0.00	0.00	2.75
Total	5.96	8.84	3.28	1.21	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item									
3.2.1		Mechanical Equipment Vessels Coalescer									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
7	4	**Calendar time** * 0.2147			**Operational time** † 0.1985						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours)** Lower	Mean	Upper	SD	n/τ	**Active rep.hrs**	**Repair (manhours)** Min	Mean	Max
Critical		**7***	**0.24**	**30.21**	**102.24**	**37.59**	**32.60**	**28.0**	**2.0**	**55.4**	**155.0**
		7†	**0.18**	**34.37**	**124.30**	**45.93**	**35.27**				
Abnormal instrument reading		3*	0.06	12.53	46.22	17.07	13.97	3.8	2.0	6.3	15.0
		3†	0.03	14.25	57.12	21.42	15.12				
Parameter deviation		4*	3.29	18.59	44.12	13.16	18.63	46.1	10.0	92.3	155.0
		4†	2.19	20.63	54.99	17.50	20.16				
Degraded		**29***	**0.68**	**119.30**	**422.93**	**156.22**	**135.05**	**19.3**	**1.0**	**36.0**	**249.0**
		29†	**0.61**	**136.63**	**508.27**	**187.65**	**146.13**				
Abnormal instrument reading		5*	0.01	19.74	85.86	33.38	23.29	7.4	4.0	10.4	16.0
		5†	0.00	23.00	102.33	40.37	25.19				
External leakage - Process medium		3*	3.94	14.13	29.45	8.07	13.97	4.3	2.0	8.7	18.0
		3†	4.41	15.47	32.03	8.73	15.12				
External leakage - Utility medium		2*	0.05	10.10	36.93	13.64	9.31	12.0	4.0	22.0	40.0
		2†	0.07	10.98	38.26	14.12	10.08				
Other		5*	3.22	24.28	61.72	19.16	23.29	33.0	3.0	64.8	249.0
		5†	3.04	26.78	70.23	22.13	25.19				
Parameter deviation		12*	0.00	44.77	216.06	89.19	55.88	24.6	1.0	48.4	199.0
		12†	0.00	53.34	256.53	105.75	60.47				
Plugged/Choked		2*	1.33	8.73	21.55	6.59	9.31	14.5	14.0	14.5	15.0
		2†	1.35	9.30	23.18	7.13	10.08				
Incipient		**124***	**0.54**	**479.75**	**1981.98**	**752.88**	**577.47**	**5.8**	**1.0**	**8.3**	**165.0**
		124†	**0.49**	**561.26**	**2348.37**	**897.68**	**624.81**				
Abnormal instrument reading		94*	0.13	352.80	1537.54	598.68	437.76	4.2	1.0	4.9	30.0
		94†	0.13	415.25	1820.03	711.63	473.65				
External leakage - Process medium		1*	0.00	4.34	18.49	7.13	4.66	2.0	2.0	2.0	2.0
		1†	0.00	4.88	21.85	8.65	5.04				
Minor in-service problems		18*	0.31	73.26	275.17	101.53	83.83	12.1	1.0	12.7	125.0
		18†	0.25	84.28	329.25	122.21	90.70				
Other		4*	1.63	20.85	58.99	19.33	18.63	3.0	3.0	43.8	165.0
		4†	1.73	23.02	65.53	21.52	20.16				
Plugged/Choked		5*	2.43	22.77	60.62	19.28	23.29	20.3	1.0	27.8	90.0
		5†	9.98	25.25	46.18	11.27	25.19				
Structural deficiency		2*	0.66	8.85	25.21	8.28	9.31	8.5	17.0	17.0	17.0
		2†	0.11	9.80	31.71	11.52	10.08				
Unknown		**3***	**0.06**	**12.53**	**46.22**	**17.07**	**13.97**	**42.0**	**84.0**	**84.0**	**84.0**
		3†	**0.03**	**14.25**	**57.12**	**21.42**	**15.12**				
Abnormal instrument reading		1*	0.00	4.34	18.49	7.13	4.66	-	-	-	-
		1†	0.00	4.88	21.85	8.65	5.04				
Unknown		2*	0.66	8.85	25.21	8.28	9.31	42.0	84.0	84.0	84.0
		2†	0.11	9.80	31.71	11.52	10.08				
Comments											

(cont.)

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Taxonomy no	Item
3.2.1	Mechanical Equipment Vessels Coalescer

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	4	0.2147	0.1985	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	163* 163†	0.87 0.78	635.77 742.11	2597.63 3079.50	982.83 1171.42	759.10 821.32	9.6	1.0	16.1	249.0

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Coalescer

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.61	0.00	0.00	0.00	0.61
Body/shell	0.00	0.00	0.00	0.00	0.00
Heater	0.31	1.23	0.61	2.45	7.36
Instrument, flow	1.23	0.00	0.00	0.00	0.00
Instrument, general	0.61	0.00	0.00	0.00	0.00
Instrument, level	54.29	0.61	0.00	0.00	0.92
Instrument, temperature	0.61	0.00	0.00	0.00	0.00
Internal power supply	1.23	0.00	0.61	0.61	0.00
Monitoring	0.00	0.00	0.00	0.61	0.00
Other	0.00	0.00	0.00	0.61	0.00
Piping	0.00	0.61	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.61	0.00	0.00	0.00	0.00
Unknown	1.23	0.00	0.00	0.61	0.61
Valves	2.45	0.00	0.00	0.61	0.31
Total	63.19	2.45	1.23	5.52	9.82

Maintainable item versus failure mode, continued
Item: Vessels - Coalescer

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	1.23
Body/shell	0.00	0.61	1.23	0.00	1.84
Heater	0.00	1.84	0.00	0.61	14.42
Instrument, flow	0.00	0.00	0.00	0.00	1.23
Instrument, general	0.00	0.61	0.00	0.00	1.23
Instrument, level	0.00	0.61	0.00	0.61	57.06
Instrument, temperature	0.00	0.00	0.00	0.00	0.61
Internal power supply	0.00	0.61	0.00	0.00	3.07
Monitoring	0.00	0.00	0.00	0.00	0.61
Other	0.00	1.23	0.00	0.00	1.84
Piping	0.00	1.84	0.00	0.00	2.45
Sand trap system	1.23	0.00	0.00	0.00	1.23
Subunit	1.23	3.07	0.00	0.00	4.91
Unknown	0.00	0.00	0.00	0.00	2.45
Valves	1.84	0.61	0.00	0.00	5.83
Total	4.29	11.04	1.23	1.23	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Coalescer

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	6.13	0.00	0.00	0.00	0.00
Corrosion	1.84	0.00	0.00	0.61	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.61	0.00	0.00	0.61	4.91
Faulty signal/indication/alarm	3.68	0.00	0.00	0.00	0.61
Instrument failure - general	22.09	0.00	0.00	0.61	1.23
Leakage	0.00	0.61	1.23	0.00	0.00
Looseness	0.00	0.61	0.00	0.00	0.00
Material failure - general	0.00	1.23	0.00	0.00	0.61
Mechanical Failure - general	2.45	0.00	0.00	1.23	0.00
Misc. external influences	2.45	0.00	0.00	1.84	1.84
Other	0.00	0.00	0.00	0.00	0.00
Out of adjustment	23.31	0.00	0.00	0.00	0.00
Overheating	0.00	0.00	0.00	0.00	0.00
Short circuiting	0.61	0.00	0.00	0.61	0.00
Unknown	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00
Total	63.19	2.45	1.23	5.52	9.82

Failure descriptior versus failure mode, continued
Item: Vessels - Coalescer

	PLU	SER	STD	UNK	Sum
Blockage/plugged	1.23	1.23	0.00	0.00	8.59
Corrosion	0.00	0.00	1.23	0.00	3.68
Earth/isolation fault	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.00	0.61	0.00	0.61	7.36
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	4.29
Instrument failure - general	0.61	0.61	0.00	0.61	25.77
Leakage	0.00	1.23	0.00	0.00	3.07
Looseness	0.00	0.00	0.00	0.00	0.61
Material failure - general	0.00	0.00	0.00	0.00	1.84
Mechanical Failure - general	0.00	1.23	0.00	0.00	4.91
Misc. external influences	0.61	4.91	0.00	0.00	11.66
Other	0.00	1.23	0.00	0.00	1.23
Out of adjustment	0.00	0.00	0.00	0.00	23.31
Overheating	0.61	0.00	0.00	0.00	0.61
Short circuiting	0.00	0.00	0.00	0.00	1.23
Unknown	0.61	0.00	0.00	0.00	0.61
Wear	0.61	0.00	0.00	0.00	0.61
Total	4.29	11.04	1.23	1.23	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.1.1	Mechanical Equipment Vessels Coalescer (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**	**14.5**	**14.0**	**14.5**	**15.0**
	2†	**6.93**	**39.05**	**122.91**	**39.05**	**39.05**				
Plugged/Choked	2*	6.75	38.05	119.77	38.05	38.05	14.5	14.0	14.5	15.0
	2†	6.93	39.05	122.91	39.05	39.05				
Incipient	**8***	**75.72**	**152.21**	**274.64**	**152.21**	**152.21**	**35.0**	**6.0**	**37.0**	**125.0**
	8†	**77.71**	**156.20**	**281.85**	**156.20**	**156.20**				
Abnormal instrument reading	6*	49.75	114.16	225.27	114.16	114.16	13.5	6.0	13.5	30.0
	6†	51.06	117.15	231.18	117.15	117.15				
Minor in-service problems	1*	0.95	19.03	90.28	19.03	19.03	125.0	125.0	125.0	125.0
	1†	0.98	19.53	92.65	19.53	19.53				
Plugged/Choked	1*	0.95	19.03	90.28	19.03	19.03	74.0	90.0	90.0	90.0
	1†	0.98	19.53	92.65	19.53	19.53				
All modes	**10***	**103.22**	**190.26**	**322.68**	**190.26**	**190.26**	**30.9**	**6.0**	**32.5**	**125.0**
	10†	**105.92**	**195.25**	**331.15**	**195.25**	**195.25**				

Comments

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Taxonomy no	Item
3.2.1.2	Mechanical Equipment Vessels Coalescer (50-100)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	4	0.1622	0.1472	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**3.42**	**35.45**	**96.50**	**31.06**	**43.17**	**28.0**	**2.0**	**55.4**	**155.0**
	7†	**1.20**	**38.85**	**118.01**	**40.70**	**47.54**				
Abnormal instrument reading	3*	2.38	16.15	40.16	12.32	18.50	3.8	2.0	6.3	15.0
	3†	0.67	17.31	52.17	17.73	20.37				
Parameter deviation	4*	1.11	21.47	64.11	21.39	24.67	46.1	10.0	92.3	155.0
	4†	0.66	23.72	72.36	25.12	27.17				
Degraded	**27***	**0.50**	**116.91**	**439.66**	**162.21**	**166.49**	**19.6**	**1.0**	**37.6**	**249.0**
	27†	**0.34**	**133.69**	**527.82**	**196.69**	**183.37**				
Abnormal instrument reading	5*	0.11	22.78	83.97	31.01	30.83	7.4	4.0	10.4	16.0
	5†	0.05	25.68	103.46	38.90	33.96				
External leakage - Process medium	3*	0.98	16.82	49.54	16.46	18.50	4.3	2.0	8.7	18.0
	3†	0.97	18.56	55.34	18.45	20.37				
External leakage - Utility medium	2*	0.15	11.77	37.74	13.64	12.33	12.0	4.0	22.0	40.0
	2†	0.27	12.90	39.96	14.12	13.58				
Other	5*	0.75	27.69	84.53	29.38	30.83	33.0	3.0	64.8	249.0
	5†	1.01	30.49	92.35	31.70	33.96				
Parameter deviation	12*	0.00	47.37	222.85	90.90	74.00	24.6	1.0	48.4	199.0
	12†	0.00	55.74	265.94	109.27	81.50				
Incipient	**116***	**0.12**	**463.64**	**2046.82**	**804.03**	**715.31**	**3.6**	**1.0**	**6.2**	**165.0**
	116†	**0.10**	**544.46**	**2436.41**	**963.99**	**787.81**				
Abnormal instrument reading	88*	0.02	342.60	1590.81	643.27	542.65	3.5	1.0	4.3	26.0
	88†	0.02	404.60	1890.97	768.16	597.65				
External leakage - Process medium	1*	0.03	5.38	19.30	7.13	6.17	2.0	2.0	2.0	2.0
	1†	0.02	5.96	23.29	8.65	6.79				
Minor in-service problems	17*	0.30	73.81	281.11	103.61	104.83	4.0	1.0	4.6	16.0
	17†	0.17	84.38	337.55	126.42	115.45				
Other	4*	8.20	24.39	47.56	12.33	24.67	3.0	3.0	43.8	165.0
	4†	9.02	26.84	52.36	13.58	27.17				
Plugged/Choked	4*	0.88	21.72	65.39	22.15	24.67	2.3	1.0	12.3	42.0
	4†	0.61	24.19	74.14	25.90	27.17				
Structural deficiency	2*	0.03	9.92	38.52	14.26	12.33	8.5	17.0	17.0	17.0
	2†	1.75	12.41	31.14	9.60	13.58				
Unknown	**3***	**2.38**	**16.15**	**40.16**	**12.32**	**18.50**	**42.0**	**84.0**	**84.0**	**84.0**
	3†	**0.67**	**17.31**	**52.17**	**17.73**	**20.37**				
Abnormal instrument reading	1*	0.03	5.38	19.30	7.13	6.17	-	-	-	-
	1†	0.02	5.96	23.29	8.65	6.79				
Unknown	2*	0.03	9.92	38.52	14.26	12.33	42.0	84.0	84.0	84.0
	2†	1.75	12.41	31.14	9.60	13.58				
All modes	**153***	**0.21**	**613.51**	**2680.66**	**1045.82**	**943.47**	**8.1**	**1.0**	**14.9**	**249.0**
	153†	**0.16**	**718.96**	**3185.61**	**1254.03**	**1039.09**				

Comments

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Taxonomy no	Item
3.2.2	Mechanical Equipment Vessels Contactor

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	5	0.1761	0.1696	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**0.00**	**87.66**	**460.28**	**207.73**	**119.23**	**13.1**	**4.0**	**27.1**	**74.0**
	21†	**0.00**	**91.37**	**479.59**	**216.36**	**123.82**				
Abnormal instrument reading	9*	0.00	38.78	195.84	84.19	51.10	14.5	13.0	31.2	74.0
	9†	0.00	40.39	204.04	87.71	53.07				
External leakage - Process medium	1*	0.00	5.06	22.92	9.12	5.68	20.5	41.0	41.0	41.0
	1†	0.00	5.26	23.88	9.51	5.90				
External leakage - Utility medium	1*	0.00	5.06	22.92	9.12	5.68	16.0	32.0	32.0	32.0
	1†	0.00	5.26	23.88	9.51	5.90				
Other	1*	0.00	5.06	22.92	9.12	5.68	9.5	19.0	19.0	19.0
	1†	0.00	5.26	23.88	9.51	5.90				
Parameter deviation	1*	0.00	5.06	22.92	9.12	5.68	20.0	40.0	40.0	40.0
	1†	0.00	5.26	23.88	9.51	5.90				
Structural deficiency	8*	0.00	34.71	173.16	73.86	45.42	9.8	4.0	19.5	36.0
	8†	0.00	36.15	180.41	76.96	47.17				
Degraded	**5***	**4.80**	**28.58**	**68.82**	**20.72**	**28.39**	**46.3**	**1.0**	**42.8**	**177.0**
	5†	**4.73**	**29.75**	**72.69**	**22.08**	**29.48**				
Abnormal instrument reading	1*	0.30	5.72	17.03	5.68	5.68	-	20.0	20.0	20.0
	1†	0.32	5.95	17.70	5.90	5.90				
External leakage - Process medium	3*	1.77	17.75	47.98	15.39	17.03	4.0	1.0	5.7	12.0
	3†	1.76	18.47	50.42	16.25	17.69				
Structural deficiency	1*	0.00	5.06	22.92	9.12	5.68	88.5	177.0	177.0	177.0
	1†	0.00	5.26	23.88	9.51	5.90				
Incipient	**41***	**65.25**	**226.54**	**467.33**	**126.99**	**232.77**	**8.9**	**2.0**	**12.8**	**66.0**
	41†	**67.69**	**234.96**	**484.68**	**131.70**	**241.75**				
Abnormal instrument reading	16*	0.78	103.11	350.42	128.92	90.84	8.2	3.0	5.9	12.0
	16†	0.82	106.37	360.60	132.62	94.34				
External leakage - Process medium	7*	0.01	38.81	169.67	66.22	39.74	1.0	2.0	13.7	40.0
	7†	0.01	40.70	178.11	69.56	41.27				
External leakage - Utility medium	2*	0.79	10.50	29.89	9.81	11.35	19.5	30.0	39.0	48.0
	2†	0.77	10.90	31.30	10.31	11.79				
Minor in-service problems	4*	0.24	22.03	71.81	26.15	22.71	4.0	8.0	8.0	8.0
	4†	0.29	22.71	72.81	26.33	23.59				
Other	8*	1.07	39.57	120.85	42.02	45.42	10.0	3.0	16.6	40.0
	8†	1.06	41.11	125.81	43.87	47.17				
Parameter deviation	2*	0.79	10.50	29.89	9.81	11.35	3.3	6.0	6.5	7.0
	2†	0.77	10.90	31.30	10.31	11.79				
Structural deficiency	2*	0.79	10.50	29.89	9.81	11.35	21.0	18.0	42.0	66.0
	2†	0.77	10.90	31.30	10.31	11.79				
Unknown	**1***	**0.30**	**5.72**	**17.03**	**5.68**	**5.68**	**-**	**9.0**	**9.0**	**9.0**
	1†	**0.32**	**5.95**	**17.70**	**5.90**	**5.90**				

Comments

(cont.)

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Taxonomy no		Item								
3.2.2		Mechanical Equipment Vessels Contactor								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
7	5	**Calendar time *** 0.1761		**Operational time †** 0.1696						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours)**				**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
External leakage - Process medium		1*	0.30	5.72	17.03	5.68	5.68	-	9.0	9.0	9.0
		1†	0.32	5.95	17.70	5.90	5.90				
All modes		**68***	**32.18**	**348.66**	**957.62**	**309.61**	**386.07**	**12.0**	**1.0**	**19.8**	**177.0**
		68†	**32.95**	**362.17**	**997.50**	**322.94**	**400.95**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Vessels - Contactor

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	1.47	0.00
Cabling & junction boxes	0.00	0.00	0.00	1.47	0.00
Instrument, level	30.88	4.41	0.00	0.00	4.41
Instrument, pressure	5.88	0.00	0.00	0.00	0.00
Internal power supply	1.47	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	1.47	0.00
Other	0.00	0.00	0.00	1.47	0.00
Piping	0.00	1.47	0.00	0.00	0.00
Subunit	0.00	4.41	0.00	1.47	0.00
Unknown	0.00	0.00	0.00	2.94	0.00
Valves	0.00	7.35	4.41	2.94	0.00
Total	38.24	17.65	4.41	13.24	4.41

Maintainable item versus failure mode, continued
Item: Vessels - Contactor

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	4.41	0.00	5.88
Cabling & junction boxes	0.00	0.00	0.00	0.00	1.47
Instrument, level	0.00	0.00	0.00	0.00	39.71
Instrument, pressure	0.00	0.00	0.00	0.00	5.88
Internal power supply	0.00	0.00	0.00	0.00	1.47
Monitoring	0.00	0.00	0.00	0.00	1.47
Other	0.00	0.00	0.00	0.00	1.47
Piping	0.00	0.00	8.82	0.00	10.29
Subunit	0.00	0.00	0.00	0.00	5.88
Unknown	0.00	0.00	0.00	0.00	2.94
Valves	0.00	5.88	2.94	0.00	23.53
Total	0.00	5.88	16.18	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Contactor

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	4.41	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	1.47
Cavitation	1.47	0.00	1.47	0.00	0.00
Contamination	1.47	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	1.47	0.00	0.00	1.47	0.00
Faulty signal/indication/alarm	5.88	1.47	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	1.47	1.47
Leakage	0.00	13.24	1.47	2.94	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	1.47	0.00	1.47	0.00	0.00
Misc. external influences	0.00	0.00	0.00	1.47	0.00
Miscellaneous - general	0.00	0.00	0.00	4.41	0.00
No signal/indication/alarm	5.88	0.00	0.00	0.00	0.00
Other	0.00	1.47	0.00	1.47	0.00
Out of adjustment	14.71	0.00	0.00	0.00	1.47
Sticking	1.47	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00
Wear	0.00	1.47	0.00	0.00	0.00
Total	38.24	17.65	4.41	13.24	4.41

Failure descriptior versus failure mode, continued
Item: Vessels - Contactor

	PLU	SER	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	4.41
Breakage	0.00	1.47	0.00	0.00	2.94
Cavitation	0.00	0.00	10.29	0.00	13.24
Contamination	0.00	0.00	0.00	0.00	1.47
Corrosion	0.00	0.00	2.94	0.00	2.94
Electrical failure - general	0.00	0.00	0.00	0.00	2.94
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	7.35
Instrument failure - general	0.00	0.00	0.00	0.00	2.94
Leakage	0.00	0.00	2.94	0.00	20.59
Material failure - general	0.00	1.47	0.00	0.00	1.47
Mechanical Failure - general	0.00	0.00	0.00	0.00	2.94
Misc. external influences	0.00	0.00	0.00	0.00	1.47
Miscellaneous - general	0.00	0.00	0.00	0.00	4.41
No signal/indication/alarm	0.00	0.00	0.00	0.00	5.88
Other	0.00	0.00	0.00	0.00	2.94
Out of adjustment	0.00	0.00	0.00	0.00	16.18
Sticking	0.00	1.47	0.00	0.00	2.94
Unknown	0.00	1.47	0.00	0.00	1.47
Wear	0.00	0.00	0.00	0.00	1.47
Total	0.00	5.88	16.18	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.2.1	Mechanical Equipment Vessels Contactor (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0307	0.0291	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.06 0.06	15.57 16.40	59.80 62.99	22.02 23.20	0.00 0.00	-	-	-	-

Comments

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Taxonomy no
3.2.2.2

Item
Mechanical Equipment
Vessels
Contactor
(10-50)m3

Population	Installations
1	1

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
0.0263	0.0256

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Degraded	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
External leakage - Process medium	1*	1.90	38.05	180.56	38.05	38.05	4.0	4.0	4.0	4.0
	1†	1.95	39.05	185.29	39.05	39.05				
Incipient	**10***	**206.43**	**380.52**	**645.36**	**380.52**	**380.52**	**10.1**	**3.0**	**5.2**	**12.0**
	10†	**211.85**	**390.50**	**662.29**	**390.50**	**390.50**				
Abnormal instrument reading	10*	206.43	380.52	645.36	380.52	380.52	10.1	3.0	5.2	12.0
	10†	211.85	390.50	662.29	390.50	390.50				
All modes	**11***	**234.78**	**418.57**	**692.92**	**418.57**	**418.57**	**9.5**	**3.0**	**5.1**	**12.0**
	11†	**240.94**	**429.55**	**711.11**	**429.55**	**429.55**				

Comments

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Taxonomy no	Item
3.2.2.3	Mechanical Equipment Vessels Contactor (50-100)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	3	0.1192	0.1149	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**0.04**	**144.73**	**638.97**	**251.01**	**176.20**	**13.1**	**4.0**	**27.1**	**74.0**
	21†	**0.04**	**150.84**	**665.80**	**261.52**	**182.79**				
Abnormal instrument reading	9*	0.05	63.20	266.53	102.33	75.51	14.5	13.0	31.2	74.0
	9†	0.05	65.83	277.75	106.66	78.34				
External leakage - Process medium	1*	0.01	7.73	31.24	11.77	8.39	20.5	41.0	41.0	41.0
	1†	0.01	8.03	32.54	12.27	8.70				
External leakage - Utility medium	1*	0.01	7.73	31.24	11.77	8.39	16.0	32.0	32.0	32.0
	1†	0.01	8.03	32.54	12.27	8.70				
Other	1*	0.01	7.73	31.24	11.77	8.39	9.5	19.0	19.0	19.0
	1†	0.01	8.03	32.54	12.27	8.70				
Parameter deviation	1*	0.01	7.73	31.24	11.77	8.39	20.0	40.0	40.0	40.0
	1†	0.01	8.03	32.54	12.27	8.70				
Structural deficiency	8*	0.05	56.41	235.52	89.91	67.12	9.8	4.0	19.5	36.0
	8†	0.05	58.75	245.43	93.73	69.63				
Degraded	**4***	**3.03**	**34.54**	**95.80**	**31.12**	**33.56**	**88.5**	**1.0**	**52.5**	**177.0**
	4†	**2.95**	**36.09**	**101.34**	**33.10**	**34.82**				
Abnormal instrument reading	1*	0.55	8.69	25.33	8.39	8.39	-	20.0	20.0	20.0
	1†	0.58	9.04	26.30	8.70	8.70				
External leakage - Process medium	2*	0.09	18.14	66.31	24.50	16.78	-	1.0	6.5	12.0
	2†	0.09	18.99	70.02	25.86	17.41				
Structural deficiency	1*	0.01	7.73	31.24	11.77	8.39	88.5	177.0	177.0	177.0
	1†	0.01	8.03	32.54	12.27	8.70				
Incipient	**31***	**158.49**	**255.36**	**370.95**	**65.09**	**260.10**	**8.3**	**2.0**	**15.3**	**66.0**
	31†	**158.06**	**264.85**	**393.92**	**72.35**	**269.83**				
Abnormal instrument reading	6*	21.60	49.96	87.86	20.55	50.34	3.5	4.0	7.0	10.0
	6†	22.45	51.87	91.19	21.32	52.22				
External leakage - Process medium	7*	0.39	63.00	220.51	81.40	58.73	1.0	2.0	13.7	40.0
	7†	0.40	66.09	232.02	85.66	60.93				
External leakage - Utility medium	2*	1.60	15.75	42.39	13.56	16.78	19.5	30.0	39.0	48.0
	2†	1.60	16.35	44.38	14.27	17.41				
Minor in-service problems	4*	3.05	34.52	95.63	31.04	33.56	4.0	8.0	8.0	8.0
	4†	3.45	35.50	96.48	31.03	34.82				
Other	8*	15.47	63.48	138.23	39.08	67.12	10.0	3.0	16.6	40.0
	8†	15.60	65.88	144.68	41.12	69.63				
Parameter deviation	2*	1.60	15.75	42.39	13.56	16.78	3.3	6.0	6.5	7.0
	2†	1.60	16.35	44.38	14.27	17.41				
Structural deficiency	2*	1.60	15.75	42.39	13.56	16.78	21.0	18.0	42.0	66.0
	2†	1.60	16.35	44.38	14.27	17.41				
Unknown	**1***	**0.55**	**8.69**	**25.33**	**8.39**	**8.39**	**-**	**9.0**	**9.0**	**9.0**
	1†	**0.58**	**9.04**	**26.30**	**8.70**	**8.70**				

Comments

(cont.)

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Taxonomy no	Item
3.2.2.3	Mechanical Equipment Vessels Contactor (50-100)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	3	0.1192	0.1149	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Process medium	1*	0.55	8.69	25.33	8.39	8.39	-	9.0	9.0	9.0
	1†	0.58	9.04	26.30	8.70	8.70				
All modes	**57***	**70.35**	**440.13**	**1073.70**	**325.93**	**478.25**	**12.7**	**1.0**	**22.5**	**177.0**
	57†	**71.78**	**458.52**	**1124.32**	**342.34**	**496.14**				

Comments

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Taxonomy no		Item								
3.2.3		Mechanical Equipment Vessels Destillation column								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
3	1	**Calendar time** * 0.0526		**Operational time** † 0.0522						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**				**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	**n/τ**		**Min**	**Mean**	**Max**
Degraded		**2***	**6.74**	**38.00**	**119.60**	**38.00**	**38.00**	-	**14.0**	**197.0**	**380.0**
		2†	**6.80**	**38.31**	**120.59**	**38.31**	**38.31**				
Other		1*	0.95	19.00	90.15	19.00	19.00	-	14.0	14.0	14.0
		1†	0.96	19.16	90.90	19.16	19.16				
Structural deficiency		1*	0.95	19.00	90.15	19.00	19.00	-	380.0	380.0	380.0
		1†	0.96	19.16	90.90	19.16	19.16				
Incipient		**13***	**146.07**	**247.00**	**392.65**	**247.00**	**247.00**	-	**2.0**	**38.9**	**79.0**
		13†	**147.28**	**249.04**	**395.90**	**249.04**	**249.04**				
External leakage - Process medium		13*	146.07	247.00	392.65	247.00	247.00	-	2.0	38.9	79.0
		13†	147.28	249.04	395.90	249.04	249.04				
All modes		**15***	**175.65**	**285.00**	**438.80**	**285.00**	**285.00**	-	**2.0**	**60.0**	**380.0**
		15†	**177.11**	**287.36**	**442.43**	**287.36**	**287.36**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Destillation column

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	0.00	0.00
Control unit	0.00	0.00	0.00	6.67	0.00
Other	0.00	66.67	0.00	0.00	0.00
Unknown	0.00	6.67	0.00	0.00	0.00
Valves	0.00	13.33	0.00	0.00	0.00
Total	0.00	86.67	0.00	6.67	0.00

Maintainable item versus failure mode, continued
Item: Vessels - Destillation column

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	6.67	0.00	6.67
Control unit	0.00	0.00	0.00	0.00	6.67
Other	0.00	0.00	0.00	0.00	66.67
Unknown	0.00	0.00	0.00	0.00	6.67
Valves	0.00	0.00	0.00	0.00	13.33
Total	0.00	0.00	6.67	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Vessels - Destillation column

	AIR	ELP	ELU	OTH	PDE
Control failure	0.00	0.00	0.00	6.67	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	86.67	0.00	0.00	0.00
Total	0.00	86.67	0.00	6.67	0.00

Failure descriptior versus failure mode, continued
Item: Vessels - Destillation column

	PLU	SER	STD	UNK	Sum
Control failure	0.00	0.00	0.00	0.00	6.67
Corrosion	0.00	0.00	6.67	0.00	6.67
Leakage	0.00	0.00	0.00	0.00	86.67
Total	0.00	0.00	6.67	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.3.1	Mechanical Equipment Vessels Destillation column (100-300)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0351	0.0348	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**1.42**	**28.50**	**135.23**	**28.50**	**28.50**	-	**14.0**	**14.0**	**14.0**
	1†	**1.44**	**28.74**	**136.35**	**28.74**	**28.74**				
Other	1*	1.42	28.50	135.23	28.50	28.50	-	14.0	14.0	14.0
	1†	1.44	28.74	136.35	28.74	28.74				
Incipient	**7***	**93.62**	**199.50**	**374.77**	**199.50**	**199.50**	-	**19.0**	**51.4**	**79.0**
	7†	**94.40**	**201.15**	**377.87**	**201.15**	**201.15**				
External leakage - Process medium	7*	93.62	199.50	374.77	199.50	199.50	-	19.0	51.4	79.0
	7†	94.40	201.15	377.87	201.15	201.15				
All modes	**8***	**113.43**	**228.00**	**411.39**	**228.00**	**228.00**	-	**14.0**	**46.8**	**79.0**
	8†	**114.37**	**229.89**	**414.80**	**229.89**	**229.89**				

Comments

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Taxonomy no	Item
3.2.3.2	Mechanical Equipment Vessels Destillation column (300-1000)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0174	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**2.85**	**57.00**	**270.46**	**57.00**	**57.00**	-	**380.0**	**380.0**	**380.0**
	1†	**2.87**	**57.47**	**272.70**	**57.47**	**57.47**				
Structural deficiency	1*	2.85	57.00	270.46	57.00	57.00	-	380.0	380.0	380.0
	1†	2.87	57.47	272.70	57.47	57.47				
Incipient	**6***	**149.05**	**342.00**	**674.87**	**342.00**	**342.00**	-	**2.0**	**24.3**	**73.0**
	6†	**150.29**	**344.83**	**680.46**	**344.83**	**344.83**				
External leakage - Process medium	6*	149.05	342.00	674.87	342.00	342.00	-	2.0	24.3	73.0
	6†	150.29	344.83	680.46	344.83	344.83				
All modes	**7***	**187.24**	**399.00**	**749.54**	**399.00**	**399.00**	-	**2.0**	**75.1**	**380.0**
	7†	**188.79**	**402.30**	**755.75**	**402.30**	**402.30**				

Comments

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Taxonomy no	Item
3.2.4	Mechanical Equipment Vessels Flash drum

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	7	1.1611	1.0038	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**0.00**	**11.91**	**64.61**	**30.07**	**18.09**	**7.2**	**1.0**	**8.4**	**74.0**
	21†	**0.00**	**13.09**	**68.81**	**31.10**	**20.92**				
Abnormal instrument reading	19*	0.00	9.65	54.53	28.97	16.36	3.4	1.0	4.3	17.0
	19†	0.00	10.10	56.80	29.96	18.93				
External leakage - Process medium	2*	0.21	1.87	4.89	1.54	1.72	41.3	17.0	45.5	74.0
	2†	0.01	2.31	8.06	2.97	1.99				
Degraded	**34***	**0.06**	**24.42**	**96.38**	**35.91**	**29.28**	**12.0**	**1.0**	**86.3**	**2228.9**
	34†	**0.14**	**27.39**	**99.66**	**36.82**	**33.87**				
Abnormal instrument reading	8*	0.00	4.66	24.44	11.02	6.89	5.7	1.0	9.1	48.0
	8†	0.00	5.04	25.69	11.10	7.97				
External leakage - Process medium	4*	0.01	3.29	13.02	4.86	3.45	4.8	2.0	4.8	10.0
	4†	0.00	3.88	17.91	7.21	3.98				
Other	4*	1.19	3.46	6.69	1.72	3.45	4.3	2.0	4.3	6.0
	4†	0.03	3.55	11.92	4.38	3.98				
Parameter deviation	3*	0.08	2.35	7.13	2.45	2.58	7.0	1.0	13.0	36.0
	3†	0.67	2.79	6.09	1.73	2.99				
Plugged/Choked	9*	0.27	9.75	29.74	10.33	7.75	34.7	2.0	312.7	2228.9
	9†	0.32	10.98	33.44	11.58	8.97				
Structural deficiency	6*	0.00	3.75	18.37	7.71	5.17	3.8	2.0	6.2	12.0
	6†	0.00	4.12	18.94	7.59	5.98				
Incipient	**202***	**0.00**	**110.07**	**599.53**	**279.70**	**173.98**	**4.7**	**1.0**	**5.8**	**72.0**
	202†	**0.00**	**119.72**	**635.66**	**290.72**	**201.23**				
Abnormal instrument reading	160*	0.00	82.37	459.10	238.38	137.80	4.8	1.0	5.1	72.0
	160†	0.00	88.75	490.49	248.75	159.39				
External leakage - Process medium	3*	0.06	2.25	6.89	2.40	2.58	3.0	2.0	5.3	7.0
	3†	0.16	2.59	7.59	2.52	2.99				
External leakage - Utility medium	2*	0.18	1.79	4.80	1.54	1.72	14.5	2.0	28.0	54.0
	2†	0.40	2.05	4.78	1.41	1.99				
Minor in-service problems	19*	1.59	14.48	38.27	12.12	16.36	4.8	1.0	8.3	43.0
	19†	3.45	16.60	37.84	11.03	18.93				
Other	4*	0.39	3.51	9.26	2.93	3.45	1.7	1.0	14.3	52.0
	4†	1.23	3.92	7.84	2.08	3.98				
Plugged/Choked	6*	0.00	3.75	18.37	7.71	5.17	6.0	2.0	9.8	21.0
	6†	0.00	4.12	18.94	7.59	5.98				
Structural deficiency	6*	0.04	4.82	15.96	5.84	5.17	2.3	1.0	2.7	7.0
	6†	0.08	5.38	16.96	6.08	5.98				
Unknown	2*	0.00	1.51	6.29	2.40	1.72	1.5	1.0	1.5	2.0
	2†	0.00	1.67	6.56	2.44	1.99				
Unknown	**10***	**0.23**	**12.42**	**38.76**	**13.78**	**8.61**	**11.1**	**4.0**	**18.8**	**49.0**
	10†	**0.28**	**13.09**	**40.46**	**14.26**	**9.96**				

Comments

(cont.)

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Taxonomy no		Item									
3.2.4		Mechanical Equipment Vessels Flash drum									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
34	7	**Calendar time** * 1.1611			**Operational time** † 1.0038						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
Abnormal instrument reading		4*	0.39	3.51	9.26	2.93	3.45	15.2	6.0	33.5	49.0
		4†	1.23	3.92	7.84	2.08	3.98				
External leakage - Process medium		1*	0.00	1.52	7.14	2.91	0.86	-	10.0	10.0	10.0
		1†	0.00	1.62	7.53	3.05	1.00				
Other		2*	0.00	4.59	21.07	8.43	1.72	-	12.0	14.0	16.0
		2†	0.00	4.85	22.49	9.08	1.99				
Unknown		3*	0.06	2.84	8.79	3.10	2.58	5.0	4.0	5.3	6.0
		3†	0.27	3.06	8.50	2.76	2.99				
All modes		**267***	**0.00**	**158.03**	**813.27**	**352.77**	**229.96**	**5.9**	**1.0**	**16.2**	**2228.9**
		267†	**0.00**	**172.64**	**859.33**	**365.87**	**265.99**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Flash drum

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.37	0.00	0.00	0.75
Instrument, flow	2.62	0.00	0.00	0.00	0.00
Instrument, general	1.87	0.00	0.00	0.00	0.00
Instrument, level	47.94	0.00	0.00	0.00	0.00
Instrument, pressure	1.87	0.00	0.00	0.37	0.00
Instrument, temperature	1.87	0.00	0.00	0.00	0.00
Other	0.00	0.75	0.37	0.00	0.00
Piping	0.00	1.50	0.00	0.75	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.37	0.37	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00
Unknown	2.62	0.00	0.00	0.75	0.00
Valves	12.36	0.75	0.37	1.87	0.37
Total	71.54	3.75	0.75	3.75	1.12

Maintainable item versus failure mode, continued
Item: Vessels - Flash drum

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	0.00	0.00	1.12
Instrument, flow	0.00	0.00	0.00	0.00	2.62
Instrument, general	0.00	0.37	0.19	0.00	2.43
Instrument, level	0.75	1.12	0.00	0.00	49.81
Instrument, pressure	0.00	0.00	0.00	0.00	2.25
Instrument, temperature	0.00	0.00	0.37	0.00	2.25
Other	0.00	1.87	0.00	0.00	3.00
Piping	0.37	0.37	1.50	0.00	4.49
Sand trap system	0.75	0.00	0.00	0.00	0.75
Subunit	0.75	0.37	0.00	0.00	1.87
Support	0.00	0.00	0.37	0.00	0.37
Unknown	0.37	0.37	0.75	0.75	5.62
Valves	2.62	2.62	1.31	1.12	23.41
Total	5.62	7.12	4.49	1.87	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Flash drum

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	18.35	0.00	0.00	0.00	0.00
Burst	0.00	0.00	0.00	0.00	0.00
Cavitation	0.37	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.37	0.00	0.00
Combined causes	0.00	0.00	0.00	0.00	0.00
Control failure	0.37	0.00	0.00	0.00	0.75
Corrosion	0.37	0.00	0.00	0.75	0.00
Earth/isolation fault	1.50	0.00	0.00	0.00	0.00
Electrical failure - general	0.37	0.00	0.00	0.00	0.00
Erosion	0.00	0.37	0.00	0.00	0.00
Faulty signal/indication/alarm	1.12	0.00	0.00	0.00	0.00
Instrument failure - general	26.59	0.00	0.00	0.75	0.37
Leakage	0.37	1.50	0.37	0.00	0.00
Looseness	0.00	0.37	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.37	0.00
Mechanical Failure - general	4.49	0.37	0.00	1.12	0.00
Misc. external influences	3.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Out of adjustment	13.86	0.00	0.00	0.75	0.00
Sticking	0.00	0.00	0.00	0.00	0.00
Unknown	0.37	0.00	0.00	0.00	0.00
Vibration	0.37	0.00	0.00	0.00	0.00
Wear	0.00	1.12	0.00	0.00	0.00
Total	71.54	3.75	0.75	3.75	1.12

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Vessels - Flash drum

	PLU	SER	STD	UNK	Sum
Blockage/plugged	3.00	0.37	0.00	0.37	22.10
Burst	0.00	0.75	0.00	0.00	0.75
Cavitation	0.00	0.00	0.00	0.00	0.37
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.37
Combined causes	1.12	0.00	0.00	0.00	1.12
Control failure	0.00	0.00	0.00	0.00	1.12
Corrosion	0.00	1.12	1.50	0.00	3.75
Earth/isolation fault	0.00	0.00	0.00	0.00	1.50
Electrical failure - general	0.00	0.00	0.00	0.00	0.37
Erosion	0.00	0.00	0.00	0.00	0.37
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	1.12
Instrument failure - general	0.00	1.12	0.37	1.12	30.34
Leakage	0.00	0.00	0.75	0.00	3.00
Looseness	0.00	0.00	0.00	0.00	0.37
Material failure - general	0.00	0.00	0.00	0.00	0.37
Mechanical Failure - general	0.37	1.50	0.75	0.00	8.61
Misc. external influences	0.37	0.37	0.75	0.00	4.49
Other	0.00	0.37	0.00	0.00	0.37
Out of adjustment	0.00	0.37	0.00	0.00	14.98
Sticking	0.37	0.37	0.00	0.00	0.75
Unknown	0.37	0.00	0.00	0.37	1.12
Vibration	0.00	0.00	0.37	0.00	0.75
Wear	0.00	0.75	0.00	0.00	1.87
Total	5.62	7.12	4.49	1.87	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.4.1	Mechanical Equipment Vessels Flash drum (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	5	0.5399	0.4456	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**0.00**	**11.57**	**56.45**	**23.58**	**12.97**	**4.9**	**2.0**	**5.9**	**13.0**
	7†	**0.00**	**11.12**	**54.48**	**22.87**	**13.09**				
Abnormal instrument reading	7*	0.00	11.57	56.45	23.58	12.97	4.9	2.0	5.9	13.0
	7†	0.00	11.08	57.80	25.82	15.71				
Degraded	**19***	**0.00**	**30.90**	**144.93**	**59.01**	**35.19**	**5.7**	**1.0**	**8.4**	**48.0**
	19†	**0.00**	**30.32**	**141.18**	**57.20**	**35.53**				
Abnormal instrument reading	5*	0.00	8.60	39.69	15.98	9.26	7.6	3.0	12.4	48.0
	5†	0.00	8.16	38.16	15.50	9.35				
External leakage - Process medium	2*	0.09	3.81	11.73	4.11	3.70	3.5	2.0	3.5	5.0
	2†	0.06	3.60	11.30	4.03	3.74				
Other	3*	0.01	5.50	22.01	8.24	5.56	3.5	2.0	3.5	5.0
	3†	0.01	5.16	21.16	8.02	5.61				
Parameter deviation	3*	0.01	5.50	22.01	8.24	5.56	7.0	1.0	13.0	36.0
	3†	0.01	5.16	21.16	8.02	5.61				
Plugged/Choked	3*	0.60	6.38	17.42	5.62	5.56	6.3	2.0	6.3	9.0
	3†	0.53	5.95	16.45	5.34	5.61				
Structural deficiency	3*	0.01	5.50	22.01	8.24	5.56	3.3	2.0	6.0	10.0
	3†	0.01	5.16	21.16	8.02	5.61				
Incipient	**74***	**0.01**	**122.34**	**561.87**	**225.09**	**137.07**	**5.1**	**1.0**	**6.2**	**72.0**
	74†	**0.01**	**114.49**	**535.68**	**217.76**	**138.40**				
Abnormal instrument reading	61*	0.00	101.75	490.31	202.29	112.99	5.4	1.0	5.6	72.0
	61†	0.00	92.53	459.57	195.34	114.09				
External leakage - Process medium	3*	0.05	5.15	16.93	6.18	5.56	3.0	2.0	5.3	7.0
	3†	0.04	5.05	17.21	6.33	5.61				
Minor in-service problems	5*	0.70	8.05	22.39	7.28	9.26	4.2	4.0	7.0	9.0
	5†	0.22	8.03	24.50	8.50	9.35				
Other	3*	0.32	6.93	20.79	6.99	5.56	1.5	1.0	18.3	52.0
	3†	0.15	6.47	19.93	7.00	5.61				
Plugged/Choked	1*	0.00	1.90	8.22	3.19	1.85	6.0	6.0	6.0	6.0
	1†	0.00	1.78	8.14	3.24	1.87				
Structural deficiency	1*	0.00	1.90	8.22	3.19	1.85	2.0	2.0	2.0	2.0
	1†	0.00	1.78	8.14	3.24	1.87				
Unknown	**5***	**0.15**	**10.97**	**35.00**	**12.63**	**9.26**	**9.0**	**4.0**	**13.2**	**40.0**
	5†	**0.10**	**10.27**	**33.87**	**12.38**	**9.35**				
Abnormal instrument reading	2*	0.09	3.81	11.73	4.11	3.70	13.0	6.0	23.0	40.0
	2†	0.06	3.60	11.30	4.03	3.74				
External leakage - Process medium	1*	0.00	4.27	18.53	7.20	1.85	-	10.0	10.0	10.0
	1†	0.00	4.06	18.12	7.16	1.87				
Unknown	2*	0.09	3.81	11.73	4.11	3.70	5.0	4.0	5.0	6.0
	2†	0.06	3.60	11.30	4.03	3.74				

Comments

(cont.)

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Taxonomy no	Item
3.2.4.1	Mechanical Equipment Vessels Flash drum (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	5	0.5399	0.4456	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	105* 105†	0.01 0.01	172.46 165.31	804.98 776.40	326.72 316.38	194.49 196.38	5.3	1.0	6.9	72.0

Comments

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Taxonomy no	Item
3.2.4.2	Mechanical Equipment Vessels Flash drum (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	4	0.3440	0.3131	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**0.05**	**28.16**	**113.44**	**42.65**	**37.79**	**8.5**	**1.0**	**9.2**	**74.0**
	13†	**0.09**	**29.30**	**114.51**	**42.51**	**41.52**				
Abnormal instrument reading	12*	0.00	23.42	111.16	45.56	34.89	2.5	1.0	3.3	17.0
	12†	0.00	24.23	113.42	46.12	38.33				
External leakage - Process medium	1*	0.01	3.73	14.79	5.52	2.91	74.0	74.0	74.0	74.0
	1†	0.02	3.93	15.10	5.56	3.19				
Degraded	**9***	**2.52**	**25.08**	**67.66**	**21.68**	**26.17**	**29.8**	**1.0**	**34.3**	**147.0**
	9†	**3.85**	**26.54**	**66.25**	**20.37**	**28.75**				
Abnormal instrument reading	3*	0.58	7.52	21.32	6.99	8.72	1.0	1.0	1.0	1.0
	3†	1.62	8.49	19.79	5.85	9.58				
External leakage - Process medium	1*	0.01	3.73	14.79	5.52	2.91	10.0	10.0	10.0	10.0
	1†	0.02	3.93	15.10	5.56	3.19				
Plugged/Choked	3*	0.16	10.00	31.52	11.29	8.72	72.0	8.0	82.0	147.0
	3†	0.26	10.53	32.29	11.29	9.58				
Structural deficiency	2*	0.01	4.78	19.07	7.13	5.81	5.0	4.0	8.0	12.0
	2†	0.02	5.14	19.58	7.22	6.39				
Incipient	**120***	**0.01**	**234.55**	**1100.04**	**447.86**	**348.87**	**4.1**	**1.0**	**4.8**	**43.0**
	120†	**0.01**	**239.34**	**1122.08**	**456.73**	**383.28**				
Abnormal instrument reading	97*	0.00	183.83	902.66	379.77	282.00	4.1	1.0	4.5	41.0
	97†	0.00	186.79	920.48	388.61	309.82				
Minor in-service problems	13*	4.60	32.76	82.32	25.40	37.79	5.3	1.0	9.0	43.0
	13†	8.41	35.87	79.00	22.49	41.52				
Other	1*	0.01	2.57	9.66	3.56	2.91	2.0	2.0	2.0	2.0
	1†	0.02	2.79	9.78	3.61	3.19				
Plugged/Choked	2*	0.01	4.78	19.07	7.13	5.81	3.5	2.0	3.5	5.0
	2†	0.02	5.14	19.58	7.22	6.39				
Structural deficiency	5*	3.34	13.59	29.51	8.33	14.54	2.4	1.0	2.8	7.0
	5†	5.46	14.97	28.32	7.14	15.97				
Unknown	2*	0.01	4.78	19.07	7.13	5.81	1.5	1.0	1.5	2.0
	2†	0.02	5.14	19.58	7.22	6.39				
Unknown	**4***	**0.07**	**14.76**	**54.09**	**19.98**	**11.63**	**19.5**	**6.0**	**18.3**	**39.0**
	4†	**0.08**	**15.56**	**56.98**	**21.05**	**12.78**				
Abnormal instrument reading	1*	0.01	2.57	9.66	3.56	2.91	19.5	39.0	39.0	39.0
	1†	0.02	2.79	9.78	3.61	3.19				
Other	2*	0.00	8.45	36.05	13.92	5.81	-	12.0	14.0	16.0
	2†	0.00	8.95	38.23	14.76	6.39				
Unknown	1*	0.01	3.72	14.78	5.52	2.91	-	6.0	6.0	6.0
	1†	0.01	3.98	15.42	5.71	3.19				
All modes	**146***	**0.12**	**301.67**	**1310.21**	**509.09**	**424.46**	**6.1**	**1.0**	**7.3**	**147.0**
	146†	**0.14**	**308.13**	**1331.04**	**516.28**	**466.33**				

Comments

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Taxonomy no	Item
3.2.4.3	Mechanical Equipment Vessels Flash drum (50-100)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0377	0.0360	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.27**	**24.40**	**79.28**	**28.83**	**26.56**	**1.5**	**3.0**	**3.0**	**3.0**
	1†	**0.29**	**25.50**	**82.71**	**30.06**	**27.76**				
Minor in-service problems	1*	0.27	24.40	79.28	28.83	26.56	1.5	3.0	3.0	3.0
	1†	0.29	25.50	82.71	30.06	27.76				
All modes	**1***	**0.27**	**24.40**	**79.28**	**28.83**	**26.56**	**1.5**	**3.0**	**3.0**	**3.0**
	1†	**0.29**	**25.50**	**82.71**	**30.06**	**27.76**				

Comments

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Taxonomy no	Item
3.2.4.4	Mechanical Equipment Vessels Flash drum (100-300)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0131	0.0125	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.12	30.69	117.85	43.40	0.00	-	-	-	-
	0†	0.13	32.48	124.71	45.93	0.00				

Comments

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Taxonomy no	Item
3.2.4.5	Mechanical Equipment Vessels Flash drum Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	5	0.2264	0.1966	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.04**	**5.11**	**17.15**	**6.29**	**4.42**	**8.5**	**17.0**	**17.0**	**17.0**
	1†	**0.24**	**5.45**	**16.37**	**5.51**	**5.09**				
External leakage - Process medium	1*	0.04	5.11	17.15	6.29	4.42	8.5	17.0	17.0	17.0
	1†	0.24	5.45	16.37	5.51	5.09				
Degraded	**6***	**2.23**	**32.26**	**92.97**	**30.67**	**26.50**	**4.8**	**2.0**	**449.6**	**2228.9**
	6†	**3.64**	**34.06**	**90.62**	**28.81**	**30.51**				
External leakage - Process medium	1*	0.05	3.88	12.51	4.54	4.42	2.0	2.0	2.0	2.0
	1†	0.02	4.46	16.59	6.13	5.09				
Other	1*	0.02	5.56	21.70	8.05	4.42	6.0	6.0	6.0	6.0
	1†	0.05	5.71	19.11	7.01	5.09				
Plugged/Choked	3*	0.24	17.57	56.00	20.19	13.25	8.0	8.0	1118.4	2228.9
	3†	0.51	18.08	55.11	19.11	15.26				
Structural deficiency	1*	0.04	5.11	17.15	6.29	4.42	3.0	3.0	3.0	3.0
	1†	0.24	5.45	16.37	5.51	5.09				
Incipient	**7***	**2.88**	**36.03**	**101.56**	**33.22**	**30.91**	**12.6**	**2.0**	**19.7**	**54.0**
	7†	**4.20**	**38.57**	**102.18**	**32.40**	**35.60**				
Abnormal instrument reading	2*	1.75	9.97	23.71	7.08	8.83	18.0	5.0	18.0	31.0
	2†	2.29	10.88	24.73	7.19	10.17				
External leakage - Utility medium	2*	0.15	8.21	25.62	9.11	8.83	14.5	2.0	28.0	54.0
	2†	0.27	9.42	28.69	9.94	10.17				
Plugged/Choked	3*	0.00	17.30	79.35	31.75	13.25	7.7	10.0	15.3	21.0
	3†	0.00	18.21	83.27	33.22	15.26				
Unknown	**1***	**0.00**	**10.55**	**46.49**	**18.24**	**4.42**	**-**	**49.0**	**49.0**	**49.0**
	1†	**0.00**	**10.92**	**48.76**	**19.27**	**5.09**				
Abnormal instrument reading	1*	0.00	10.55	46.49	18.24	4.42	-	49.0	49.0	49.0
	1†	0.00	10.92	48.76	19.27	5.09				
All modes	**15***	**9.96**	**85.68**	**223.25**	**70.06**	**66.24**	**9.6**	**2.0**	**175.1**	**2228.9**
	15†	**13.29**	**90.07**	**223.91**	**68.71**	**76.29**				

Comments

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Taxonomy no		Item									
3.2.5		Mechanical Equipment Vessels Hydrocyclone									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
20	3	**Calendar time** * 0.4854			**Operational time** † 0.4759						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
Critical		**3***	**0.04**	**6.15**	**21.55**	**7.95**	**6.18**	**5.0**	**5.0**	**169.7**	**264.0**
		3†	**0.04**	**6.25**	**21.55**	**7.94**	**6.30**				
External leakage - Process medium		3*	0.04	6.15	21.55	7.95	6.18	5.0	5.0	169.7	264.0
		3†	0.04	6.25	21.55	7.94	6.30				
Degraded		**4***	**2.81**	**8.34**	**16.24**	**4.21**	**8.24**	**21.3**	**3.0**	**24.3**	**70.0**
		4†	**2.43**	**8.61**	**17.89**	**4.89**	**8.40**				
Other		2*	0.02	3.57	12.73	4.70	4.12	2.5	3.0	3.5	4.0
		2†	0.02	3.66	12.94	4.78	4.20				
Plugged/Choked		1*	0.01	4.38	17.19	6.39	2.06	70.0	70.0	70.0	70.0
		1†	0.02	4.86	18.86	6.98	2.10				
Structural deficiency		1*	0.01	1.88	6.40	2.35	2.06	10.0	20.0	20.0	20.0
		1†	0.02	1.93	6.50	2.39	2.10				
Incipient		**1***	**0.01**	**1.88**	**6.40**	**2.35**	**2.06**	**3.0**	**3.0**	**3.0**	**3.0**
		1†	**0.02**	**1.93**	**6.50**	**2.39**	**2.10**				
Other		1*	0.01	1.88	6.40	2.35	2.06	3.0	3.0	3.0	3.0
		1†	0.02	1.93	6.50	2.39	2.10				
All modes		**8***	**8.24**	**16.52**	**27.13**	**5.83**	**16.48**	**15.5**	**3.0**	**76.1**	**264.0**
		8†	**8.45**	**16.90**	**27.72**	**5.94**	**16.81**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Hydrocyclone

	AIR	ELP	ELU	OTH	PDE
Piping	0.00	25.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00
Valves	0.00	12.50	0.00	37.50	0.00
Total	0.00	37.50	0.00	37.50	0.00

Maintainable item versus failure mode, continued
Item: Vessels - Hydrocyclone

	PLU	SER	STD	UNK	Sum
Piping	0.00	0.00	0.00	0.00	25.00
Sand trap system	12.50	0.00	0.00	0.00	12.50
Subunit	0.00	0.00	12.50	0.00	12.50
Valves	0.00	0.00	0.00	0.00	50.00
Total	12.50	0.00	12.50	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Vessels - Hydrocyclone

	AIR	ELP	ELU	OTH	PDE
Combined causes	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	12.50	0.00	12.50	0.00
Mechanical Failure - general	0.00	0.00	0.00	25.00	0.00
Wear	0.00	25.00	0.00	0.00	0.00
Total	0.00	37.50	0.00	37.50	0.00

Failure descriptior versus failure mode, continued
Item: Vessels - Hydrocyclone

	PLU	SER	STD	UNK	Sum
Combined causes	12.50	0.00	0.00	0.00	12.50
Leakage	0.00	0.00	0.00	0.00	25.00
Mechanical Failure - general	0.00	0.00	12.50	0.00	37.50
Wear	0.00	0.00	0.00	0.00	25.00
Total	12.50	0.00	12.50	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.5.1	Mechanical Equipment Vessels Hydrocyclone (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
17	3	0.3803	0.3722	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.58**	**7.02**	**19.64**	**6.41**	**7.89**	**5.0**	**5.0**	**169.7**	**264.0**
	3†	**0.72**	**7.20**	**19.45**	**6.23**	**8.06**				
External leakage - Process medium	3*	0.58	7.02	19.64	6.41	7.89	5.0	5.0	169.7	264.0
	3†	0.72	7.20	19.45	6.23	8.06				
Degraded	**3***	**2.00**	**8.65**	**19.13**	**5.46**	**7.89**	**27.3**	**4.0**	**31.3**	**70.0**
	3†	**1.79**	**9.06**	**20.96**	**6.16**	**8.06**				
Other	1*	0.00	2.64	10.85	4.12	2.63	2.0	4.0	4.0	4.0
	1†	0.00	2.71	11.06	4.18	2.69				
Plugged/Choked	1*	0.01	4.43	17.56	6.55	2.63	70.0	70.0	70.0	70.0
	1†	0.01	4.90	19.42	7.25	2.69				
Structural deficiency	1*	0.00	2.64	10.85	4.12	2.63	10.0	20.0	20.0	20.0
	1†	0.00	2.71	11.06	4.18	2.69				
All modes	**6***	**6.91**	**15.82**	**27.69**	**6.44**	**15.78**	**21.8**	**4.0**	**100.5**	**264.0**
	6†	**7.11**	**16.21**	**28.34**	**6.58**	**16.12**				

Comments

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Taxonomy no	Item
3.2.5.2	Mechanical Equipment Vessels Hydrocyclone Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1052	0.1037	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.48**	**9.51**	**45.11**	**9.51**	**9.51**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.48**	**9.65**	**45.77**	**9.65**	**9.65**				
Other	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0
	1†	0.48	9.65	45.77	9.65	9.65				
Incipient	**1***	**0.48**	**9.51**	**45.11**	**9.51**	**9.51**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.48**	**9.65**	**45.77**	**9.65**	**9.65**				
Other	1*	0.48	9.51	45.11	9.51	9.51	3.0	3.0	3.0	3.0
	1†	0.48	9.65	45.77	9.65	9.65				
All modes	**2***	**3.37**	**19.01**	**59.84**	**19.01**	**19.01**	**3.0**	**3.0**	**3.0**	**3.0**
	2†	**3.42**	**19.29**	**60.72**	**19.29**	**19.29**				

Comments

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Taxonomy no	Item
3.2.6	Mechanical Equipment Vessels Mol sieve dryer

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	1	0.1053	0.1032	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**7***	**31.21**	**66.50**	**124.92**	**66.50**	**66.50**	-	**1.0**	**10.1**	**37.0**
	7†	**31.83**	**67.83**	**127.42**	**67.83**	**67.83**				
Abnormal instrument reading	1*	0.47	9.50	45.08	9.50	9.50	-	3.0	3.0	3.0
	1†	0.48	9.69	45.98	9.69	9.69				
External leakage - Process medium	5*	18.71	47.50	99.89	47.50	47.50	-	1.0	6.2	20.0
	5†	19.09	48.45	101.89	48.45	48.45				
Structural deficiency	1*	0.47	9.50	45.08	9.50	9.50	-	37.0	37.0	37.0
	1†	0.48	9.69	45.98	9.69	9.69				
All modes	**7***	**31.21**	**66.50**	**124.92**	**66.50**	**66.50**	-	**1.0**	**10.1**	**37.0**
	7†	**31.83**	**67.83**	**127.42**	**67.83**	**67.83**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Mol sieve dryer

	AIR	ELP	ELU	OTH	PDE
Other	0.00	14.29	0.00	0.00	0.00
Unknown	14.29	0.00	0.00	0.00	0.00
Valves	0.00	57.14	0.00	0.00	0.00
Total	14.29	71.43	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Vessels - Mol sieve dryer

	PLU	SER	STD	UNK	Sum
Other	0.00	0.00	14.29	0.00	28.57
Unknown	0.00	0.00	0.00	0.00	14.29
Valves	0.00	0.00	0.00	0.00	57.14
Total	0.00	0.00	14.29	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Vessels - Mol sieve dryer

	AIR	ELP	ELU	OTH	PDE
Corrosion	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	14.29	0.00	0.00	0.00	0.00
Leakage	0.00	71.43	0.00	0.00	0.00
Total	14.29	71.43	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Vessels - Mol sieve dryer

	PLU	SER	STD	UNK	Sum
Corrosion	0.00	0.00	14.29	0.00	14.29
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	14.29
Leakage	0.00	0.00	0.00	0.00	71.43
Total	0.00	0.00	14.29	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.6.1	Mechanical Equipment Vessels Mol sieve dryer (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	1	0.1053	0.1032	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**7***	**31.21**	**66.50**	**124.92**	**66.50**	**66.50**	-	**1.0**	**10.1**	**37.0**
	7†	**31.83**	**67.83**	**127.42**	**67.83**	**67.83**				
Abnormal instrument reading	1*	0.47	9.50	45.08	9.50	9.50	-	3.0	3.0	3.0
	1†	0.48	9.69	45.98	9.69	9.69				
External leakage - Process medium	5*	18.71	47.50	99.89	47.50	47.50	-	1.0	6.2	20.0
	5†	19.09	48.45	101.89	48.45	48.45				
Structural deficiency	1*	0.47	9.50	45.08	9.50	9.50	-	37.0	37.0	37.0
	1†	0.48	9.69	45.98	9.69	9.69				
All modes	**7***	**31.21**	**66.50**	**124.92**	**66.50**	**66.50**	-	**1.0**	**10.1**	**37.0**
	7†	**31.83**	**67.83**	**127.42**	**67.83**	**67.83**				

Comments

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Taxonomy no	Item
3.2.7	Mechanical Equipment Vessels Scrubber

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	7	0.6545	0.6286	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**0.01**	**22.98**	**97.53**	**37.57**	**16.81**	**5.8**	**2.0**	**8.8**	**28.0**
	11†	**0.02**	**23.96**	**101.64**	**39.14**	**17.50**				
Abnormal instrument reading	1*	0.00	2.13	10.24	4.22	1.53	2.5	5.0	5.0	5.0
	1†	0.00	2.22	10.68	4.40	1.59				
External leakage - Process medium	1*	0.00	1.34	6.04	2.40	1.53	7.0	9.0	9.0	9.0
	1†	0.00	1.41	6.51	2.62	1.59				
External leakage - Utility medium	1*	0.00	2.13	10.24	4.22	1.53	2.0	4.0	4.0	4.0
	1†	0.00	2.22	10.68	4.40	1.59				
Other	3*	0.00	5.70	24.09	9.26	4.58	5.3	6.0	8.7	10.0
	3†	0.00	5.98	25.22	9.68	4.77				
Parameter deviation	2*	0.20	2.88	8.29	2.74	3.06	-	2.0	3.0	4.0
	2†	0.37	3.01	7.77	2.43	3.18				
Structural deficiency	2*	0.00	4.97	24.38	10.25	3.06	9.5	10.0	19.0	28.0
	2†	0.00	5.18	25.41	10.68	3.18				
Unknown	1*	0.00	2.13	10.24	4.22	1.53	-	-	-	-
	1†	0.00	2.22	10.68	4.40	1.59				
Degraded	**17***	**0.01**	**19.20**	**81.74**	**31.53**	**25.98**	**10.8**	**4.0**	**8.7**	**22.0**
	17†	**0.02**	**19.82**	**82.99**	**31.74**	**27.05**				
Abnormal instrument reading	1*	0.00	1.52	7.97	3.60	1.53	-	20.0	20.0	20.0
	1†	0.00	1.59	8.36	3.79	1.59				
External leakage - Process medium	6*	2.66	8.54	17.12	4.55	9.17	9.3	4.0	7.5	16.0
	6†	2.72	8.88	17.94	4.79	9.55				
External leakage - Utility medium	3*	0.00	3.90	16.77	6.49	4.58	-	4.0	10.3	20.0
	3†	0.00	4.02	16.74	6.38	4.77				
Other	6*	0.00	6.97	36.52	16.43	9.17	-	4.0	5.0	8.0
	6†	0.00	7.08	36.92	16.50	9.55				
Plugged/Choked	1*	0.00	1.34	6.04	2.40	1.53	15.0	22.0	22.0	22.0
	1†	0.00	1.41	6.51	2.62	1.59				
Incipient	**68***	**6.53**	**93.41**	**268.84**	**88.64**	**103.90**	**10.8**	**1.0**	**11.2**	**53.0**
	68†	**7.50**	**96.89**	**274.57**	**90.00**	**108.18**				
Abnormal instrument reading	43*	0.79	50.06	157.81	56.54	65.70	11.8	1.0	11.1	39.0
	43†	0.91	52.15	163.16	58.14	68.41				
External leakage - Utility medium	4*	0.00	8.70	38.98	15.43	6.11	8.3	4.0	13.5	42.0
	4†	0.00	9.02	40.53	16.06	6.36				
Minor in-service problems	8*	2.10	12.06	28.79	8.61	12.22	13.5	4.0	14.5	53.0
	8†	2.45	12.50	28.96	8.52	12.73				
Other	3*	0.86	4.91	11.70	3.50	4.58	2.0	4.0	6.0	8.0
	3†	0.91	5.08	12.02	3.58	4.77				
Parameter deviation	4*	0.25	5.88	17.68	5.97	6.11	-	2.0	8.5	14.0
	4†	0.40	6.07	17.63	5.83	6.36				

Comments

(cont.)

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Taxonomy no		Item
3.2.7		Mechanical Equipment Vessels Scrubber

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	7	0.6545	0.6286	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	5*	0.05	8.15	28.84	10.65	7.64	-	8.0	10.0	14.0
	5†	0.05	8.37	29.44	10.87	7.95				
Unknown	1*	0.00	2.13	10.24	4.22	1.53	2.0	4.0	4.0	4.0
	1†	0.00	2.22	10.68	4.40	1.59				
All modes	**96***	**4.77**	**134.32**	**405.92**	**138.74**	**146.69**	**9.7**	**1.0**	**10.5**	**53.0**
	96†	**5.90**	**139.21**	**418.52**	**141.36**	**152.73**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Scrubber

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	1.04	1.04	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00
Control unit	1.04	0.00	0.00	0.00	0.00
Heater	0.00	0.00	0.00	0.00	0.00
Instrument, flow	0.52	0.00	0.00	0.00	0.00
Instrument, level	38.02	2.08	1.04	2.08	6.25
Instrument, pressure	4.17	0.00	1.04	2.08	0.00
Instrument, temperature	2.08	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00
Unknown	1.04	1.04	0.00	0.00	0.00
Valves	0.00	4.17	5.21	7.29	0.00
Total	46.88	7.29	8.33	12.50	6.25

Maintainable item versus failure mode, continued
Item: Vessels - Scrubber

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	0.00	2.08	0.00	4.17
Cabling & junction boxes	0.00	1.04	1.04	0.00	2.08
Control unit	0.00	0.00	0.00	0.00	1.04
Heater	0.00	1.04	0.00	0.00	1.04
Instrument, flow	0.00	0.00	0.00	0.00	0.52
Instrument, level	0.00	2.08	0.00	0.00	51.56
Instrument, pressure	0.00	1.04	0.00	0.00	8.33
Instrument, temperature	0.00	0.00	0.00	0.00	2.08
Monitoring	0.00	1.04	0.00	0.00	1.04
Piping	0.00	0.00	1.56	0.00	1.56
Support	0.00	0.00	1.04	0.00	1.04
Unknown	0.00	2.08	1.04	0.00	5.21
Valves	1.04	0.00	0.52	2.08	20.31
Total	1.04	8.33	7.29	2.08	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Scrubber

	AIR	ELP	ELU	OTH	PDE
Breakage	2.08	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	1.04	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00
Common mode failure	0.00	0.00	0.00	0.00	1.04
Corrosion	1.04	0.00	0.00	1.04	0.00
Deformation	0.00	0.00	0.00	2.08	0.00
Earth/isolation fault	1.04	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00
Fatigue	0.00	1.04	0.00	0.00	0.00
Faulty signal/indication/alarm	13.54	0.00	0.00	0.00	1.04
Instrument failure - general	5.21	0.00	1.04	1.04	1.04
Leakage	0.00	0.00	4.17	0.00	0.00
Looseness	0.00	1.04	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.04	1.04	0.00	0.00
No cause found	0.00	1.04	0.00	0.00	0.00
No signal/indication/alarm	6.25	0.00	0.00	1.04	0.00
Other	0.00	0.00	0.00	1.04	0.00
Out of adjustment	16.67	0.00	0.00	1.04	3.12
Unknown	0.00	0.00	1.04	1.04	0.00
Vibration	0.00	0.00	0.00	0.00	0.00
Wear	1.04	3.12	1.04	3.12	0.00
Total	46.88	7.29	8.33	12.50	6.25

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Vessels - Scrubber

	PLU	SER	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	2.08
Cavitation	0.00	0.00	2.08	0.00	3.12
Clearance/ alignment failure	1.04	0.00	0.00	0.00	1.04
Common mode failure	0.00	0.00	0.00	0.00	1.04
Corrosion	0.00	3.12	3.12	0.00	8.33
Deformation	0.00	0.00	1.04	0.00	3.12
Earth/isolation fault	0.00	0.00	0.00	0.00	1.04
Electrical failure - general	0.00	1.04	0.00	0.00	1.04
External influence - general	0.00	1.04	0.00	0.00	1.04
Fatigue	0.00	0.00	0.00	0.00	1.04
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	14.58
Instrument failure - general	0.00	1.04	0.00	0.00	9.37
Leakage	0.00	0.00	0.00	0.00	4.17
Looseness	0.00	0.00	0.00	0.00	1.04
Mechanical Failure - general	0.00	0.00	1.04	0.00	3.12
No cause found	0.00	0.00	0.00	0.00	1.04
No signal/indication/alarm	0.00	0.00	0.00	1.04	8.33
Other	0.00	1.04	0.00	1.04	3.12
Out of adjustment	0.00	0.00	0.00	0.00	20.83
Unknown	0.00	0.00	0.00	0.00	2.08
Vibration	0.00	1.04	0.00	0.00	1.04
Wear	0.00	0.00	0.00	0.00	8.33
Total	1.04	8.33	7.29	2.08	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.7.1	Mechanical Equipment Vessels Scrubber (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
17	6	0.4880	0.4675	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**0.04**	**27.83**	**113.35**	**42.83**	**22.54**	**5.8**	**2.0**	**8.8**	**28.0**
	11†	**0.04**	**28.99**	**118.09**	**44.63**	**23.53**				
Abnormal instrument reading	1*	0.00	2.73	11.90	4.63	2.05	2.5	5.0	5.0	5.0
	1†	0.00	2.84	12.39	4.82	2.14				
External leakage - Process medium	1*	0.01	1.81	7.01	2.59	2.05	7.0	9.0	9.0	9.0
	1†	0.00	1.90	7.57	2.83	2.14				
External leakage - Utility medium	1*	0.00	2.73	11.90	4.63	2.05	2.0	4.0	4.0	4.0
	1†	0.00	2.84	12.39	4.82	2.14				
Other	3*	0.03	7.24	27.47	10.13	6.15	5.3	6.0	8.7	10.0
	3†	0.03	7.59	28.71	10.59	6.42				
Parameter deviation	2*	0.00	3.45	14.98	5.82	4.10	-	2.0	3.0	4.0
	2†	0.00	3.55	15.11	5.83	4.28				
Structural deficiency	2*	0.00	6.21	29.09	11.84	4.10	9.5	10.0	19.0	28.0
	2†	0.00	6.46	30.30	12.33	4.28				
Unknown	1*	0.00	2.73	11.90	4.63	2.05	-	-	-	-
	1†	0.00	2.84	12.39	4.82	2.14				
Degraded	**16***	**0.03**	**22.31**	**90.50**	**34.14**	**32.78**	**10.8**	**4.0**	**8.0**	**22.0**
	16†	**0.06**	**23.10**	**91.29**	**34.03**	**34.23**				
External leakage - Process medium	6*	0.29	9.93	30.23	10.46	12.29	9.3	4.0	7.5	16.0
	6†	0.31	10.36	31.51	10.89	12.83				
External leakage - Utility medium	3*	0.06	5.32	17.32	6.30	6.15	-	4.0	10.3	20.0
	3†	0.14	5.56	17.05	5.96	6.42				
Other	6*	0.00	8.90	43.22	17.94	12.29	-	4.0	5.0	8.0
	6†	0.00	9.08	43.45	17.87	12.83				
Plugged/Choked	1*	0.01	1.81	7.01	2.59	2.05	15.0	22.0	22.0	22.0
	1†	0.00	1.90	7.57	2.83	2.14				
Incipient	**63***	**11.76**	**105.96**	**279.35**	**88.32**	**129.09**	**10.8**	**1.0**	**10.1**	**53.0**
	63†	**13.74**	**110.01**	**282.94**	**88.28**	**134.77**				
Abnormal instrument reading	39*	1.60	55.41	168.73	58.44	79.91	11.8	1.0	9.8	36.0
	39†	2.07	57.76	174.51	59.62	83.43				
External leakage - Utility medium	4*	0.01	10.80	45.74	17.60	8.20	8.3	4.0	13.5	42.0
	4†	0.01	11.19	47.53	18.31	8.56				
Minor in-service problems	7*	3.17	13.96	31.03	8.89	14.34	13.5	4.0	12.6	53.0
	7†	3.84	14.50	30.77	8.54	14.97				
Other	3*	0.03	7.35	27.06	10.00	6.15	2.0	4.0	6.0	8.0
	3†	0.03	7.61	28.24	10.43	6.42				
Parameter deviation	4*	2.56	8.03	15.97	4.22	8.20	-	2.0	8.5	14.0
	4†	2.74	8.32	16.37	4.28	8.56				
Structural deficiency	5*	0.43	10.50	31.61	10.71	10.25	-	8.0	10.0	14.0
	5†	0.54	10.80	32.35	10.80	10.70				

Comments

(cont.)

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Taxonomy no	Item
3.2.7.1	Mechanical Equipment Vessels Scrubber (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
17	6	0.4880	0.4675	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	1*	0.00	2.73	11.90	4.63	2.05	2.0	4.0	4.0	4.0
	1†	0.00	2.84	12.39	4.82	2.14				
All modes	**90***	**11.49**	**151.67**	**431.32**	**141.58**	**184.41**	**9.7**	**1.0**	**9.5**	**53.0**
	90†	**13.41**	**157.17**	**438.14**	**142.63**	**192.52**				

Comments

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Taxonomy no	Item
3.2.7.2	Mechanical Equipment Vessels Scrubber (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.1664	0.1611	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.05**	**5.55**	**18.38**	**6.73**	**6.01**	-	**20.0**	**20.0**	**20.0**
	1†	**0.05**	**5.75**	**19.30**	**7.08**	**6.21**				
Abnormal instrument reading	1*	0.05	5.55	18.38	6.73	6.01	-	20.0	20.0	20.0
	1†	0.05	5.75	19.30	7.08	6.21				
Incipient	**5***	**0.77**	**25.93**	**78.87**	**27.26**	**30.05**	-	**8.0**	**25.0**	**39.0**
	5†	**0.64**	**27.00**	**82.96**	**29.07**	**31.04**				
Abnormal instrument reading	4*	1.39	21.17	61.49	20.34	24.04	-	8.0	24.3	39.0
	4†	1.17	21.99	65.43	21.81	24.83				
Minor in-service problems	1*	0.05	5.55	18.38	6.73	6.01	-	28.0	28.0	28.0
	1†	0.05	5.75	19.30	7.08	6.21				
All modes	**6***	**0.55**	**30.69**	**95.84**	**34.11**	**36.05**	-	**8.0**	**24.2**	**39.0**
	6†	**0.49**	**32.00**	**101.10**	**36.27**	**37.25**				

Comments

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Taxonomy no		Item									
3.2.8		Mechanical Equipment Vessels Separator									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
83	13	**Calendar time** * 4.6937			**Operational time** † 1.3051						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**59***	**0.22**	**28.86**	**98.13**	**36.11**	**12.57**	**5.2**	**1.0**	**7.4**	**45.0**
		59†	**0.24**	**35.92**	**124.00**	**45.72**	**45.21**				
Abnormal instrument reading		23*	0.00	13.44	65.65	27.46	4.90	4.8	1.0	6.9	20.0
		23†	0.00	14.03	79.08	41.87	17.62				
External leakage - Process medium		21*	0.00	6.92	38.88	20.48	4.47	5.9	1.0	6.1	18.0
		21†	0.00	9.55	55.26	30.03	16.09				
Other		7*	0.00	5.14	26.52	11.58	1.49	6.4	1.0	12.6	45.0
		7†	0.00	5.33	29.57	17.63	5.36				
Parameter deviation		3*	0.10	0.56	1.32	0.39	0.64	2.2	1.0	4.0	8.0
		3†	0.00	2.39	13.26	6.81	2.30				
Plugged/Choked		5*	0.00	3.10	13.59	5.31	1.07	2.5	2.0	9.2	22.0
		5†	0.00	4.05	17.55	6.81	3.83				
Degraded		**145***	**0.34**	**68.29**	**248.96**	**91.98**	**30.89**	**5.1**	**1.0**	**7.5**	**64.0**
		145†	**0.34**	**102.44**	**397.11**	**146.90**	**111.10**				
Abnormal instrument reading		42*	0.00	22.66	120.19	54.93	8.95	6.3	1.0	9.0	64.0
		42†	0.00	24.96	134.08	86.45	32.18				
External leakage - Process medium		19*	0.05	9.92	35.73	13.20	4.05	5.8	1.5	7.8	25.0
		19†	0.09	15.61	54.85	20.25	14.56				
External leakage - Utility medium		7*	0.01	4.62	17.99	6.67	1.49	8.8	4.0	15.9	40.0
		7†	0.01	5.07	20.62	7.78	5.36				
Other		23*	0.15	12.31	39.62	14.36	4.90	5.3	1.0	9.0	32.0
		23†	0.38	16.77	51.67	18.16	17.62				
Parameter deviation		12*	0.00	4.02	16.91	6.48	2.56	3.8	1.0	6.3	40.0
		12†	0.06	8.92	30.89	11.39	9.19				
Plugged/Choked		37*	0.15	10.81	34.34	12.36	7.88	3.7	1.0	4.3	15.0
		37†	0.02	29.68	124.87	47.88	28.35				
Structural deficiency		5*	0.00	2.87	15.28	7.01	1.07	2.4	1.0	2.4	4.0
		5†	0.00	3.15	18.29	9.96	3.83				
Incipient		**623***	**0.20**	**323.16**	**1371.71**	**528.35**	**132.73**	**5.1**	**0.5**	**7.2**	**104.0**
		623†	**0.00**	**385.12**	**1885.58**	**790.88**	**477.37**				
Abnormal instrument reading		428*	0.01	217.01	1007.37	407.25	91.19	5.2	1.0	6.8	97.0
		428†	0.00	252.30	1351.08	622.79	327.95				
External leakage - Process medium		31*	0.14	8.65	27.28	9.77	6.60	4.0	1.0	6.9	52.0
		31†	0.00	23.71	107.38	42.70	23.75				
External leakage - Utility medium		9*	0.00	5.90	28.34	11.67	1.92	4.0	4.0	9.3	20.0
		9†	0.00	6.15	33.86	16.93	6.90				
Minor in-service problems		81*	0.01	48.14	219.88	87.70	17.26	4.7	1.0	8.0	95.0
		81†	0.00	49.42	271.94	134.72	62.07				
Other		21*	0.14	14.74	48.51	17.72	4.47	6.2	2.0	9.7	40.0
		21†	0.03	15.30	61.88	23.31	16.09				
Comments											

(cont.)

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Taxonomy no
3.2.8

Item
Mechanical Equipment
Vessels
Separator

Population	Installations
83	13

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
4.6937	1.3051

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours) Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Parameter deviation	25*	0.76	14.80	44.18	14.74	5.33	5.0	0.5	6.4	40.0
	25†	0.68	21.26	64.48	22.18	19.16				
Plugged/Choked	23*	0.00	10.38	49.20	20.15	4.90	5.0	1.0	7.8	104.0
	23†	0.00	15.42	75.08	31.29	17.62				
Structural deficiency	4*	0.00	2.60	10.64	4.03	0.85	2.8	2.0	19.3	56.0
	4†	0.02	2.99	10.62	3.92	3.06				
Unknown	1*	0.00	0.56	2.75	1.16	0.21	11.0	11.0	11.0	11.0
	1†	0.00	0.71	3.93	2.03	0.77				
Unknown	**10***	**0.00**	**5.63**	**25.75**	**10.28**	**2.13**	**4.3**	**1.0**	**15.1**	**52.0**
	10†	**0.00**	**6.89**	**33.95**	**14.33**	**7.66**				
Other	1*	0.00	0.72	3.58	1.53	0.21	-	52.0	52.0	52.0
	1†	0.01	0.78	2.50	0.90	0.77				
Parameter deviation	1*	0.00	0.19	0.59	0.21	0.21	-	-	-	-
	1†	0.00	0.80	4.30	2.76	0.77				
Unknown	8*	0.00	4.78	23.62	10.00	1.70	4.3	1.0	9.9	31.0
	8†	0.00	5.18	28.59	14.42	6.13				
All modes	**837***	**0.56**	**425.07**	**1739.83**	**658.73**	**178.32**	**5.1**	**0.5**	**7.3**	**104.0**
	837†	**0.04**	**526.87**	**2433.20**	**979.64**	**641.34**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Separator

	AIR	ELP	ELU	OTH	PDE
Actuating device	0.24	0.06	0.12	0.36	0.12
Body/shell	0.00	0.00	0.12	0.00	0.00
Cabling & junction boxes	0.24	0.00	0.00	0.12	0.00
Control unit	1.31	0.00	0.00	0.36	0.12
Instrument, flow	6.33	0.00	0.00	0.00	0.60
Instrument, general	0.48	0.00	0.00	0.00	0.00
Instrument, level	40.92	0.72	0.36	0.90	2.63
Instrument, pressure	2.27	0.12	0.00	0.12	0.00
Instrument, temperature	0.72	0.00	0.00	0.00	0.00
Monitoring	0.48	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00
Piping	0.06	0.60	0.12	0.00	0.00
Plates, trays, vanes, pads	0.00	0.00	0.00	0.00	0.00
Sand trap system	0.00	0.00	0.00	0.00	0.00
Subunit	0.24	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.12	0.00
Unknown	0.48	0.12	0.12	0.24	0.12
Valves	5.14	6.87	1.08	4.00	1.31
Total	58.90	8.48	1.91	6.21	4.90

Maintainable item versus failure mode, continued
Item: Vessels - Separator

	PLU	SER	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.90
Body/shell	0.00	0.24	0.36	0.00	0.72
Cabling & junction boxes	0.00	0.12	0.00	0.00	0.48
Control unit	0.12	0.00	0.00	0.00	1.91
Instrument, flow	0.00	0.36	0.00	0.00	7.29
Instrument, general	0.00	0.36	0.00	0.00	0.84
Instrument, level	0.00	1.67	0.00	0.36	47.55
Instrument, pressure	0.00	0.24	0.00	0.12	2.87
Instrument, temperature	0.00	0.00	0.00	0.00	0.72
Monitoring	0.00	0.00	0.00	0.00	0.48
Other	0.24	0.00	0.00	0.00	0.24
Piping	0.00	1.55	0.24	0.00	2.57
Plates, trays, vanes, pads	0.00	0.24	0.00	0.00	0.24
Sand trap system	0.24	0.00	0.00	0.00	0.24
Subunit	3.46	0.12	0.00	0.00	3.82
Support	0.00	0.12	0.00	0.00	0.24
Unknown	0.24	0.60	0.00	0.24	2.15
Valves	3.46	4.06	0.48	0.36	26.76
Total	7.77	9.68	1.08	1.08	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Separator

	AIR	ELP	ELU	OTH	PDE
Blockage/plugged	5.73	0.12	0.00	0.60	0.36
Breakage	0.48	0.12	0.36	0.48	0.24
Clearance/ alignment failure	0.24	0.00	0.00	0.00	0.00
Combined causes	0.12	0.12	0.00	0.00	0.12
Common mode failure	0.12	0.00	0.00	0.00	0.00
Contamination	0.12	0.00	0.00	0.00	0.00
Control failure	0.48	0.00	0.00	0.24	0.12
Corrosion	0.24	0.12	0.12	0.36	0.00
Deformation	0.12	0.00	0.00	0.00	0.00
Earth/isolation fault	0.24	0.00	0.00	0.00	0.00
Electrical failure - general	0.60	0.00	0.00	0.12	0.00
Erosion	0.00	2.51	0.00	0.00	0.24
External influence - general	0.12	0.00	0.00	0.12	0.00
Faulty signal/indication/alarm	5.14	0.00	0.00	0.12	0.00
Instrument failure - general	19.83	0.00	0.00	0.60	1.31
Leakage	0.36	2.27	0.36	0.48	0.00
Looseness	0.24	0.48	0.12	0.00	0.00
Material failure - general	0.00	0.36	0.12	0.60	0.12
Mechanical Failure - general	1.79	0.96	0.12	0.60	0.24
Misc. external influences	1.08	0.00	0.00	0.12	0.00
Miscellaneous - general	0.00	0.00	0.00	0.12	0.00
No cause found	0.12	0.00	0.12	0.12	0.00
No signal/indication/alarm	0.96	0.00	0.00	0.00	0.00
Open circuit	0.24	0.00	0.00	0.00	0.00
Out of adjustment	19.71	0.00	0.12	0.84	1.67
Short circuiting	0.00	0.00	0.00	0.12	0.00
Sticking	0.24	0.00	0.12	0.12	0.00
Unknown	0.12	0.12	0.00	0.00	0.36
Vibration	0.24	0.00	0.00	0.00	0.00
Wear	0.24	1.31	0.36	0.48	0.12
Total	58.90	8.48	1.91	6.21	4.90

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Vessels - Separator

	PLU	SER	STD	UNK	Sum
Blockage/plugged	5.38	0.96	0.00	0.00	13.14
Breakage	0.12	0.12	0.00	0.00	1.91
Clearance/ alignment failure	0.24	0.12	0.00	0.00	0.60
Combined causes	0.00	0.00	0.00	0.00	0.36
Common mode failure	0.00	0.00	0.00	0.00	0.12
Contamination	0.12	0.12	0.00	0.00	0.36
Control failure	0.12	0.00	0.00	0.00	0.96
Corrosion	0.36	0.84	0.36	0.00	2.39
Deformation	0.00	0.00	0.00	0.00	0.12
Earth/isolation fault	0.00	0.24	0.00	0.00	0.48
Electrical failure - general	0.00	0.12	0.00	0.00	0.84
Erosion	0.00	0.00	0.00	0.00	2.75
External influence - general	0.12	0.72	0.00	0.00	1.08
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	5.26
Instrument failure - general	0.48	1.55	0.12	0.72	24.61
Leakage	0.00	0.12	0.00	0.00	3.58
Looseness	0.00	0.00	0.00	0.00	0.84
Material failure - general	0.00	1.43	0.12	0.00	2.75
Mechanical Failure - general	0.48	0.84	0.24	0.12	5.38
Misc. external influences	0.00	1.67	0.24	0.00	3.11
Miscellaneous - general	0.00	0.00	0.00	0.00	0.12
No cause found	0.00	0.00	0.00	0.00	0.36
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.96
Open circuit	0.00	0.00	0.00	0.00	0.24
Out of adjustment	0.12	0.36	0.00	0.12	22.94
Short circuiting	0.00	0.00	0.00	0.00	0.12
Sticking	0.12	0.00	0.00	0.00	0.60
Unknown	0.00	0.24	0.00	0.12	0.96
Vibration	0.00	0.00	0.00	0.00	0.24
Wear	0.12	0.24	0.00	0.00	2.87
Total	7.77	9.68	1.08	1.08	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.8.1	Mechanical Equipment Vessels Separator (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
50	5	3.7259	0.3552	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**1.95**	**10.69**	**25.23**	**7.50**	**2.95**	**2.1**	**1.0**	**6.0**	**22.0**
	11†	**3.25**	**28.83**	**75.68**	**23.87**	**30.97**				
Abnormal instrument reading	1*	0.51	4.50	11.82	3.73	0.27	-	2.0	2.0	2.0
	1†	0.00	4.18	18.52	7.30	2.82				
External leakage - Process medium	3*	0.07	0.72	1.96	0.63	0.81	1.7	2.0	2.7	4.0
	3†	0.03	7.40	28.64	10.59	8.45				
Parameter deviation	3*	0.07	0.72	1.96	0.63	0.81	2.2	1.0	4.0	8.0
	3†	0.03	7.40	28.64	10.59	8.45				
Plugged/Choked	4*	0.34	6.94	20.78	6.95	1.07	3.0	3.0	11.0	22.0
	4†	1.12	10.74	28.74	9.17	11.26				
Degraded	**61***	**27.86**	**94.50**	**193.41**	**52.23**	**16.37**	**3.2**	**1.0**	**6.1**	**40.0**
	61†	**28.23**	**182.94**	**450.11**	**137.33**	**171.74**				
Abnormal instrument reading	2*	0.09	0.53	1.27	0.38	0.54	1.0	1.0	1.0	1.0
	2†	0.16	5.27	16.04	5.54	5.63				
External leakage - Process medium	13*	5.86	32.04	75.51	22.43	3.49	3.1	1.5	6.3	20.0
	13†	1.02	45.48	140.13	49.26	36.60				
External leakage - Utility medium	2*	1.56	10.06	24.71	7.53	0.54	-	8.0	24.0	40.0
	2†	0.00	9.75	43.52	17.20	5.63				
Other	12*	9.19	37.22	80.72	22.76	3.22	1.8	1.0	8.9	21.0
	12†	1.03	46.30	142.75	50.21	33.78				
Parameter deviation	6*	0.37	1.57	3.46	0.98	1.61	2.0	1.0	2.7	8.0
	6†	6.71	16.25	29.16	6.97	16.89				
Plugged/Choked	26*	1.41	8.50	20.53	6.19	6.98	4.0	3.0	4.5	15.0
	26†	1.18	62.59	194.82	69.14	73.20				
Incipient	**101***	**38.63**	**136.00**	**281.87**	**76.86**	**27.11**	**1.9**	**0.5**	**3.2**	**40.0**
	101†	**48.88**	**285.56**	**684.35**	**205.39**	**284.35**				
Abnormal instrument reading	53*	14.23	67.68	153.90	44.78	14.22	1.8	1.0	2.7	15.0
	53†	11.80	151.28	428.18	140.28	149.21				
External leakage - Process medium	20*	3.30	5.12	7.28	1.22	5.37	1.9	1.0	2.0	4.0
	20†	0.02	42.92	183.30	70.79	56.31				
External leakage - Utility medium	2*	1.56	10.06	24.71	7.53	0.54	-	12.0	12.5	13.0
	2†	0.00	9.75	43.52	17.20	5.63				
Minor in-service problems	2*	1.56	10.06	24.71	7.53	0.54	-	3.0	5.0	7.0
	2†	0.00	9.75	43.52	17.20	5.63				
Other	3*	4.14	14.73	30.63	8.37	0.81	-	8.0	19.3	40.0
	3†	0.10	13.92	47.62	17.54	8.45				
Parameter deviation	15*	6.08	23.47	50.13	13.98	4.03	1.6	0.5	2.0	4.0
	15†	25.03	42.23	63.08	11.68	42.23				
Plugged/Choked	6*	0.27	1.46	3.44	1.02	1.61	3.5	1.0	3.5	4.0
	6†	0.10	14.37	49.45	18.22	16.89				

Comments

(cont.)

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Taxonomy no		Item
3.2.8.1		Mechanical Equipment Vessels Separator (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
50	5	3.7259	0.3552	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**1***	**0.01**	**0.25**	**0.77**	**0.27**	**0.27**	-	-	-	-
	1†	**0.00**	**2.58**	**11.36**	**4.45**	**2.82**				
Parameter deviation	1*	0.01	0.25	0.77	0.27	0.27	-	-	-	-
	1†	0.00	2.58	11.36	4.45	2.82				
All modes	**174***	**79.09**	**250.41**	**499.99**	**132.28**	**46.70**	**2.4**	**0.5**	**4.4**	**40.0**
	174†	**85.37**	**499.14**	**1196.46**	**359.14**	**489.87**				

Comments

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Taxonomy no	Item
3.2.8.2	Mechanical Equipment Vessels Separator (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	7	0.3440	0.3375	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.28**	**17.87**	**56.42**	**20.23**	**17.44**	**6.5**	**1.0**	**11.0**	**45.0**
	6†	**0.29**	**18.24**	**57.38**	**20.53**	**17.78**				
Abnormal instrument reading	3*	0.02	7.60	30.09	11.22	8.72	2.5	1.0	3.7	6.0
	3†	0.02	7.77	31.03	11.61	8.89				
Other	3*	0.00	11.42	57.69	24.79	8.72	9.2	2.0	18.3	45.0
	3†	0.00	11.59	58.49	25.14	8.89				
Degraded	**32***	**0.22**	**79.24**	**310.37**	**115.33**	**93.02**	**5.7**	**1.0**	**9.6**	**47.0**
	32†	**0.21**	**81.45**	**320.78**	**119.44**	**94.83**				
Abnormal instrument reading	5*	3.15	14.44	32.48	9.38	14.53	8.3	2.0	14.2	47.0
	5†	2.83	14.79	34.49	10.19	14.82				
External leakage - Process medium	1*	0.00	2.61	12.81	5.39	2.91	-	16.0	16.0	16.0
	1†	0.00	2.65	12.92	5.39	2.96				
External leakage - Utility medium	4*	0.09	10.96	36.91	13.56	11.63	11.3	5.0	14.8	35.0
	4†	0.10	11.16	37.27	13.67	11.85				
Other	7*	3.74	19.10	44.27	13.03	20.35	5.4	1.0	8.9	32.0
	7†	3.47	19.48	46.17	13.75	20.74				
Parameter deviation	4*	0.28	11.05	33.88	11.84	11.63	7.8	2.0	14.0	40.0
	4†	0.23	11.33	35.14	12.43	11.85				
Plugged/Choked	10*	0.00	23.64	117.28	49.81	29.07	3.0	1.0	3.8	8.0
	10†	0.00	24.42	121.41	51.64	29.63				
Structural deficiency	1*	0.00	2.61	12.81	5.39	2.91	4.0	4.0	4.0	4.0
	1†	0.00	2.68	13.25	5.61	2.96				
Incipient	**146***	**0.78**	**328.25**	**1301.09**	**485.49**	**424.40**	**5.5**	**1.0**	**9.1**	**95.0**
	146†	**0.77**	**336.66**	**1337.46**	**499.41**	**432.65**				
Abnormal instrument reading	81*	0.02	183.13	831.43	330.94	235.45	4.6	1.0	7.3	95.0
	81†	0.02	189.04	859.90	342.50	240.03				
External leakage - Process medium	3*	0.04	9.16	34.21	12.63	8.72	2.0	4.0	8.7	12.0
	3†	0.04	9.34	35.28	13.01	8.89				
External leakage - Utility medium	5*	0.00	11.46	59.31	26.06	14.53	-	4.0	10.2	20.0
	5†	0.00	11.57	59.75	26.13	14.82				
Minor in-service problems	32*	0.10	70.67	287.36	108.51	93.02	7.7	1.0	12.3	95.0
	32†	0.10	72.23	294.31	111.23	94.83				
Other	12*	0.29	30.86	101.99	37.30	34.88	10.5	2.0	9.8	30.0
	12†	0.33	31.42	102.51	37.34	35.56				
Parameter deviation	5*	0.06	13.02	48.35	17.85	14.53	20.0	2.0	11.6	40.0
	5†	0.07	13.19	48.01	17.74	14.82				
Plugged/Choked	6*	1.87	15.73	40.83	12.79	17.44	3.0	2.0	5.8	10.0
	6†	1.88	16.05	41.75	13.09	17.78				
Structural deficiency	2*	0.09	5.39	16.89	6.03	5.81	-	12.0	34.0	56.0
	2†	0.15	5.50	16.79	5.84	5.93				

Comments

(cont.)

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Taxonomy no	Item
3.2.8.2	Mechanical Equipment Vessels Separator (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	7	0.3440	0.3375	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**1***	**0.00**	**2.61**	**12.81**	**5.39**	**2.91**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**0.00**	**2.68**	**13.25**	**5.61**	**2.96**				
Unknown	1*	0.00	2.61	12.81	5.39	2.91	4.0	4.0	4.0	4.0
	1†	0.00	2.68	13.25	5.61	2.96				
All modes	**185***	**1.51**	**425.82**	**1644.87**	**607.44**	**537.77**	**5.6**	**1.0**	**9.2**	**95.0**
	185†	**1.47**	**436.81**	**1692.81**	**626.13**	**548.23**				

Comments

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Taxonomy no 3.2.8.3

Item
Mechanical Equipment
Vessels
Separator
(50-100)m3

Population	Installations
11	6

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
0.3031	0.2962

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**6***	**0.01**	**17.46**	**74.56**	**28.79**	**19.79**	**6.7**	**2.0**	**6.8**	**18.0**
	6†	**0.01**	**17.66**	**74.85**	**28.81**	**20.26**				
Abnormal instrument reading	1*	0.00	2.91	12.62	4.90	3.30	2.0	3.0	3.0	3.0
	1†	0.00	2.97	12.69	4.90	3.38				
External leakage - Process medium	5*	0.00	14.78	73.90	31.57	16.50	7.6	2.0	7.6	18.0
	5†	0.00	14.91	74.40	31.73	16.88				
Degraded	**5***	**0.01**	**25.83**	**111.91**	**43.45**	**16.50**	**5.6**	**2.0**	**5.6**	**10.0**
	5†	**0.01**	**26.46**	**114.77**	**44.58**	**16.88**				
External leakage - Process medium	4*	0.00	23.47	110.10	44.84	13.20	6.5	2.0	6.5	10.0
	4†	0.00	24.10	113.02	46.01	13.51				
Other	1*	0.00	3.18	15.72	6.66	3.30	2.0	2.0	2.0	2.0
	1†	0.00	3.23	15.85	6.67	3.38				
Incipient	**47***	**6.92**	**137.01**	**409.93**	**136.83**	**155.05**	**10.6**	**1.0**	**13.4**	**52.0**
	47†	**8.03**	**139.07**	**410.19**	**136.35**	**158.70**				
Abnormal instrument reading	34*	0.71	101.50	348.29	128.32	112.17	10.7	1.0	12.5	50.0
	34†	0.77	102.67	349.42	128.58	114.80				
External leakage - Process medium	8*	0.84	23.53	71.08	24.29	26.39	12.8	2.0	18.6	52.0
	8†	0.91	24.10	72.68	24.74	27.01				
External leakage - Utility medium	1*	0.00	3.18	15.72	6.66	3.30	4.0	4.0	4.0	4.0
	1†	0.00	3.23	15.85	6.67	3.38				
Minor in-service problems	1*	0.00	3.18	15.72	6.66	3.30	3.0	3.0	3.0	3.0
	1†	0.00	3.23	15.85	6.67	3.38				
Other	2*	0.04	6.40	22.79	8.42	6.60	3.0	3.0	6.0	9.0
	2†	0.04	6.57	23.43	8.66	6.75				
Parameter deviation	1*	0.00	2.91	12.62	4.90	3.30	16.0	35.0	35.0	35.0
	1†	0.00	2.97	12.69	4.90	3.38				
Unknown	**2***	**0.00**	**7.10**	**31.32**	**12.30**	**6.60**	**-**	**27.0**	**39.5**	**52.0**
	2†	**0.00**	**7.40**	**32.92**	**12.99**	**6.75**				
Other	1*	0.21	3.39	9.94	3.30	3.30	-	52.0	52.0	52.0
	1†	0.22	3.49	10.19	3.38	3.38				
Unknown	1*	0.21	3.39	9.94	3.30	3.30	-	27.0	27.0	27.0
	1†	0.22	3.49	10.19	3.38	3.38				
All modes	**60***	**13.74**	**185.87**	**530.58**	**174.41**	**197.94**	**9.6**	**1.0**	**12.9**	**52.0**
	60†	**15.01**	**188.84**	**532.88**	**174.37**	**202.59**				

Comments

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Taxonomy no	Item
3.2.8.4	Mechanical Equipment Vessels Separator (100-300)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	5	0.2199	0.2164	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**0.32**	**60.91**	**219.34**	**81.05**	**77.32**	**5.8**	**1.0**	**7.4**	**18.0**
	17†	**0.34**	**61.60**	**219.31**	**81.02**	**78.57**				
Abnormal instrument reading	1*	0.01	4.12	16.84	6.37	4.55	9.0	18.0	18.0	18.0
	1†	0.01	4.19	17.06	6.44	4.62				
External leakage - Process medium	12*	0.00	42.42	218.27	94.67	54.58	6.1	1.0	6.2	15.0
	12†	0.00	42.67	219.42	95.15	55.46				
Other	4*	0.03	14.86	59.63	22.38	18.19	4.3	1.0	8.3	13.0
	4†	0.03	15.11	60.40	22.61	18.49				
Degraded	**5***	**1.39**	**20.94**	**60.67**	**20.05**	**22.74**	**8.3**	**3.0**	**8.8**	**25.0**
	5†	**1.53**	**21.28**	**61.00**	**20.08**	**23.11**				
External leakage - Process medium	1*	0.01	4.12	16.84	6.37	4.55	22.5	25.0	25.0	25.0
	1†	0.01	4.19	17.06	6.44	4.62				
External leakage - Utility medium	1*	0.00	4.28	18.70	7.30	4.55	4.0	4.0	4.0	4.0
	1†	0.00	4.34	18.80	7.30	4.62				
Other	2*	0.70	8.74	24.63	8.05	9.10	6.0	4.0	6.0	8.0
	2†	0.85	8.89	24.23	7.80	9.24				
Plugged/Choked	1*	0.00	4.52	21.03	8.51	4.55	3.0	3.0	3.0	3.0
	1†	0.00	4.63	21.55	8.73	4.62				
Incipient	**44***	**9.91**	**190.24**	**567.44**	**189.25**	**200.12**	**9.1**	**1.0**	**10.8**	**97.0**
	44†	**11.21**	**193.32**	**569.92**	**189.42**	**203.36**				
Abnormal instrument reading	33*	0.90	138.56	481.49	177.63	150.09	11.1	1.0	12.2	97.0
	33†	0.98	140.63	483.57	178.20	152.52				
External leakage - Utility medium	1*	0.00	4.28	18.70	7.30	4.55	4.0	4.0	4.0	4.0
	1†	0.00	4.34	18.80	7.30	4.62				
Minor in-service problems	5*	3.14	20.57	50.77	15.51	22.74	3.4	2.0	6.4	11.0
	5†	3.35	20.94	51.09	15.51	23.11				
Other	2*	0.70	8.74	24.63	8.05	9.10	3.0	3.0	3.0	3.0
	2†	0.85	8.89	24.23	7.80	9.24				
Parameter deviation	3*	0.01	24.49	108.55	42.74	13.64	5.0	6.0	9.7	13.0
	3†	0.01	25.28	111.74	43.93	13.87				
All modes	**66***	**4.61**	**263.11**	**823.03**	**293.23**	**300.19**	**8.2**	**1.0**	**9.8**	**97.0**
	66†	**5.26**	**266.83**	**828.46**	**293.36**	**305.04**				

Comments

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Taxonomy no	Item
3.2.8.5	Mechanical Equipment Vessels Separator (300-1000)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0701	0.0693	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**18***	**165.88**	**256.67**	**380.59**	**256.67**	**256.67**	**4.8**	**1.0**	**7.0**	**20.0**
	18†	**167.91**	**259.82**	**385.25**	**259.82**	**259.82**				
Abnormal instrument reading	17*	154.44	242.41	363.58	242.41	242.41	5.0	1.0	7.3	20.0
	17†	156.33	245.38	368.03	245.38	245.38				
Plugged/Choked	1*	0.71	14.26	67.66	14.26	14.26	2.0	2.0	2.0	2.0
	1†	0.72	14.43	68.49	14.43	14.43				
Degraded	**41***	**442.98**	**584.65**	**758.57**	**584.65**	**584.65**	**5.7**	**1.0**	**7.7**	**64.0**
	41†	**448.40**	**591.80**	**767.86**	**591.80**	**591.80**				
Abnormal instrument reading	35*	368.88	499.09	661.70	499.09	499.09	6.4	1.0	8.7	64.0
	35†	373.39	505.20	669.80	505.20	505.20				
Parameter deviation	2*	5.06	28.52	89.76	28.52	28.52	1.5	1.0	1.5	2.0
	2†	5.12	28.87	90.86	28.87	28.87				
Structural deficiency	4*	19.46	57.04	130.55	57.04	57.04	2.0	1.0	2.0	3.0
	4†	19.70	57.74	132.14	57.74	57.74				
Incipient	**279***	**3594.91**	**3978.44**	**4393.14**	**3978.44**	**3978.44**	**4.3**	**1.0**	**6.0**	**104.0**
	279†	**3638.91**	**4027.14**	**4446.92**	**4027.14**	**4027.14**				
Abnormal instrument reading	222*	2824.44	3165.64	3538.10	3165.64	3165.64	4.3	1.0	5.8	78.0
	222†	2859.01	3204.39	3581.41	3204.39	3204.39				
Minor in-service problems	41*	442.98	584.65	758.57	584.65	584.65	3.7	1.0	5.2	28.0
	41†	448.40	591.80	767.86	591.80	591.80				
Other	1*	0.71	14.26	67.66	14.26	14.26	3.0	3.0	3.0	3.0
	1†	0.72	14.43	68.49	14.43	14.43				
Parameter deviation	1*	0.71	14.26	67.66	14.26	14.26	2.5	5.0	5.0	5.0
	1†	0.72	14.43	68.49	14.43	14.43				
Plugged/Choked	11*	87.98	156.86	259.67	156.86	156.86	6.4	1.0	11.3	104.0
	11†	89.06	158.78	262.85	158.78	158.78				
Structural deficiency	2*	5.06	28.52	89.76	28.52	28.52	2.8	2.0	4.5	7.0
	2†	5.12	28.87	90.86	28.87	28.87				
Unknown	1*	0.71	14.26	67.66	14.26	14.26	11.0	11.0	11.0	11.0
	1†	0.72	14.43	68.49	14.43	14.43				
Unknown	**6***	**37.29**	**85.56**	**168.83**	**85.56**	**85.56**	**4.3**	**1.0**	**7.6**	**31.0**
	6†	**37.75**	**86.61**	**170.90**	**86.61**	**86.61**				
Unknown	6*	37.29	85.56	168.83	85.56	85.56	4.3	1.0	7.6	31.0
	6†	37.75	86.61	170.90	86.61	86.61				
All modes	**344***	**4478.51**	**4905.32**	**5363.22**	**4905.32**	**4905.32**	**4.5**	**1.0**	**6.3**	**104.0**
	344†	**4533.33**	**4965.36**	**5428.87**	**4965.36**	**4965.36**				

Comments

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Taxonomy no	Item
3.2.8.6	Mechanical Equipment Vessels Separator Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.63**	**32.63**	**154.82**	**32.63**	**32.63**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**1.63**	**32.65**	**154.94**	**32.65**	**32.65**				
External leakage - Process medium	1*	1.63	32.63	154.82	32.63	32.63	8.0	8.0	8.0	8.0
	1†	1.63	32.65	154.94	32.65	32.65				
Degraded	**1***	**1.63**	**32.63**	**154.82**	**32.63**	**32.63**	**24.0**	**24.0**	**24.0**	**24.0**
	1†	**1.63**	**32.65**	**154.94**	**32.65**	**32.65**				
Other	1*	1.63	32.63	154.82	32.63	32.63	24.0	24.0	24.0	24.0
	1†	1.63	32.65	154.94	32.65	32.65				
Incipient	**6***	**85.32**	**195.77**	**386.32**	**195.77**	**195.77**	**8.3**	**2.0**	**8.3**	**30.0**
	6†	**85.39**	**195.92**	**386.62**	**195.92**	**195.92**				
Abnormal instrument reading	5*	64.28	163.14	343.09	163.14	163.14	8.8	2.0	8.8	30.0
	5†	64.33	163.27	343.36	163.27	163.27				
Other	1*	1.63	32.63	154.82	32.63	32.63	6.0	6.0	6.0	6.0
	1†	1.63	32.65	154.94	32.65	32.65				
All modes	**8***	**129.86**	**261.03**	**470.99**	**261.03**	**261.03**	**10.3**	**2.0**	**10.3**	**30.0**
	8†	**129.96**	**261.23**	**471.36**	**261.23**	**261.23**				

Comments

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Taxonomy no	Item
3.2.9	Mechanical Equipment Vessels Stripper

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0482	0.0471	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.04	9.82	37.71	13.89	0.00	-	-	-	-
	0†	0.04	10.20	39.17	14.43	0.00				

Comments

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Taxonomy no	Item
3.2.9.1	Mechanical Equipment Vessels Stripper (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0482	0.0471	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	5.04	19.37	7.13	0.00	-	-	-	-
	0†	0.02	5.20	19.98	7.36	0.00				

Comments

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Taxonomy no	Item
3.2.10	Mechanical Equipment Vessels Surge tank

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	7	0.3400	0.2770	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.47**	**5.65**	**15.82**	**5.16**	**5.88**	**14.3**	**24.0**	**28.5**	**33.0**
	2†	**1.02**	**6.76**	**16.69**	**5.11**	**7.22**				
Abnormal instrument reading	2*	0.47	5.65	15.82	5.16	5.88	14.3	24.0	28.5	33.0
	2†	1.02	6.76	16.69	5.11	7.22				
Degraded	**4***	**0.89**	**10.62**	**29.67**	**9.67**	**11.76**	**23.8**	**1.0**	**25.5**	**72.0**
	4†	**0.20**	**13.16**	**41.57**	**14.91**	**14.44**				
Other	2*	0.11	5.29	16.33	5.76	5.88	36.0	1.0	36.5	72.0
	2†	0.04	6.55	22.62	8.34	7.22				
Parameter deviation	1*	0.01	2.56	9.75	3.59	2.94	-	6.0	6.0	6.0
	1†	0.00	3.36	16.82	7.19	3.61				
Structural deficiency	1*	0.00	3.17	16.85	7.70	2.94	11.5	23.0	23.0	23.0
	1†	0.00	3.49	18.13	8.03	3.61				
Incipient	**26***	**8.10**	**62.38**	**159.28**	**49.54**	**76.47**	**67.2**	**1.0**	**67.7**	**594.0**
	26†	**0.84**	**79.22**	**258.50**	**94.16**	**93.86**				
Abnormal instrument reading	13*	0.00	23.11	115.25	49.15	38.23	0.5	1.0	7.6	21.0
	13†	0.00	37.61	198.31	90.00	46.93				
External leakage - Utility medium	1*	0.01	2.56	9.75	3.59	2.94	-	12.0	12.0	12.0
	1†	0.00	3.36	16.82	7.19	3.61				
Minor in-service problems	2*	0.01	5.41	21.32	7.94	5.88	108.5	36.0	126.5	217.0
	2†	0.02	6.89	26.65	9.85	7.22				
Other	5*	0.08	14.33	50.74	18.74	14.71	97.2	13.0	194.4	594.0
	5†	0.20	16.10	51.64	18.68	18.05				
Parameter deviation	1*	0.00	3.17	16.85	7.70	2.94	5.5	11.0	11.0	11.0
	1†	0.00	3.49	18.13	8.03	3.61				
Structural deficiency	4*	0.00	12.42	63.65	27.56	11.76	51.5	58.0	103.0	179.0
	4†	0.00	13.27	67.48	29.12	14.44				
All modes	**32***	**12.27**	**76.21**	**185.56**	**56.26**	**94.12**	**55.2**	**1.0**	**59.9**	**594.0**
	32†	**1.67**	**95.38**	**298.37**	**106.31**	**115.52**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Vessels - Surge tank

	AIR	ELP	ELU	OTH	PDE
Body/shell	0.00	0.00	0.00	6.25	0.00
Instrument, level	34.38	0.00	0.00	0.00	3.13
Instrument, pressure	9.38	0.00	0.00	0.00	0.00
Instrument, temperature	3.13	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	3.13	0.00
Subunit	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	3.13
Valves	0.00	0.00	3.13	12.50	0.00
Total	46.88	0.00	3.13	21.88	6.25

Maintainable item versus failure mode, continued
Item: Vessels - Surge tank

	PLU	SER	STD	UNK	Sum
Body/shell	0.00	3.13	6.25	0.00	15.63
Instrument, level	0.00	0.00	0.00	0.00	37.50
Instrument, pressure	0.00	0.00	0.00	0.00	9.38
Instrument, temperature	0.00	0.00	0.00	0.00	3.13
Other	0.00	0.00	0.00	0.00	3.13
Subunit	0.00	0.00	3.13	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	3.13
Valves	0.00	3.13	6.25	0.00	25.00
Total	0.00	6.25	15.63	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Vessels - Surge tank

	AIR	ELP	ELU	OTH	PDE
Cavitation	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	3.13	0.00
Control failure	6.25	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	12.50	0.00
Faulty signal/indication/alarm	6.25	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	3.13	0.00	3.13
Misc. external influences	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	3.13
No signal/indication/alarm	9.38	0.00	0.00	0.00	0.00
Out of adjustment	25.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	6.25	0.00
Total	46.88	0.00	3.13	21.88	6.25

Failure descriptior versus failure mode, continued
Item: Vessels - Surge tank

	PLU	SER	STD	UNK	Sum
Cavitation	0.00	0.00	3.13	0.00	3.13
Clearance/ alignment failure	0.00	0.00	0.00	0.00	3.13
Control failure	0.00	0.00	0.00	0.00	6.25
Corrosion	0.00	0.00	12.50	0.00	25.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	6.25
Instrument failure - general	0.00	0.00	0.00	0.00	6.25
Misc. external influences	0.00	3.13	0.00	0.00	3.13
No cause found	0.00	0.00	0.00	0.00	3.13
No signal/indication/alarm	0.00	0.00	0.00	0.00	9.38
Out of adjustment	0.00	0.00	0.00	0.00	25.00
Sticking	0.00	3.13	0.00	0.00	3.13
Unknown	0.00	0.00	0.00	0.00	6.25
Total	0.00	6.25	15.63	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.2.10.1	Mechanical Equipment Vessels Surge tank (1-10)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1542	0.0976	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.09**	**18.66**	**68.33**	**25.24**	**12.97**	**14.3**	**24.0**	**28.5**	**33.0**
	2†	**0.40**	**21.45**	**66.78**	**23.70**	**20.48**				
Abnormal instrument reading	2*	0.09	18.66	68.33	25.24	12.97	14.3	24.0	28.5	33.0
	2†	0.40	21.45	66.78	23.70	20.48				
Degraded	**2***	**0.12**	**11.30**	**36.90**	**13.45**	**12.97**	**-**	**1.0**	**3.5**	**6.0**
	2†	**1.93**	**19.87**	**54.03**	**17.38**	**20.48**				
Other	1*	0.09	5.93	18.74	6.72	6.48	-	1.0	1.0	1.0
	1†	0.05	9.90	36.42	13.45	10.24				
Parameter deviation	1*	0.09	5.93	18.74	6.72	6.48	-	6.0	6.0	6.0
	1†	0.05	9.90	36.42	13.45	10.24				
Incipient	**14***	**0.58**	**70.27**	**235.96**	**86.62**	**90.78**	**-**	**2.0**	**10.4**	**36.0**
	14†	**0.66**	**134.03**	**488.08**	**180.33**	**143.37**				
Abnormal instrument reading	12*	0.59	60.76	200.14	73.12	77.81	-	2.0	8.2	21.0
	12†	0.60	115.00	415.14	153.40	122.89				
External leakage - Utility medium	1*	0.09	5.93	18.74	6.72	6.48	-	12.0	12.0	12.0
	1†	0.05	9.90	36.42	13.45	10.24				
Minor in-service problems	1*	0.09	5.93	18.74	6.72	6.48	-	36.0	36.0	36.0
	1†	0.05	9.90	36.42	13.45	10.24				
All modes	**18***	**22.04**	**102.15**	**230.55**	**66.76**	**116.71**	**14.3**	**1.0**	**11.7**	**36.0**
	18†	**9.67**	**175.50**	**520.38**	**173.25**	**184.34**				

Comments

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Taxonomy no	Item
3.2.10.2	Mechanical Equipment Vessels Surge tank (10-50)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	4	0.1122	0.1098	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.59**	**9.25**	**26.92**	**8.91**	**8.91**	**297.0**	**594.0**	**594.0**	**594.0**
	1†	**0.63**	**9.50**	**27.56**	**9.11**	**9.11**				
Other	1*	0.59	9.25	26.92	8.91	8.91	297.0	594.0	594.0	594.0
	1†	0.63	9.50	27.56	9.11	9.11				
All modes	**1***	**0.59**	**9.25**	**26.92**	**8.91**	**8.91**	**297.0**	**594.0**	**594.0**	**594.0**
	1†	**0.63**	**9.50**	**27.56**	**9.11**	**9.11**				

Comments

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Taxonomy no	Item
3.2.10.3	Mechanical Equipment Vessels Surge tank (50-100)m3

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0245	0.0235	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**62.9**	**58.0**	**125.8**	**217.0**
	5†	**83.74**	**212.55**	**446.99**	**212.55**	**212.55**				
Minor in-service problems	1*	2.04	40.77	193.45	40.77	40.77	108.5	217.0	217.0	217.0
	1†	2.13	42.51	201.71	42.51	42.51				
Structural deficiency	4*	55.65	163.08	373.25	163.08	163.08	51.5	58.0	103.0	179.0
	4†	58.03	170.04	389.18	170.04	170.04				
All modes	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**62.9**	**58.0**	**125.8**	**217.0**
	5†	**83.74**	**212.55**	**446.99**	**212.55**	**212.55**				

Comments

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Taxonomy no	Item
3.2.10.4	Mechanical Equipment Vessels Surge tank Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0491	0.0461	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**7.24**	**40.77**	**96.73**	**28.83**	**40.77**	**23.8**	**23.0**	**47.5**	**72.0**
	2†	**7.71**	**43.42**	**103.01**	**30.70**	**43.41**				
Other	1*	1.02	20.38	61.05	20.38	20.38	36.0	72.0	72.0	72.0
	1†	1.16	21.86	65.12	21.71	21.71				
Structural deficiency	1*	1.02	20.38	61.05	20.38	20.38	11.5	23.0	23.0	23.0
	1†	0.09	21.49	81.53	30.06	21.71				
Incipient	**6***	**45.25**	**122.31**	**229.94**	**57.66**	**122.31**	**32.5**	**1.0**	**65.0**	**180.0**
	6†	**44.58**	**130.67**	**253.35**	**65.34**	**130.24**				
Abnormal instrument reading	1*	1.02	20.38	61.05	20.38	20.38	0.5	1.0	1.0	1.0
	1†	0.09	21.49	81.53	30.06	21.71				
Other	4*	0.70	81.54	272.35	99.87	81.54	47.3	13.0	94.5	180.0
	4†	0.70	88.26	297.75	109.41	86.83				
Parameter deviation	1*	1.02	20.38	61.05	20.38	20.38	5.5	11.0	11.0	11.0
	1†	0.09	21.49	81.53	30.06	21.71				
All modes	**8***	**81.13**	**163.08**	**268.06**	**57.66**	**163.08**	**30.3**	**1.0**	**60.6**	**180.0**
	8†	**80.69**	**174.03**	**296.09**	**66.65**	**173.66**				

Comments

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Heaters and Boilers

Inventory description

The boundary definition is shown in Figure 19 and corresponding subdivision in Maintainable Items in Table 14.

The boundary definition applies to hydrocarbon (HC) fired heaters and (re)boilers supplying energy to heat or boil a medium. The energy may be supplied through combustion of hydrocarbons, through supply of a high temperature medium (e.g. steam) or by electricity.

The heater and boiler components will typically include a vessel/shell in which the heating process is performed. For heaters and HC-fired boilers, a burner device and exhaust system are included. Unlike most boilers, the heaters contain a tube coil through which the medium to be heated is flowing.

For HC fired heaters and boilers, the fuel control valve is inside the equipment boundary, while fuel conditioning equipment (e.g. scrubbers) and ESD/PSD valves are outside the boundary.

Inlet, outlet, pressure relief and drain valves are specifically excluded. Valves and instruments included are those locally mounted and/or which form a pressure boundary (e.g. block valves, calibration valves, and local indicators/gauges).

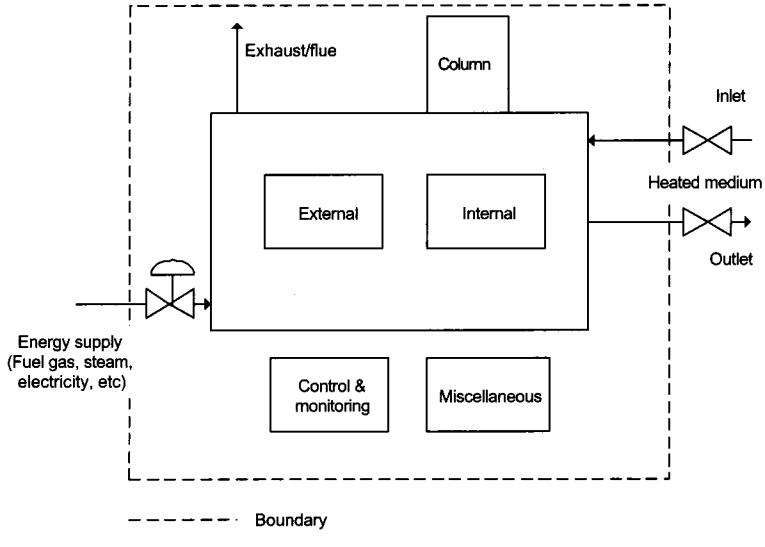

Figure 19-Heaters and boilers, Boundary Definition

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Table 14 Heaters and Boilers, Subdivision in Maintainable Items

HEATERS AND BOILERS				
Column	Control & monitoring	External	Internal	Miscellaneous
• Body/shell • Packing • Reflux coil/ condenser	• Actuating device • Cabling & junction boxes • Control unit • Instruments • Internal power supply • Monitoring • Valves	• Body/shell • Piping • Support • Valves	• Body/shell • Burner • Exhaust stack • Fire tube • Support • Tube coil	• Fan

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR	Abnormal instrument reading
ELP	External leakage - Process medium
ELU	External leakage - Utility medium
IHT	Insufficient heat transfer
INL	Internal leakage
SER	Minor in-service problems
OTH	Other
OHE	Overheating
PDE	Parameter deviation
PLU	Plugged/Choked
STD	Structural deficiency

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Taxonomy no	Item
3.3	Mechanical Equipment Heaters and boilers

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	6	0.2505	0.2262	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**8.07**	**47.31**	**113.47**	**34.08**	**51.90**	**14.0**	**1.0**	**22.4**	**41.0**
	13†	**8.28**	**52.89**	**129.69**	**39.49**	**57.48**				
Abnormal instrument reading	4*	0.02	12.34	50.67	19.21	15.97	12.4	13.0	24.8	41.0
	4†	0.02	13.57	54.95	20.71	17.69				
Insufficient heat transfer	3*	0.00	11.48	52.32	20.85	11.98	2.8	1.0	2.8	4.0
	3†	0.00	14.31	68.01	27.89	13.26				
Overheating	1*	0.00	3.94	19.57	8.32	3.99	37.5	35.0	35.0	35.0
	1†	0.00	4.32	21.37	9.05	4.42				
Parameter deviation	2*	0.00	6.50	28.42	11.10	7.98	20.5	41.0	41.0	41.0
	2†	0.00	7.14	31.06	12.07	8.84				
Structural deficiency	3*	1.11	12.77	35.44	11.52	11.98	16.0	19.0	22.0	25.0
	3†	1.48	13.92	37.08	11.79	13.26				
Degraded	**92***	**0.00**	**316.53**	**1669.39**	**757.82**	**367.28**	**12.7**	**0.5**	**22.3**	**813.0**
	92†	**0.00**	**418.77**	**2166.48**	**951.49**	**406.78**				
External leakage - Utility medium	2*	1.67	8.35	19.25	5.65	7.98	98.8	2.0	196.5	391.0
	2†	1.67	9.41	22.33	6.66	8.84				
Insufficient heat transfer	87*	0.00	296.51	1606.25	746.82	347.32	10.8	0.5	18.4	813.0
	87†	0.00	395.94	2076.67	935.85	384.67				
Internal leakage	1*	0.25	4.11	12.04	3.99	3.99	-	-	-	-
	1†	0.00	4.50	23.05	9.98	4.42				
Parameter deviation	1*	0.00	3.51	14.58	5.55	3.99	9.5	19.0	19.0	19.0
	1†	0.00	3.87	15.91	6.04	4.42				
Plugged/Choked	1*	0.00	3.93	19.50	8.29	3.99	8.0	8.0	8.0	8.0
	1†	0.28	4.56	13.34	4.42	4.42				
Incipient	**53***	**3.17**	**191.23**	**600.46**	**214.53**	**211.59**	**5.7**	**0.5**	**9.4**	**113.0**
	53†	**1.99**	**229.21**	**765.18**	**280.54**	**234.34**				
Abnormal instrument reading	18*	4.81	73.99	215.09	71.17	71.86	5.8	0.5	9.6	44.0
	18†	3.30	85.69	258.32	87.81	79.59				
External leakage - Process medium	2*	0.03	7.88	30.45	11.25	7.98	2.5	2.0	2.5	3.0
	2†	0.00	9.53	41.65	16.25	8.84				
External leakage - Utility medium	1*	0.00	3.94	19.57	8.32	3.99	4.5	9.0	9.0	9.0
	1†	0.00	4.32	21.37	9.05	4.42				
Minor in-service problems	17*	0.03	62.13	266.14	102.91	67.87	7.1	1.5	11.2	113.0
	17†	0.02	76.93	337.98	132.36	75.17				
Other	14*	13.05	51.42	110.57	30.99	55.89	2.6	1.0	4.2	7.0
	14†	7.35	57.49	147.20	45.84	61.90				
Overheating	1*	0.00	3.51	14.58	5.55	3.99	28.5	57.0	57.0	57.0
	1†	0.00	3.87	15.91	6.04	4.42				
Unknown	**1***	**0.00**	**8.46**	**39.70**	**16.17**	**3.99**	**-**	**12.0**	**12.0**	**12.0**
	1†	**0.00**	**8.94**	**42.14**	**17.21**	**4.42**				
Abnormal instrument reading	1*	0.00	8.46	39.70	16.17	3.99	-	12.0	12.0	12.0
	1†	0.00	8.94	42.14	17.21	4.42				

Comments

(cont.)

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Taxonomy no		Item									
3.3		Mechanical Equipment Heaters and boilers									
Population	Installations	Aggregated time in service (10^6 hours)						No of demands			
		Calendar time *			Operational time †						
9	6	0.2505			0.2262						
Failure mode		No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes		159* 159†	0.12 0.13	555.60 704.23	2469.51 3141.33	973.80 1240.98	634.76 703.02	10.5	0.5	18.0	813.0
Comments											

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Maintainable item versus failure mode, to be continued
Item: Heaters and boilers

	AIR	ELP	ELU	IHT	INL	OHE
Actuating device	0.00	0.00	0.00	0.63	0.00	0.00
Body/shell	0.00	0.00	0.00	0.00	0.00	0.00
Burner(s)	0.63	0.63	0.63	6.29	0.00	0.00
Cabling & junction boxes	2.52	0.00	0.00	6.60	0.00	0.63
Control unit	0.63	0.00	0.00	0.94	0.00	0.00
Instrument, flame	0.00	0.00	0.00	35.53	0.00	0.00
Instrument, flow	0.63	0.63	0.00	0.00	0.00	0.00
Instrument, general	1.89	0.00	0.00	0.63	0.00	0.00
Instrument, level	1.89	0.00	0.00	0.00	0.00	0.00
Instrument, pressure	1.89	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	2.52	0.00	0.00	0.00	0.00	0.63
Internal power supply	0.63	0.00	0.00	1.26	0.00	0.00
Monitoring	0.63	0.00	0.00	0.31	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.63	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tube coil	0.00	0.00	0.00	0.00	0.63	0.00
Unknown	0.63	0.00	0.00	3.77	0.00	0.00
Valves	0.00	0.00	0.63	0.63	0.00	0.00
Total	14.47	1.26	1.89	56.60	0.63	1.26

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Heaters and boilers

	OTH	PDE	PLU	SER	STD	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.63
Body/shell	0.00	0.00	0.00	0.63	0.00	0.63
Burner(s)	0.63	0.00	0.00	1.89	0.00	10.69
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	9.75
Control unit	0.00	0.00	0.00	1.26	0.00	2.83
Instrument, flame	0.00	0.00	0.00	1.26	0.00	36.79
Instrument, flow	0.63	0.63	0.00	0.00	0.00	2.52
Instrument, general	0.00	0.00	0.00	0.63	0.00	3.14
Instrument, level	0.00	0.00	0.00	0.00	0.00	1.89
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	1.89
Instrument, temperature	0.00	1.26	0.00	0.63	0.00	5.03
Internal power supply	0.00	0.00	0.00	0.00	0.00	1.89
Monitoring	0.00	0.00	0.00	0.00	0.00	0.94
Other	3.14	0.00	0.00	0.63	1.26	5.03
Piping	0.00	0.00	0.00	0.63	0.00	1.26
Subunit	0.00	0.00	0.00	0.00	0.63	0.63
Support	0.00	0.00	0.00	0.63	0.00	0.63
Tube coil	0.00	0.00	0.00	0.00	0.00	0.63
Unknown	1.89	0.00	0.63	1.26	0.00	8.18
Valves	2.52	0.00	0.00	1.26	0.00	5.03
Total	8.81	1.89	0.63	10.69	1.89	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heaters and boilers

	AIR	ELP	ELU	IHT	INL	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	1.26	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	5.66	0.00	0.00
Control failure	1.26	0.00	0.00	1.26	0.00	0.00
Corrosion	0.63	0.63	0.00	2.52	0.00	0.00
Deformation	0.00	0.00	0.00	0.63	0.00	0.00
Electrical failure - general	1.89	0.00	0.00	1.89	0.00	0.63
Faulty signal/indication/alarm	2.52	0.00	0.00	0.63	0.00	0.00
Instrument failure - general	2.52	0.00	0.63	33.96	0.00	0.63
Leakage	0.00	0.00	1.26	0.00	0.00	0.00
Looseness	0.00	0.63	0.00	0.63	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.63	0.00
Mechanical Failure - general	0.00	0.00	0.00	4.40	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.63	0.00	0.00
No power/ voltage	1.26	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	2.52	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	1.26	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.26	0.00	0.00	0.63	0.00	0.00
Short circuiting	0.63	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.63	0.00	0.00
Unknown	0.00	0.00	0.00	0.63	0.00	0.00
Total	14.47	1.26	1.89	56.60	0.63	1.26

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Heaters and boilers

	OTH	PDE	PLU	SER	STD	Sum
Blockage/plugged	0.63	0.00	0.00	0.63	0.00	1.26
Breakage	1.26	0.00	0.00	0.00	0.00	2.52
Cavitation	0.00	0.00	0.00	0.63	0.63	1.26
Clearance/ alignment failure	0.00	0.00	0.00	0.63	0.00	0.63
Contamination	0.00	0.00	0.00	0.00	0.00	5.66
Control failure	0.00	0.00	0.63	0.00	0.00	3.14
Corrosion	0.63	0.00	0.00	1.26	0.00	5.66
Deformation	0.00	0.00	0.00	0.63	0.00	1.26
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	4.40
Faulty signal/indication/alarm	0.00	0.63	0.00	0.00	0.00	3.77
Instrument failure - general	1.89	1.26	0.00	2.52	0.00	43.40
Leakage	0.63	0.00	0.00	0.00	0.00	1.89
Looseness	0.00	0.00	0.00	0.63	0.00	1.89
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.63
Mechanical Failure - general	0.63	0.00	0.00	0.63	1.26	6.92
Misc. external influences	0.63	0.00	0.00	0.00	0.00	0.63
Miscellaneous - general	0.63	0.00	0.00	0.00	0.00	1.26
No power/ voltage	0.00	0.00	0.00	0.00	0.00	1.26
No signal/indication/alarm	0.00	0.00	0.00	0.63	0.00	3.14
Open circuit	0.00	0.00	0.00	0.00	0.00	1.26
Other	0.63	0.00	0.00	0.00	0.00	0.63
Out of adjustment	0.00	0.00	0.00	2.52	0.00	4.40
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.63
Sticking	0.63	0.00	0.00	0.00	0.00	1.26
Unknown	0.63	0.00	0.00	0.00	0.00	1.26
Total	8.81	1.89	0.63	10.69	1.89	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item								
3.3.1		Mechanical Equipment Heaters and boilers Direct HC fired heater								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
2	1	**Calendar time** * 0.0491		**Operational time** † 0.0451						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**				**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**3***	**16.72**	**61.15**	**158.08**	**61.15**	**61.15**	**23.5**	**19.0**	**27.0**	**35.0**
		3†	**18.19**	**66.54**	**172.00**	**66.54**	**66.54**				
Overheating		1*	1.02	20.38	96.73	20.38	20.38	37.5	35.0	35.0	35.0
		1†	1.11	22.18	105.24	22.18	22.18				
Structural deficiency		2*	7.24	40.77	128.32	40.77	40.77	9.5	19.0	19.0	19.0
		2†	7.87	44.36	139.62	44.36	44.36				
Degraded		**3***	**16.72**	**61.15**	**158.08**	**61.15**	**61.15**	**220.2**	**86.0**	**440.3**	**813.0**
		3†	**18.19**	**66.54**	**172.00**	**66.54**	**66.54**				
Insufficient heat transfer		3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
		3†	18.19	66.54	172.00	66.54	66.54				
Incipient		**13***	**156.72**	**265.00**	**421.27**	**265.00**	**265.00**	**9.5**	**2.0**	**19.1**	**113.0**
		13†	**170.51**	**288.33**	**458.35**	**288.33**	**288.33**				
Abnormal instrument reading		7*	66.96	142.69	268.06	142.69	142.69	6.5	2.0	13.0	44.0
		7†	72.86	155.25	291.65	155.25	155.25				
External leakage - Utility medium		1*	1.02	20.38	96.73	20.38	20.38	4.5	9.0	9.0	9.0
		1†	1.11	22.18	105.24	22.18	22.18				
Minor in-service problems		2*	7.24	40.77	128.32	40.77	40.77	32.3	16.0	64.5	113.0
		2†	7.87	44.36	139.62	44.36	44.36				
Other		3*	16.72	61.15	158.08	61.15	61.15	2.2	4.0	4.3	5.0
		3†	18.19	66.54	172.00	66.54	66.54				
All modes		**19***	**253.60**	**387.31**	**568.28**	**387.31**	**387.31**	**48.4**	**2.0**	**94.4**	**813.0**
		19†	**275.92**	**421.40**	**618.29**	**421.40**	**421.40**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heaters and boilers - Direct HC fired heater

	AIR	ELP	ELU	IHT	INL	OHE
Body/shell	0.00	0.00	0.00	0.00	0.00	0.00
Burner(s)	0.00	0.00	0.00	10.53	0.00	0.00
Cabling & junction boxes	21.05	0.00	0.00	0.00	0.00	0.00
Instrument, general	5.26	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	5.26
Internal power supply	5.26	0.00	0.00	0.00	0.00	0.00
Monitoring	5.26	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Valves	0.00	0.00	5.26	5.26	0.00	0.00
Total	36.84	0.00	5.26	15.79	0.00	5.26

Maintainable item versus failure mode, continued
Item: Heaters and boilers - Direct HC fired heater

	OTH	PDE	PLU	SER	STD	Sum
Body/shell	0.00	0.00	0.00	5.26	0.00	5.26
Burner(s)	0.00	0.00	0.00	0.00	0.00	10.53
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	21.05
Instrument, general	0.00	0.00	0.00	0.00	0.00	5.26
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	5.26
Internal power supply	0.00	0.00	0.00	0.00	0.00	5.26
Monitoring	0.00	0.00	0.00	0.00	0.00	5.26
Other	5.26	0.00	0.00	0.00	10.53	15.79
Piping	0.00	0.00	0.00	5.26	0.00	5.26
Unknown	10.53	0.00	0.00	0.00	0.00	10.53
Valves	0.00	0.00	0.00	0.00	0.00	10.53
Total	15.79	0.00	0.00	10.53	10.53	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heaters and boilers - Direct HC fired heater

	AIR	ELP	ELU	IHT	INL	OHE
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	5.26	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	15.79	0.00	0.00	5.26	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	5.26	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	5.26
Leakage	0.00	0.00	5.26	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.26	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00
No power/ voltage	10.53	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	5.26	0.00	0.00	0.00	0.00	0.00
Total	36.84	0.00	5.26	15.79	0.00	5.26

Failure descriptior versus failure mode, continued
Item: Heaters and boilers - Direct HC fired heater

	OTH	PDE	PLU	SER	STD	Sum
Cavitation	0.00	0.00	0.00	5.26	0.00	5.26
Corrosion	0.00	0.00	0.00	0.00	0.00	5.26
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	21.05
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	5.26
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	5.26
Leakage	5.26	0.00	0.00	0.00	0.00	10.53
Mechanical Failure - general	0.00	0.00	0.00	0.00	10.53	15.79
Misc. external influences	5.26	0.00	0.00	0.00	0.00	5.26
Miscellaneous - general	5.26	0.00	0.00	0.00	0.00	5.26
No power/ voltage	0.00	0.00	0.00	0.00	0.00	10.53
No signal/indication/alarm	0.00	0.00	0.00	5.26	0.00	10.53
Total	15.79	0.00	0.00	10.53	10.53	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.3.1.1	Mechanical Equipment Heaters and boilers Direct HC fired heater Heating medium

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0491	0.0451	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**16.72**	**61.15**	**158.08**	**61.15**	**61.15**	**23.5**	**19.0**	**27.0**	**35.0**
	3†	**18.19**	**66.54**	**172.00**	**66.54**	**66.54**				
Overheating	1*	1.02	20.38	96.73	20.38	20.38	37.5	35.0	35.0	35.0
	1†	1.11	22.18	105.24	22.18	22.18				
Structural deficiency	2*	7.24	40.77	128.32	40.77	40.77	9.5	19.0	19.0	19.0
	2†	7.87	44.36	139.62	44.36	44.36				
Degraded	**3***	**16.72**	**61.15**	**158.08**	**61.15**	**61.15**	**220.2**	**86.0**	**440.3**	**813.0**
	3†	**18.19**	**66.54**	**172.00**	**66.54**	**66.54**				
Insufficient heat transfer	3*	16.72	61.15	158.08	61.15	61.15	220.2	86.0	440.3	813.0
	3†	18.19	66.54	172.00	66.54	66.54				
Incipient	**13***	**156.72**	**265.00**	**421.27**	**265.00**	**265.00**	**9.5**	**2.0**	**19.1**	**113.0**
	13†	**170.51**	**288.33**	**458.35**	**288.33**	**288.33**				
Abnormal instrument reading	7*	66.96	142.69	268.06	142.69	142.69	6.5	2.0	13.0	44.0
	7†	72.86	155.25	291.65	155.25	155.25				
External leakage - Utility medium	1*	1.02	20.38	96.73	20.38	20.38	4.5	9.0	9.0	9.0
	1†	1.11	22.18	105.24	22.18	22.18				
Minor in-service problems	2*	7.24	40.77	128.32	40.77	40.77	32.3	16.0	64.5	113.0
	2†	7.87	44.36	139.62	44.36	44.36				
Other	3*	16.72	61.15	158.08	61.15	61.15	2.2	4.0	4.3	5.0
	3†	18.19	66.54	172.00	66.54	66.54				
All modes	**19***	**253.60**	**387.31**	**568.28**	**387.31**	**387.31**	**48.4**	**2.0**	**94.4**	**813.0**
	19†	**275.92**	**421.40**	**618.29**	**421.40**	**421.40**				

Comments

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Taxonomy no	Item
3.3.2	Mechanical Equipment Heaters and boilers Electric heater/boiler

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0540	0.0534	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.33**	**16.81**	**52.23**	**18.50**	**18.50**	-	-	-	-
	1†	**0.33**	**17.00**	**52.83**	**18.72**	**18.72**				
Internal leakage	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72				
Incipient	**2***	**0.76**	**32.09**	**98.62**	**34.56**	**37.00**	**2.5**	**4.0**	**5.0**	**6.0**
	2†	**0.87**	**32.51**	**99.33**	**34.56**	**37.44**				
Minor in-service problems	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44				
Unknown	**1***	**0.13**	**31.80**	**120.37**	**44.39**	**18.50**	-	**12.0**	**12.0**	**12.0**
	1†	**0.13**	**33.50**	**127.94**	**47.14**	**18.72**				
Abnormal instrument reading	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72				
All modes	**4***	**25.42**	**74.21**	**143.66**	**37.00**	**74.01**	**2.5**	**4.0**	**7.3**	**12.0**
	4†	**25.95**	**75.35**	**145.59**	**37.44**	**74.88**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heaters and boilers - Electric heater/boiler

	AIR	ELP	ELU	IHT	INL	OHE
Instrument, pressure	25.00	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	0.00
Support	0.00	0.00	0.00	0.00	0.00	0.00
Tube coil	0.00	0.00	0.00	0.00	25.00	0.00
Total	25.00	0.00	0.00	0.00	25.00	0.00

Maintainable item versus failure mode, continued
Item: Heaters and boilers - Electric heater/boiler

	OTH	PDE	PLU	SER	STD	Sum
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	25.00
Instrument, temperature	0.00	0.00	0.00	25.00	0.00	25.00
Support	0.00	0.00	0.00	25.00	0.00	25.00
Tube coil	0.00	0.00	0.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	50.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Heaters and boilers - Electric heater/boiler

	AIR	ELP	ELU	IHT	INL	OHE
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	25.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	25.00	0.00
Total	25.00	0.00	0.00	0.00	25.00	0.00

Failure descriptior versus failure mode, continued
Item: Heaters and boilers - Electric heater/boiler

	OTH	PDE	PLU	SER	STD	Sum
Corrosion	0.00	0.00	0.00	25.00	0.00	25.00
Deformation	0.00	0.00	0.00	25.00	0.00	25.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	25.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	50.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.3.2.1	Mechanical Equipment Heaters and boilers Electric heater/boiler Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0540	0.0534	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.33**	**16.81**	**52.23**	**18.50**	**18.50**	-	-	-	-
	1†	**0.33**	**17.00**	**52.83**	**18.72**	**18.72**				
Internal leakage	1*	0.33	16.81	52.23	18.50	18.50	-	-	-	-
	1†	0.33	17.00	52.83	18.72	18.72				
Incipient	**2***	**0.76**	**32.09**	**98.62**	**34.56**	**37.00**	**2.5**	**4.0**	**5.0**	**6.0**
	2†	**0.87**	**32.51**	**99.33**	**34.56**	**37.44**				
Minor in-service problems	2*	0.76	32.09	98.62	34.56	37.00	2.5	4.0	5.0	6.0
	2†	0.87	32.51	99.33	34.56	37.44				
Unknown	**1***	**0.13**	**31.80**	**120.37**	**44.39**	**18.50**	-	**12.0**	**12.0**	**12.0**
	1†	**0.13**	**33.50**	**127.94**	**47.14**	**18.72**				
Abnormal instrument reading	1*	0.13	31.80	120.37	44.39	18.50	-	12.0	12.0	12.0
	1†	0.13	33.50	127.94	47.14	18.72				
All modes	**4***	**25.42**	**74.21**	**143.66**	**37.00**	**74.01**	**2.5**	**4.0**	**7.3**	**12.0**
	4†	**25.95**	**75.35**	**145.59**	**37.44**	**74.88**				

Comments

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Taxonomy no	Item
3.3.3	Mechanical Equipment Heaters and boilers HC fired boiler

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0365	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**16.64**	**60.89**	**157.39**	**60.89**	**60.89**	**2.8**	**1.0**	**2.8**	**4.0**
	3†	**22.46**	**82.18**	**212.44**	**82.18**	**82.18**				
Insufficient heat transfer	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0
	3†	22.46	82.18	212.44	82.18	82.18				
Degraded	**86***	**1447.77**	**1745.41**	**2088.20**	**1745.41**	**1745.41**	**3.2**	**0.5**	**3.2**	**16.0**
	86†	**1954.16**	**2355.91**	**2818.59**	**2355.91**	**2355.91**				
External leakage - Utility medium	1*	1.01	20.30	96.30	20.30	20.30	2.0	2.0	2.0	2.0
	1†	1.37	27.39	129.99	27.39	27.39				
Insufficient heat transfer	84*	1410.81	1704.82	2044.01	1704.82	1704.82	3.2	0.5	3.2	16.0
	84†	1904.26	2301.12	2758.94	2301.12	2301.12				
Plugged/Choked	1*	1.01	20.30	96.30	20.30	20.30	8.0	8.0	8.0	8.0
	1†	1.37	27.39	129.99	27.39	27.39				
Incipient	**29***	**421.03**	**588.57**	**802.48**	**588.57**	**588.57**	**2.9**	**0.5**	**2.9**	**11.0**
	29†	**568.30**	**794.43**	**1083.17**	**794.43**	**794.43**				
Abnormal instrument reading	8*	80.78	162.36	292.97	162.36	162.36	1.6	0.5	1.6	3.0
	8†	109.03	219.15	395.44	219.15	219.15				
External leakage - Process medium	2*	7.20	40.59	127.76	40.59	40.59	2.5	2.0	2.5	3.0
	2†	9.72	54.79	172.45	54.79	54.79				
Minor in-service problems	13*	156.03	263.84	419.42	263.84	263.84	4.0	1.5	4.0	11.0
	13†	210.61	356.13	566.13	356.13	356.13				
Other	6*	53.07	121.77	240.30	121.77	121.77	2.3	1.0	2.3	7.0
	6†	71.64	164.37	324.35	164.37	164.37				
All modes	**118***	**2044.11**	**2394.87**	**2790.52**	**2394.87**	**2394.87**	**3.1**	**0.5**	**3.1**	**16.0**
	118†	**2759.08**	**3232.52**	**3766.56**	**3232.52**	**3232.52**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heaters and boilers - HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Actuating device	0.00	0.00	0.00	0.85	0.00	0.00
Burner(s)	0.85	0.85	0.85	6.78	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	8.90	0.00	0.00
Control unit	0.00	0.00	0.00	1.27	0.00	0.00
Instrument, flame	0.00	0.00	0.00	47.88	0.00	0.00
Instrument, flow	0.00	0.85	0.00	0.00	0.00	0.00
Instrument, general	1.69	0.00	0.00	0.85	0.00	0.00
Instrument, pressure	1.69	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	1.69	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	1.69	0.00	0.00
Monitoring	0.00	0.00	0.00	0.42	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.85	0.00	0.00	5.08	0.00	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00
Total	6.78	1.69	0.85	73.73	0.00	0.00

Maintainable item versus failure mode, continued
Item: Heaters and boilers - HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.85
Burner(s)	0.85	0.00	0.00	2.54	0.00	12.71
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	8.90
Control unit	0.00	0.00	0.00	1.69	0.00	2.97
Instrument, flame	0.00	0.00	0.00	1.69	0.00	49.58
Instrument, flow	0.00	0.00	0.00	0.00	0.00	0.85
Instrument, general	0.00	0.00	0.00	0.85	0.00	3.39
Instrument, pressure	0.00	0.00	0.00	0.00	0.00	1.69
Instrument, temperature	0.00	0.00	0.00	0.00	0.00	1.69
Internal power supply	0.00	0.00	0.00	0.00	0.00	1.69
Monitoring	0.00	0.00	0.00	0.00	0.00	0.42
Other	0.00	0.00	0.00	0.85	0.00	0.85
Unknown	0.85	0.00	0.85	1.69	0.00	9.32
Valves	3.39	0.00	0.00	1.69	0.00	5.08
Total	5.08	0.00	0.85	11.02	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heaters and boilers - HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	1.69	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	0.00	0.00	0.00	7.63	0.00	0.00
Control failure	0.85	0.00	0.00	1.69	0.00	0.00
Corrosion	0.00	0.85	0.00	3.39	0.00	0.00
Deformation	0.00	0.00	0.00	0.85	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	1.69	0.00	0.00
Faulty signal/indication/alarm	1.69	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.69	0.00	0.85	45.76	0.00	0.00
Looseness	0.00	0.85	0.00	0.85	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.08	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.85	0.00	0.00
No signal/indication/alarm	0.85	0.00	0.00	0.00	0.00	0.00
Open circuit	0.00	0.00	0.00	1.69	0.00	0.00
Out of adjustment	1.69	0.00	0.00	0.85	0.00	0.00
Sticking	0.00	0.00	0.00	0.85	0.00	0.00
Unknown	0.00	0.00	0.00	0.85	0.00	0.00
Total	6.78	1.69	0.85	73.73	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Heaters and boilers - HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Blockage/plugged	0.85	0.00	0.00	0.85	0.00	1.69
Breakage	0.00	0.00	0.00	0.00	0.00	1.69
Clearance/ alignment failure	0.00	0.00	0.00	0.85	0.00	0.85
Contamination	0.00	0.00	0.00	0.00	0.00	7.63
Control failure	0.00	0.00	0.85	0.00	0.00	3.39
Corrosion	0.00	0.00	0.00	0.85	0.00	5.08
Deformation	0.00	0.00	0.00	0.00	0.00	0.85
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	1.69
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	1.69
Instrument failure - general	2.54	0.00	0.00	3.39	0.00	54.24
Looseness	0.00	0.00	0.00	0.85	0.00	2.54
Mechanical Failure - general	0.85	0.00	0.00	0.85	0.00	6.78
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.85
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.85
Open circuit	0.00	0.00	0.00	0.00	0.00	1.69
Out of adjustment	0.00	0.00	0.00	3.39	0.00	5.93
Sticking	0.85	0.00	0.00	0.00	0.00	1.69
Unknown	0.00	0.00	0.00	0.00	0.00	0.85
Total	5.08	0.00	0.85	11.02	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.3.3.1	Mechanical Equipment Heaters and boilers HC fired boiler Oil processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0365	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**16.64**	**60.89**	**157.39**	**60.89**	**60.89**	**2.8**	**1.0**	**2.8**	**4.0**
	3†	**22.46**	**82.18**	**212.44**	**82.18**	**82.18**				
Insufficient heat transfer	3*	16.64	60.89	157.39	60.89	60.89	2.8	1.0	2.8	4.0
	3†	22.46	82.18	212.44	82.18	82.18				
Degraded	**86***	**1447.77**	**1745.41**	**2088.20**	**1745.41**	**1745.41**	**3.2**	**0.5**	**3.2**	**16.0**
	86†	**1954.16**	**2355.91**	**2818.59**	**2355.91**	**2355.91**				
External leakage - Utility medium	1*	1.01	20.30	96.30	20.30	20.30	2.0	2.0	2.0	2.0
	1†	1.37	27.39	129.99	27.39	27.39				
Insufficient heat transfer	84*	1410.81	1704.82	2044.01	1704.82	1704.82	3.2	0.5	3.2	16.0
	84†	1904.26	2301.12	2758.94	2301.12	2301.12				
Plugged/Choked	1*	1.01	20.30	96.30	20.30	20.30	8.0	8.0	8.0	8.0
	1†	1.37	27.39	129.99	27.39	27.39				
Incipient	**29***	**421.03**	**588.57**	**802.48**	**588.57**	**588.57**	**2.9**	**0.5**	**2.9**	**11.0**
	29†	**568.30**	**794.43**	**1083.17**	**794.43**	**794.43**				
Abnormal instrument reading	8*	80.78	162.36	292.97	162.36	162.36	1.6	0.5	1.6	3.0
	8†	109.03	219.15	395.44	219.15	219.15				
External leakage - Process medium	2*	7.20	40.59	127.76	40.59	40.59	2.5	2.0	2.5	3.0
	2†	9.72	54.79	172.45	54.79	54.79				
Minor in-service problems	13*	156.03	263.84	419.42	263.84	263.84	4.0	1.5	4.0	11.0
	13†	210.61	356.13	566.13	356.13	356.13				
Other	6*	53.07	121.77	240.30	121.77	121.77	2.3	1.0	2.3	7.0
	6†	71.64	164.37	324.35	164.37	164.37				
All modes	**118***	**2044.11**	**2394.87**	**2790.52**	**2394.87**	**2394.87**	**3.1**	**0.5**	**3.1**	**16.0**
	118†	**2759.08**	**3232.52**	**3766.56**	**3232.52**	**3232.52**				

Comments

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Taxonomy no	Item
3.3.4	Mechanical Equipment Heaters and boilers Non-HC fired boiler

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.0981	0.0912	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**28.70**	**68.29**	**121.58**	**28.83**	**71.35**	**16.1**	**13.0**	**29.4**	**41.0**
	7†	**28.86**	**73.14**	**133.84**	**32.67**	**76.79**				
Abnormal instrument reading	4*	11.01	37.06	75.65	20.38	40.77	12.4	13.0	24.8	41.0
	4†	11.62	39.86	81.88	22.18	43.88				
Parameter deviation	2*	0.38	17.67	54.56	19.22	20.38	20.5	41.0	41.0	41.0
	2†	0.37	19.01	59.03	20.91	21.94				
Structural deficiency	1*	0.07	16.99	63.79	23.54	10.19	22.5	25.0	25.0	25.0
	1†	0.08	17.68	65.75	24.27	10.97				
Degraded	**2***	**2.58**	**23.10**	**60.83**	**19.22**	**20.38**	**102.5**	**19.0**	**205.0**	**391.0**
	2†	**3.09**	**24.49**	**62.87**	**19.60**	**21.94**				
External leakage - Utility medium	1*	0.07	16.99	63.79	23.54	10.19	195.5	391.0	391.0	391.0
	1†	0.08	17.68	65.75	24.27	10.97				
Parameter deviation	1*	0.18	9.27	28.78	10.19	10.19	9.5	19.0	19.0	19.0
	1†	0.20	9.98	30.98	10.97	10.97				
Incipient	**9***	**50.44**	**94.51**	**149.76**	**30.58**	**91.73**	**11.1**	**2.0**	**19.6**	**57.0**
	9†	**53.93**	**101.33**	**160.81**	**32.91**	**98.73**				
Abnormal instrument reading	3*	0.23	57.76	221.36	81.54	30.58	15.5	2.0	24.3	44.0
	3†	0.24	60.19	230.13	84.79	32.91				
Other	5*	8.46	44.17	102.92	30.39	50.96	3.4	6.0	6.8	7.0
	5†	8.04	47.25	113.42	34.08	54.85				
Overheating	1*	0.18	9.27	28.78	10.19	10.19	28.5	57.0	57.0	57.0
	1†	0.20	9.98	30.98	10.97	10.97				
All modes	**18***	**120.36**	**185.32**	**261.68**	**43.24**	**183.46**	**23.9**	**2.0**	**45.5**	**391.0**
	18†	**128.93**	**198.83**	**281.04**	**46.54**	**197.46**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Heaters and boilers - Non-HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	5.56
Control unit	5.56	0.00	0.00	0.00	0.00	0.00
Instrument, flow	5.56	0.00	0.00	0.00	0.00	0.00
Instrument, level	16.67	0.00	0.00	0.00	0.00	0.00
Instrument, temperature	11.11	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Piping	0.00	0.00	5.56	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00
Total	38.89	0.00	5.56	0.00	0.00	5.56

Maintainable item versus failure mode, continued
Item: Heaters and boilers - Non-HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	5.56
Control unit	0.00	0.00	0.00	0.00	0.00	5.56
Instrument, flow	5.56	5.56	0.00	0.00	0.00	16.67
Instrument, level	0.00	0.00	0.00	0.00	0.00	16.67
Instrument, temperature	0.00	11.11	0.00	0.00	0.00	22.22
Other	22.22	0.00	0.00	0.00	0.00	22.22
Piping	0.00	0.00	0.00	0.00	0.00	5.56
Subunit	0.00	0.00	0.00	0.00	5.56	5.56
Total	27.78	16.67	0.00	0.00	5.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Heaters and boilers - Non-HC fired boiler

	AIR	ELP	ELU	IHT	INL	OHE
Breakage	0.00	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	5.56	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	5.56
Faulty signal/indication/alarm	11.11	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	5.56	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	5.56	0.00	0.00	0.00
No signal/indication/alarm	11.11	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00
Short circuiting	5.56	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00
Total	38.89	0.00	5.56	0.00	0.00	5.56

Failure descriptior versus failure mode, continued
Item: Heaters and boilers - Non-HC fired boiler

	OTH	PDE	PLU	SER	STD	Sum
Breakage	11.11	0.00	0.00	0.00	0.00	11.11
Cavitation	0.00	0.00	0.00	0.00	5.56	5.56
Control failure	0.00	0.00	0.00	0.00	0.00	5.56
Corrosion	5.56	0.00	0.00	0.00	0.00	5.56
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	5.56
Faulty signal/indication/alarm	0.00	5.56	0.00	0.00	0.00	16.67
Instrument failure - general	0.00	11.11	0.00	0.00	0.00	16.67
Leakage	0.00	0.00	0.00	0.00	0.00	5.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	11.11
Other	5.56	0.00	0.00	0.00	0.00	5.56
Short circuiting	0.00	0.00	0.00	0.00	0.00	5.56
Unknown	5.56	0.00	0.00	0.00	0.00	5.56
Total	27.78	16.67	0.00	0.00	5.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
3.3.4.1	Mechanical Equipment Heaters and boilers Non-HC fired boiler Gas treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0245	0.0235	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**2.04**	**40.77**	**193.45**	**40.77**	**40.77**	**22.5**	**25.0**	**25.0**	**25.0**
	1†	**2.13**	**42.51**	**201.71**	**42.51**	**42.51**				
Structural deficiency	1*	2.04	40.77	193.45	40.77	40.77	22.5	25.0	25.0	25.0
	1†	2.13	42.51	201.71	42.51	42.51				
Degraded	**1***	**2.04**	**40.77**	**193.45**	**40.77**	**40.77**	**195.5**	**391.0**	**391.0**	**391.0**
	1†	**2.13**	**42.51**	**201.71**	**42.51**	**42.51**				
External leakage - Utility medium	1*	2.04	40.77	193.45	40.77	40.77	195.5	391.0	391.0	391.0
	1†	2.13	42.51	201.71	42.51	42.51				
Incipient	**3***	**33.43**	**122.31**	**316.17**	**122.31**	**122.31**	**15.5**	**2.0**	**24.3**	**44.0**
	3†	**34.86**	**127.53**	**329.66**	**127.53**	**127.53**				
Abnormal instrument reading	3*	33.43	122.31	316.17	122.31	122.31	15.5	2.0	24.3	44.0
	3†	34.86	127.53	329.66	127.53	127.53				
All modes	**5***	**80.32**	**203.85**	**428.69**	**203.85**	**203.85**	**52.9**	**2.0**	**97.8**	**391.0**
	5†	**83.74**	**212.55**	**446.99**	**212.55**	**212.55**				

Comments

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Taxonomy no	Item
3.3.4.2	Mechanical Equipment Heaters and boilers Non-HC fired boiler Heating medium

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0736	0.0676	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**35.54**	**81.54**	**160.90**	**81.54**	**81.54**	**15.1**	**13.0**	**30.2**	**41.0**
	6†	**38.67**	**88.72**	**175.07**	**88.72**	**88.72**				
Abnormal instrument reading	4*	18.55	54.36	124.42	54.36	54.36	12.4	13.0	24.8	41.0
	4†	20.18	59.14	135.36	59.14	59.14				
Parameter deviation	2*	4.82	27.18	85.55	27.18	27.18	20.5	41.0	41.0	41.0
	2†	5.25	29.57	93.08	29.57	29.57				
Degraded	**1***	**0.68**	**13.59**	**64.48**	**13.59**	**13.59**	**9.5**	**19.0**	**19.0**	**19.0**
	1†	**0.74**	**14.79**	**70.16**	**14.79**	**14.79**				
Parameter deviation	1*	0.68	13.59	64.48	13.59	13.59	9.5	19.0	19.0	19.0
	1†	0.74	14.79	70.16	14.79	14.79				
Incipient	**6***	**35.54**	**81.54**	**160.90**	**81.54**	**81.54**	**8.4**	**6.0**	**16.8**	**57.0**
	6†	**38.67**	**88.72**	**175.07**	**88.72**	**88.72**				
Other	5*	26.77	67.95	142.90	67.95	67.95	3.4	6.0	6.8	7.0
	5†	29.13	73.93	155.47	73.93	73.93				
Overheating	1*	0.68	13.59	64.48	13.59	13.59	28.5	57.0	57.0	57.0
	1†	0.74	14.79	70.16	14.79	14.79				
All modes	**13***	**104.48**	**176.67**	**280.85**	**176.67**	**176.67**	**11.8**	**6.0**	**23.7**	**57.0**
	13†	**113.67**	**192.22**	**305.56**	**192.22**	**192.22**				

Comments

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CONTROL AND SAFETY EQUIPMENT

Fire and Gas Detectors

Inventory description

The boundary definition is shown in Figure 20 and corresponding subdivision in Maintainable Items in Table 15.

It has been difficult to obtain a consistent system breakdown covering all relevant technical configurations of F&G systems. Thus, the proposed breakdown is a trade-off between several factors.

The catalytic gas detector contains a sensor part and a separate electronic unit (interface unit) which combined make up a Wheatstone bridge circuit. The sensor contains element(s) which are sensitive to hydrocarbon gas (catalytic oxidation of the element). The change in electrical resistance produces an out-of-balance current in the Wheatstone bridge circuit. The interface unit may be located in control rooms or in the field (transducers). Some vendors of logic control systems have designed separate input cards for gas sensors. Thus, they do not use the interface units provided by the vendor of the gas sensor. In the proposed system breakdown, these *dedicated* gas input cards are considered to be part of the gas detector (interface unit), and not part of the Control Logic Units (CLUs).

Most conventional fire sensors gives a standard output signal which is compatible to a standard input modules of logic control systems. Thus, for these fire detectors, there are no separate interface units. For F&G Detectors there is no subdivision on subunit level, only on Maintainable Item level. One reason for this is that it is common to replace both elements on the sensor part and the interface part during repair.

In the future there will be more use of addressable fire detection systems. In these systems several individual detectors are connected to a dedicated address/interface unit.

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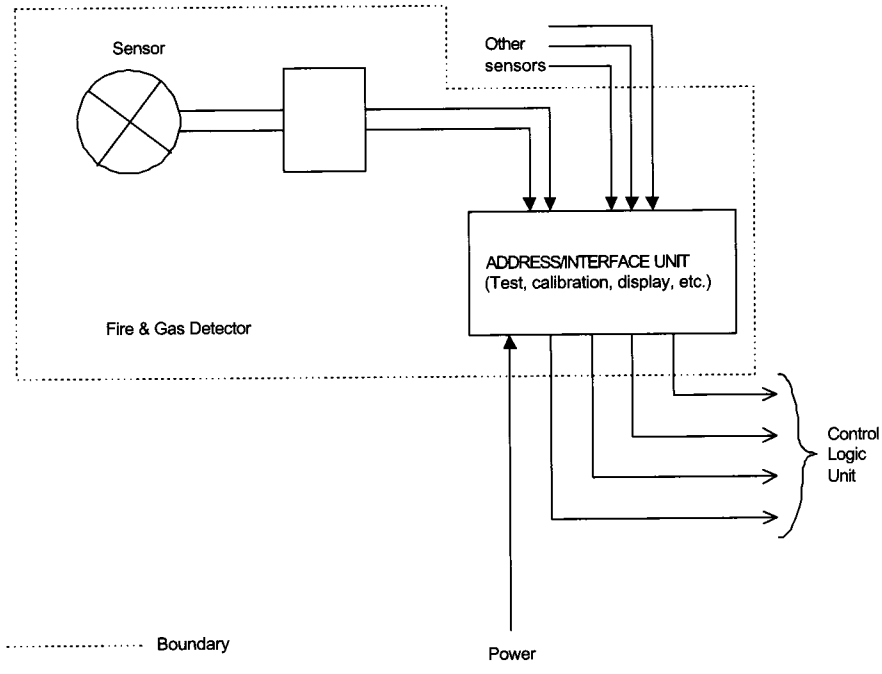

Figure 20 Fire & Gas Detectors, Boundary Definition

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Table 15 F&G Detectors, Subdivision in Maintainable Items

FIRE & GAS DETECTORS	
Sensor & Interface unit	Miscellaneous
• Mounting socket • Detector head • Cover • Control card • Display • Cabinet • Cabling	• Others

(For all subunits the MIs "Unknown" and "Subunit" are included.

List of failure modes

ERO Erratic output
FTF Fail to function on demand
HIO High output
HIU High output, unknown reading
LOO Low output
LOU Low output, unknown reading
SER Minor in-service problems
NOO No output
OTH Other
SHH Spurious high level alarm signal
SLL Spurious low level alarm signal
SPO Spurious operation
UNK Unknown
VLO Very low output

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Taxonomy no	Item
4.1	Control and Safety Equipment Fire & Gas Detectors

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
858	18	28.5689	26.9668	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**47***	**0.00**	**0.97**	**5.39**	**2.76**	**1.65**	**2.8**	**0.5**	**4.4**	**41.0**
	47†	**0.00**	**1.10**	**6.26**	**3.35**	**1.74**				
Fail to function on demand	12*	0.00	0.19	1.01	0.66	0.42	3.8	1.0	4.3	10.0
	12†	0.00	0.21	1.11	0.85	0.44				
No output	5*	0.00	0.30	1.64	0.80	0.18	1.8	1.0	3.4	4.0
	5†	0.00	0.30	1.66	0.82	0.19				
Spurious high level alarm signal	9*	0.00	0.16	0.90	0.43	0.32	2.3	1.0	2.3	8.0
	9†	0.00	0.18	0.99	0.59	0.33				
Spurious low level alarm signal	5*	0.06	0.16	0.31	0.08	0.18	3.2	0.5	3.2	6.0
	5†	0.00	0.14	0.57	0.22	0.19				
Spurious operation	16*	0.00	0.38	2.02	0.93	0.56	2.8	2.0	6.4	41.0
	16†	0.00	0.43	2.37	1.13	0.59				
Degraded	**232***	**2.24**	**9.19**	**20.01**	**5.66**	**8.12**	**1.2**	**1.0**	**1.5**	**12.5**
	232†	**2.03**	**9.44**	**21.33**	**6.18**	**8.60**				
Erratic output	44*	0.00	1.32	5.18	1.93	1.54	2.5	1.0	1.9	11.0
	44†	0.00	1.43	6.00	2.30	1.63				
Fail to function on demand	6*	0.01	0.22	0.66	0.23	0.21	0.5	1.0	1.0	1.0
	6†	0.02	0.22	0.63	0.21	0.22				
High output	10*	0.00	0.36	1.84	0.80	0.35	1.9	2.0	2.2	4.0
	10†	0.00	0.38	1.96	0.86	0.37				
High output, unknown reading	22*	0.00	0.28	0.92	1.37	0.77	3.0	1.0	1.7	3.0
	22†	0.00	0.34	0.97	1.70	0.82				
Low output	4*	0.00	0.16	0.77	0.33	0.14	2.8	1.0	3.8	6.0
	4†	0.00	0.17	0.81	0.34	0.15				
Low output, unknown reading	1*	0.00	0.09	0.52	0.26	0.04	-	10.0	10.0	10.0
	1†	0.00	0.09	0.52	0.26	0.04				
Minor in-service problems	5*	0.06	0.16	0.31	0.08	0.18	2.5	2.0	4.5	12.5
	5†	0.00	0.14	0.57	0.22	0.19				
Other	23*	0.00	1.25	6.01	2.48	0.81	0.5	1.0	1.0	1.0
	23†	0.00	1.25	6.07	2.52	0.85				
Spurious low level alarm signal	1*	0.00	0.03	0.10	0.04	0.04	2.0	2.0	2.0	2.0
	1†	0.00	0.03	0.13	0.05	0.04				
Unknown	4*	0.00	0.10	0.40	0.15	0.14	5.0	2.0	5.3	12.0
	4†	0.02	0.13	0.33	0.10	0.15				
Very low output	112*	0.77	5.43	13.63	4.20	3.92	0.5	1.0	1.0	1.0
	112†	0.80	5.43	13.52	4.15	4.15				
Incipient	**76***	**0.00**	**4.29**	**23.67**	**11.92**	**2.66**	**1.9**	**1.0**	**2.6**	**6.0**
	76†	**0.00**	**4.33**	**23.95**	**12.20**	**2.82**				
Minor in-service problems	76*	0.00	4.29	23.67	11.92	2.66	1.9	1.0	2.6	6.0
	76†	0.00	4.33	23.95	12.20	2.82				
Unknown	**8***	**0.05**	**0.30**	**0.73**	**0.22**	**0.28**	**1.4**	**1.0**	**1.8**	**6.0**
	8†	**0.07**	**0.31**	**0.67**	**0.19**	**0.30**				

Comments

(cont.)

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Taxonomy no	Item
4.1	Control and Safety Equipment Fire & Gas Detectors

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
858	18	28.5689	26.9668	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	2*	0.00	0.06	0.29	0.12	0.07	4.0	2.0	4.0	6.0
	2†	0.00	0.06	0.30	0.12	0.07				
Very low output	6*	0.00	0.26	0.84	0.31	0.21	0.5	1.0	1.0	1.0
	6†	0.00	0.26	0.82	0.30	0.22				
All modes	**363***	**1.01**	**14.72**	**42.44**	**14.00**	**12.71**	**1.5**	**0.5**	**2.1**	**41.0**
	363†	**0.81**	**15.08**	**44.84**	**14.94**	**13.46**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Fire & Gas Detectors

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Control card	0.00	0.00	0.00	0.00	0.28	0.28	0.00
Detector head	12.12	4.55	2.48	5.79	0.83	0.00	0.83
Other	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.28	0.28	0.00	0.00	0.00
Unknown	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Total	12.12	4.96	2.75	6.06	1.10	0.28	1.38

Maintainable item versus failure mode, continued
Item: Fire & Gas Detectors

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	0.28	0.00	0.00	0.00	0.28	0.00	0.55
Cabling	0.00	3.03	0.00	0.00	0.00	0.00	0.00	3.58
Control card	0.00	0.00	0.00	0.00	0.55	0.00	0.00	1.10
Detector head	4.13	17.91	2.20	1.65	3.03	0.55	32.51	88.57
Other	1.38	0.00	0.00	0.00	0.83	0.00	0.00	2.34
Subunit	0.00	0.00	0.00	0.00	0.00	0.55	0.00	1.10
Unknown	0.83	1.10	0.28	0.00	0.00	0.28	0.00	2.75
Total	6.34	22.31	2.48	1.65	4.41	1.65	32.51	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Fire & Gas Detectors

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Clearance/ alignment failure	0.28	0.00	0.00	0.00	0.00	0.00	0.00
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.38	0.55	0.28	0.00	0.28	0.00	0.28
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	1.65	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	4.41	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	1.10	0.28	0.28	0.83	0.28	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Out of adjustment	4.41	0.83	2.20	5.79	0.00	0.00	0.00
Short circuiting	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vibration	1.65	0.55	0.00	0.00	0.00	0.00	0.00
Total	12.12	4.96	2.75	6.06	1.10	0.28	1.38

Failure descriptior versus failure mode, continued
Item: Fire & Gas Detectors

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Clearance/ alignment failure	0.00	1.10	0.00	0.00	0.00	0.00	0.00	1.38
Common mode failure	0.00	3.03	0.00	0.00	0.00	0.00	0.00	3.03
Contamination	0.00	0.55	0.28	0.28	0.83	0.00	0.00	4.68
Corrosion	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.28
External influence - general	4.96	0.00	0.00	0.00	0.83	0.00	0.00	7.44
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.55	0.00	0.00	4.96
Instrument failure - general	0.00	0.00	1.10	0.55	0.28	0.28	0.00	4.96
Leakage	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.28
Looseness	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
Misc. external influences	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
Miscellaneous - general	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.28
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Out of adjustment	1.38	17.36	1.10	0.55	0.55	0.83	32.51	67.49
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
Unknown	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.55
Vibration	0.00	0.00	0.00	0.00	0.55	0.00	0.00	2.75
Total	6.34	22.31	2.48	1.65	4.41	1.65	32.51	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.1.1	Control and Safety Equipment Fire & Gas Detectors Flame

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
27	1	1.6861	1.3608	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.03**	**0.59**	**2.81**	**0.59**	**0.59**	**-**	**4.0**	**4.0**	**4.0**
	1†	**0.04**	**0.73**	**3.49**	**0.73**	**0.73**				
Spurious operation	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0
	1†	0.04	0.73	3.49	0.73	0.73				
Degraded	**7***	**1.95**	**4.15**	**7.80**	**4.15**	**4.15**	**6.5**	**1.0**	**1.7**	**3.0**
	7†	**2.41**	**5.14**	**9.66**	**5.14**	**5.14**				
Erratic output	5*	1.17	2.97	6.24	2.97	2.97	6.5	1.0	1.6	3.0
	5†	1.45	3.67	7.73	3.67	3.67				
Unknown	2*	0.21	1.19	3.73	1.19	1.19	6.5	2.0	2.0	2.0
	2†	0.26	1.47	4.63	1.47	1.47				
Incipient	**1***	**0.03**	**0.59**	**2.81**	**0.59**	**0.59**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.04**	**0.73**	**3.49**	**0.73**	**0.73**				
Minor in-service problems	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0
	1†	0.04	0.73	3.49	0.73	0.73				
All modes	**9***	**2.78**	**5.34**	**9.31**	**5.34**	**5.34**	**5.7**	**1.0**	**1.9**	**4.0**
	9†	**3.45**	**6.61**	**11.54**	**6.61**	**6.61**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Fire & Gas Detectors - Flame

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Detector head	55.56	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.56	0.00	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Fire & Gas Detectors - Flame

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	11.11	0.00	0.00	0.00	0.00	0.00	11.11
Detector head	0.00	0.00	0.00	0.00	0.00	22.22	0.00	77.78
Other	0.00	0.00	0.00	0.00	11.11	0.00	0.00	11.11
Total	0.00	11.11	0.00	0.00	11.11	22.22	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Fire & Gas Detectors - Flame

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Contamination	22.22	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	33.33	0.00	0.00	0.00	0.00	0.00	0.00
Total	55.56	0.00	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Fire & Gas Detectors - Flame

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Contamination	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.22
Instrument failure - general	0.00	0.00	0.00	0.00	11.11	0.00	0.00	11.11
Leakage	0.00	11.11	0.00	0.00	0.00	0.00	0.00	11.11
Out of adjustment	0.00	0.00	0.00	0.00	0.00	22.22	0.00	55.56
Total	0.00	11.11	0.00	0.00	11.11	22.22	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.1.1.1	Control and Safety Equipment Fire & Gas Detectors Flame Infrared

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
27	1	1.6861	1.3608	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.03**	**0.59**	**2.81**	**0.59**	**0.59**	-	**4.0**	**4.0**	**4.0**
	1†	**0.04**	**0.73**	**3.49**	**0.73**	**0.73**				
Spurious operation	1*	0.03	0.59	2.81	0.59	0.59	-	4.0	4.0	4.0
	1†	0.04	0.73	3.49	0.73	0.73				
Degraded	**7***	**1.95**	**4.15**	**7.80**	**4.15**	**4.15**	**6.5**	**1.0**	**1.7**	**3.0**
	7†	**2.41**	**5.14**	**9.66**	**5.14**	**5.14**				
Erratic output	5*	1.17	2.97	6.24	2.97	2.97	6.5	1.0	1.6	3.0
	5†	1.45	3.67	7.73	3.67	3.67				
Unknown	2*	0.21	1.19	3.73	1.19	1.19	6.5	2.0	2.0	2.0
	2†	0.26	1.47	4.63	1.47	1.47				
Incipient	**1***	**0.03**	**0.59**	**2.81**	**0.59**	**0.59**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.04**	**0.73**	**3.49**	**0.73**	**0.73**				
Minor in-service problems	1*	0.03	0.59	2.81	0.59	0.59	1.0	1.0	1.0	1.0
	1†	0.04	0.73	3.49	0.73	0.73				
All modes	**9***	**2.78**	**5.34**	**9.31**	**5.34**	**5.34**	**5.7**	**1.0**	**1.9**	**4.0**
	9†	**3.45**	**6.61**	**11.54**	**6.61**	**6.61**				

Comments

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Taxonomy no	Item
4.1.2	Control and Safety Equipment Fire & Gas Detectors H2S gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
542	13	16.7692	16.7692	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**157***	**3.68**	**11.07**	**21.69**	**5.64**	**9.36**	**0.5**	**1.0**	**1.0**	**1.0**
	157†	**3.68**	**11.07**	**21.69**	**5.64**	**9.36**				
Erratic output	16*	0.02	1.38	4.36	1.57	0.95	0.5	1.0	1.0	1.0
	16†	0.02	1.38	4.36	1.57	0.95				
Fail to function on demand	6*	0.00	0.31	1.34	0.52	0.36	0.5	1.0	1.0	1.0
	6†	0.00	0.31	1.34	0.52	0.36				
Other	23*	0.00	1.76	7.85	3.11	1.37	0.5	1.0	1.0	1.0
	23†	0.00	1.76	7.85	3.11	1.37				
Very low output	112*	3.37	7.44	12.80	2.92	6.68	0.5	1.0	1.0	1.0
	112†	3.37	7.44	12.80	2.92	6.68				
Unknown	**6***	**0.08**	**0.37**	**0.82**	**0.23**	**0.36**	**0.5**	**1.0**	**1.0**	**1.0**
	6†	**0.08**	**0.37**	**0.82**	**0.23**	**0.36**				
Very low output	6*	0.08	0.37	0.82	0.23	0.36	0.5	1.0	1.0	1.0
	6†	0.08	0.37	0.82	0.23	0.36				
All modes	**163***	**3.82**	**11.46**	**22.42**	**5.83**	**9.72**	**0.5**	**1.0**	**1.0**	**1.0**
	163†	**3.82**	**11.46**	**22.42**	**5.83**	**9.72**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Fire & Gas Detectors - H2S gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Detector head	9.82	3.68	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	9.82	3.68	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Fire & Gas Detectors - H2S gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Detector head	9.20	0.00	0.00	0.00	0.00	0.00	72.39	95.09
Other	3.07	0.00	0.00	0.00	0.00	0.00	0.00	3.07
Unknown	1.84	0.00	0.00	0.00	0.00	0.00	0.00	1.84
Total	14.11	0.00	0.00	0.00	0.00	0.00	72.39	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Fire & Gas Detectors - H2S gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
External influence - general	0.00	3.07	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	9.82	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Total	9.82	3.68	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Fire & Gas Detectors - H2S gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
External influence - general	11.04	0.00	0.00	0.00	0.00	0.00	0.00	14.11
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.82
Out of adjustment	3.07	0.00	0.00	0.00	0.00	0.00	72.39	76.07
Total	14.11	0.00	0.00	0.00	0.00	0.00	72.39	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.1.2.1	Control and Safety Equipment Fire & Gas Detectors H2S gas H2S gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
542	13	16.7692	16.7692	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**157***	**3.68**	**11.07**	**21.69**	**5.64**	**9.36**	**0.5**	**1.0**	**1.0**	**1.0**
	157†	**3.68**	**11.07**	**21.69**	**5.64**	**9.36**				
Erratic output	16*	0.02	1.38	4.36	1.57	0.95	0.5	1.0	1.0	1.0
	16†	0.02	1.38	4.36	1.57	0.95				
Fail to function on demand	6*	0.00	0.31	1.34	0.52	0.36	0.5	1.0	1.0	1.0
	6†	0.00	0.31	1.34	0.52	0.36				
Other	23*	0.00	1.76	7.85	3.11	1.37	0.5	1.0	1.0	1.0
	23†	0.00	1.76	7.85	3.11	1.37				
Very low output	112*	3.37	7.44	12.80	2.92	6.68	0.5	1.0	1.0	1.0
	112†	3.37	7.44	12.80	2.92	6.68				
Unknown	**6***	**0.08**	**0.37**	**0.82**	**0.23**	**0.36**	**0.5**	**1.0**	**1.0**	**1.0**
	6†	**0.08**	**0.37**	**0.82**	**0.23**	**0.36**				
Very low output	6*	0.08	0.37	0.82	0.23	0.36	0.5	1.0	1.0	1.0
	6†	0.08	0.37	0.82	0.23	0.36				
All modes	**163***	**3.82**	**11.46**	**22.42**	**5.83**	**9.72**	**0.5**	**1.0**	**1.0**	**1.0**
	163†	**3.82**	**11.46**	**22.42**	**5.83**	**9.72**				

Comments

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Taxonomy no		Item									
4.1.3		Control and Safety Equipment Fire & Gas Detectors Heat									
Population	Installations	Aggregated time in service (10^6 hours)						No of demands			
23	1	Calendar time * 0.7231			Operational time † 0.7052						
Failure mode		No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes		0* 0†	0.00 0.00	0.66 0.68	2.54 2.60	0.93 0.96	0.00 0.00	-	-	-	-
Comments											

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Taxonomy no		Item
4.1.3.1		Control and Safety Equipment Fire & Gas Detectors Heat Rate compensated

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
23	1	0.7231	0.7052	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	0.34	1.30	0.48	0.00	-	-	-	-
	0†	0.00	0.35	1.33	0.49	0.00				

Comments

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Taxonomy no	Item
4.1.4	Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
163	4	6.1522	4.9737	

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**46***	**2.98**	**6.17**	**10.28**	**2.25**	**7.48**	**2.8**	**0.5**	**4.4**	**41.0**
	46†	**1.32**	**6.53**	**15.00**	**4.39**	**9.25**				
Fail to function on demand	12*	0.31	1.43	3.23	0.94	1.95	3.8	1.0	4.3	10.0
	12†	0.05	1.52	4.61	1.59	2.41				
No output	5*	0.00	1.36	5.92	2.30	0.81	1.8	1.0	3.4	4.0
	5†	0.00	1.40	5.86	2.24	1.01				
Spurious high level alarm signal	9*	0.59	1.27	2.16	0.49	1.46	2.3	1.0	2.3	8.0
	9†	0.26	1.35	3.16	0.93	1.81				
Spurious low level alarm signal	5*	0.06	0.62	1.70	0.55	0.81	3.2	0.5	3.2	6.0
	5†	0.04	0.74	2.20	0.74	1.01				
Spurious operation	15*	0.91	2.19	3.91	0.93	2.44	2.8	2.0	6.6	41.0
	15†	0.77	2.55	5.17	1.39	3.02				
Degraded	**68***	**1.03**	**7.11**	**17.74**	**5.46**	**11.05**	**2.9**	**1.0**	**2.7**	**12.5**
	68†	**0.25**	**8.00**	**24.29**	**8.38**	**13.67**				
Erratic output	23*	0.01	1.92	7.25	2.67	3.74	4.4	1.0	2.7	11.0
	23†	0.00	2.27	9.80	3.80	4.62				
High output	10*	0.16	1.79	4.98	1.62	1.63	1.9	2.0	2.2	4.0
	10†	0.41	2.03	4.65	1.36	2.01				
High output, unknown reading	22*	0.01	1.87	6.83	2.52	3.58	3.0	1.0	1.7	3.0
	22†	0.00	2.20	9.35	3.60	4.42				
Low output	4*	0.07	0.80	2.21	0.72	0.65	2.8	1.0	3.8	6.0
	4†	0.25	0.86	1.78	0.48	0.80				
Low output, unknown reading	1*	0.00	0.49	2.07	0.79	0.16	-	10.0	10.0	10.0
	1†	0.00	0.48	2.04	0.78	0.20				
Minor in-service problems	5*	0.06	0.62	1.70	0.55	0.81	2.5	2.0	4.5	12.5
	5†	0.04	0.74	2.20	0.74	1.01				
Spurious low level alarm signal	1*	0.00	0.14	0.45	0.16	0.16	2.0	2.0	2.0	2.0
	1†	0.00	0.17	0.56	0.20	0.20				
Unknown	2*	0.03	0.28	0.73	0.23	0.33	2.0	2.0	7.0	12.0
	2†	0.04	0.34	0.92	0.29	0.40				
Incipient	**64***	**0.00**	**18.45**	**85.53**	**34.54**	**10.40**	**1.2**	**1.0**	**2.1**	**4.0**
	64†	**0.00**	**18.66**	**86.10**	**34.64**	**12.87**				
Minor in-service problems	64*	0.00	18.45	85.53	34.54	10.40	1.2	1.0	2.1	4.0
	64†	0.00	18.66	86.10	34.64	12.87				
All modes	**178***	**0.57**	**29.16**	**90.58**	**32.09**	**28.93**	**2.1**	**0.5**	**3.0**	**41.0**
	178†	**1.82**	**31.51**	**92.96**	**30.90**	**35.79**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Fire & Gas Detectors - Hydrocarbon gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabinet	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Control card	0.00	0.00	0.00	0.00	0.56	0.56	0.00
Detector head	12.92	5.90	5.06	11.80	1.69	0.00	1.69
Other	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.56	0.56	0.00	0.00	0.00
Unknown	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Total	12.92	6.74	5.62	12.36	2.25	0.56	2.81

Maintainable item versus failure mode, continued
Item: Fire & Gas Detectors - Hydrocarbon gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabinet	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.56
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Control card	0.00	0.00	0.00	0.00	1.12	0.00	0.00	2.25
Detector head	0.00	36.52	4.49	3.37	6.18	0.00	0.00	89.61
Other	0.00	0.00	0.00	0.00	1.12	0.00	0.00	1.40
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12
Unknown	0.00	2.25	0.56	0.00	0.00	0.56	0.00	3.93
Total	0.00	38.76	5.06	3.37	8.43	1.12	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Fire & Gas Detectors - Hydrocarbon gas

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Clearance/ alignment failure	0.56	0.00	0.00	0.00	0.00	0.00	0.00
Contamination	1.69	1.12	0.56	0.00	0.56	0.00	0.56
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	2.25	0.56	0.56	1.69	0.56	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Misc. external influences	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	2.25
Out of adjustment	7.30	1.12	4.49	11.80	0.00	0.00	0.00
Short circuiting	0.00	0.56	0.00	0.00	0.00	0.00	0.00
Vibration	3.37	1.12	0.00	0.00	0.00	0.00	0.00
Total	12.92	6.74	5.62	12.36	2.25	0.56	2.81

Failure descriptior versus failure mode, continued
Item: Fire & Gas Detectors - Hydrocarbon gas

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Clearance/ alignment failure	0.00	2.25	0.00	0.00	0.00	0.00	0.00	2.81
Contamination	0.00	1.12	0.56	0.56	1.69	0.00	0.00	8.43
Corrosion	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.56
External influence - general	0.00	0.00	0.00	0.00	1.69	0.00	0.00	2.25
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	1.12	0.00	0.00	1.12
Instrument failure - general	0.00	0.00	2.25	1.12	0.00	0.56	0.00	9.55
Looseness	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
Misc. external influences	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
Miscellaneous - general	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.56
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25
Out of adjustment	0.00	35.39	2.25	1.12	1.12	0.56	0.00	65.17
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Vibration	0.00	0.00	0.00	0.00	1.12	0.00	0.00	5.62
Total	0.00	38.76	5.06	3.37	8.43	1.12	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.1.4.1	Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Catalytic

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
24	1	0.4205	0.4163	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.12**	**2.38**	**11.28**	**2.38**	**2.38**	-	**10.0**	**10.0**	**10.0**
	1†	**0.12**	**2.40**	**11.40**	**2.40**	**2.40**				
Low output, unknown reading	1*	0.12	2.38	11.28	2.38	2.38	-	10.0	10.0	10.0
	1†	0.12	2.40	11.40	2.40	2.40				
All modes	**1***	**0.12**	**2.38**	**11.28**	**2.38**	**2.38**	-	**10.0**	**10.0**	**10.0**
	1†	**0.12**	**2.40**	**11.40**	**2.40**	**2.40**				

Comments

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Taxonomy no	Item
4.1.4.2	Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Infrared

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
137	3	5.6602	4.4982	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**43***	**2.30**	**6.08**	**11.33**	**2.82**	**7.60**	**2.9**	**0.5**	**4.0**	**41.0**
	43†	**1.16**	**6.78**	**16.27**	**4.88**	**9.56**				
Fail to function on demand	11*	0.42	1.55	3.25	0.90	1.94	4.0	1.0	3.7	8.0
	11†	0.16	1.73	4.74	1.53	2.45				
No output	5*	0.00	1.77	7.17	2.70	0.88	1.8	1.0	3.4	4.0
	5†	0.01	1.81	7.07	2.63	1.11				
Spurious high level alarm signal	9*	0.67	1.41	2.38	0.53	1.59	2.3	1.0	2.3	8.0
	9†	0.28	1.54	3.65	1.08	2.00				
Spurious low level alarm signal	5*	0.05	0.69	1.95	0.64	0.88	3.2	0.5	3.2	6.0
	5†	0.03	0.84	2.53	0.86	1.11				
Spurious operation	13*	0.26	1.67	4.10	1.25	2.30	2.8	2.0	5.8	41.0
	13†	0.08	1.92	5.78	1.96	2.89				
Degraded	**67***	**2.11**	**8.56**	**18.59**	**5.25**	**11.84**	**2.9**	**1.0**	**2.6**	**12.5**
	67†	**1.03**	**9.81**	**26.20**	**8.35**	**14.90**				
Erratic output	23*	0.02	2.38	7.81	2.85	4.06	4.4	1.0	2.7	11.0
	23†	0.01	2.90	10.97	4.05	5.11				
High output	10*	0.24	2.22	5.92	1.88	1.77	1.9	2.0	2.2	4.0
	10†	0.60	2.45	5.34	1.51	2.22				
High output, unknown reading	22*	0.03	2.31	7.43	2.69	3.89	3.0	1.0	1.7	3.0
	22†	0.01	2.80	10.40	3.84	4.89				
Low output	4*	0.07	0.98	2.82	0.93	0.71	2.8	1.0	3.8	6.0
	4†	0.21	1.03	2.37	0.70	0.89				
Minor in-service problems	5*	0.05	0.69	1.95	0.64	0.88	2.5	2.0	4.5	12.5
	5†	0.03	0.84	2.53	0.86	1.11				
Spurious low level alarm signal	1*	0.00	0.16	0.49	0.18	0.18	2.0	2.0	2.0	2.0
	1†	0.00	0.20	0.62	0.22	0.22				
Unknown	2*	0.04	0.31	0.82	0.26	0.35	2.0	2.0	7.0	12.0
	2†	0.03	0.38	1.06	0.34	0.44				
Incipient	**64***	**0.02**	**24.55**	**103.70**	**39.85**	**11.31**	**1.2**	**1.0**	**2.1**	**4.0**
	64†	**0.02**	**24.83**	**103.83**	**39.68**	**14.23**				
Minor in-service problems	64*	0.02	24.55	103.70	39.85	11.31	1.2	1.0	2.1	4.0
	64†	0.02	24.83	103.83	39.68	14.23				
All modes	**174***	**2.05**	**36.40**	**107.66**	**35.82**	**30.74**	**2.1**	**0.5**	**2.8**	**41.0**
	174†	**4.38**	**39.47**	**104.09**	**32.91**	**38.68**				

Comments

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Taxonomy no	Item
4.1.4.3	Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Photo-electric beam

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0540	0.0420	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.93**	**18.52**	**87.87**	**18.52**	**18.52**	**2.0**	**10.0**	**10.0**	**10.0**
	1†	**1.19**	**23.84**	**113.11**	**23.84**	**23.84**				
Fail to function on demand	1*	0.93	18.52	87.87	18.52	18.52	2.0	10.0	10.0	10.0
	1†	1.19	23.84	113.11	23.84	23.84				
All modes	**1***	**0.93**	**18.52**	**87.87**	**18.52**	**18.52**	**2.0**	**10.0**	**10.0**	**10.0**
	1†	**1.19**	**23.84**	**113.11**	**23.84**	**23.84**				

Comments

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Taxonomy no	Item
4.1.4.4	Control and Safety Equipment Fire & Gas Detectors Hydrocarbon gas Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0173	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**	-	**4.0**	**12.0**	**20.0**
	2†	**20.47**	**115.31**	**362.93**	**115.31**	**115.31**				
Spurious operation	2*	20.26	114.16	359.30	114.16	114.16	-	4.0	12.0	20.0
	2†	20.47	115.31	362.93	115.31	115.31				
All modes	**2***	**20.26**	**114.16**	**359.30**	**114.16**	**114.16**	-	**4.0**	**12.0**	**20.0**
	2†	**20.47**	**115.31**	**362.93**	**115.31**	**115.31**				

Comments

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Taxonomy no		Item									
4.1.5		Control and Safety Equipment Fire & Gas Detectors Smoke/Combustion									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
103	1	**Calendar time** * 3.2383			**Operational time** † 3.1580						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Incipient		**11***	**1.91**	**3.40**	**5.62**	**3.40**	**3.40**	**6.0**	**6.0**	**6.0**	**6.0**
		11†	**1.95**	**3.48**	**5.77**	**3.48**	**3.48**				
Minor in-service problems		11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0
		11†	1.95	3.48	5.77	3.48	3.48				
Unknown		**2***	**0.11**	**0.62**	**1.94**	**0.62**	**0.62**	**4.0**	**2.0**	**4.0**	**6.0**
		2†	**0.11**	**0.63**	**1.99**	**0.63**	**0.63**				
Unknown		2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0
		2†	0.11	0.63	1.99	0.63	0.63				
All modes		**13***	**2.37**	**4.01**	**6.38**	**4.01**	**4.01**	**5.7**	**2.0**	**5.7**	**6.0**
		13†	**2.43**	**4.12**	**6.54**	**4.12**	**4.12**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Fire & Gas Detectors - Smoke/Combustion

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Cabling	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Fire & Gas Detectors - Smoke/Combustion

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Cabling	0.00	84.62	0.00	0.00	0.00	0.00	0.00	84.62
Subunit	0.00	0.00	0.00	0.00	0.00	15.38	0.00	15.38
Total	0.00	84.62	0.00	0.00	0.00	15.38	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Fire & Gas Detectors - Smoke/Combustion

	ERO	FTF	HIO	HIU	LOO	LOU	NOO
Common mode failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Fire & Gas Detectors - Smoke/Combustion

	OTH	SER	SHH	SLL	SPO	UNK	VLO	Sum
Common mode failure	0.00	84.62	0.00	0.00	0.00	0.00	0.00	84.62
Unknown	0.00	0.00	0.00	0.00	0.00	15.38	0.00	15.38
Total	0.00	84.62	0.00	0.00	0.00	15.38	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.1.5.1	Control and Safety Equipment Fire & Gas Detectors Smoke/Combustion Photo-electric

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
103	1	3.2383	3.1580	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**11***	**1.91**	**3.40**	**5.62**	**3.40**	**3.40**	**6.0**	**6.0**	**6.0**	**6.0**
	11†	**1.95**	**3.48**	**5.77**	**3.48**	**3.48**				
Minor in-service problems	11*	1.91	3.40	5.62	3.40	3.40	6.0	6.0	6.0	6.0
	11†	1.95	3.48	5.77	3.48	3.48				
Unknown	**2***	**0.11**	**0.62**	**1.94**	**0.62**	**0.62**	**4.0**	**2.0**	**4.0**	**6.0**
	2†	**0.11**	**0.63**	**1.99**	**0.63**	**0.63**				
Unknown	2*	0.11	0.62	1.94	0.62	0.62	4.0	2.0	4.0	6.0
	2†	0.11	0.63	1.99	0.63	0.63				
All modes	**13***	**2.37**	**4.01**	**6.38**	**4.01**	**4.01**	**5.7**	**2.0**	**5.7**	**6.0**
	13†	**2.43**	**4.12**	**6.54**	**4.12**	**4.12**				

Comments

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Process Sensors

Inventory description

The boundary definition shown in Figure 21 comprises the sensing element and the (local) electronics for signal conversion and transmission. The sensing element measures some process parameter (e.g. pressure, level, temperature, flow, etc.) and the electronics converts the measurement to a standard electric signal that is transmitted to a computer, a solid state controller or a PLC. Some sensors may be calibrated by adjusting a screw at the electronic housing.

Isolation valves (block valves) and associated pipework are also included.

The subdivision in Subunits and Maintainable Items is similar to the F&G detectors, and is shown in Table 16.

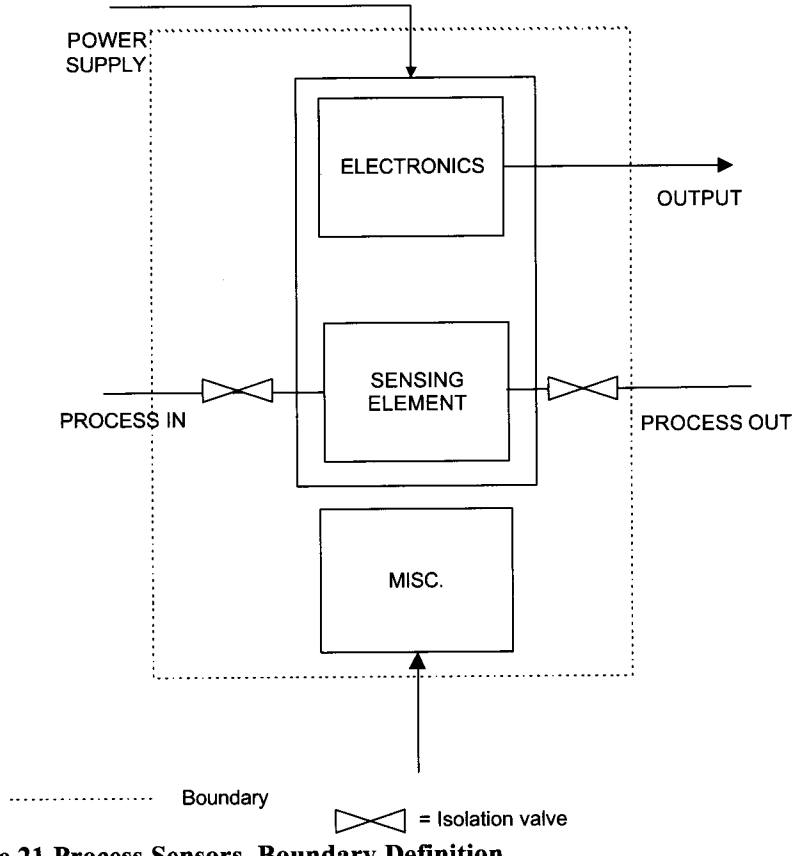

Figure 21 Process Sensors, Boundary Definition

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Table 16 Prosess Sensors, Subdivision in Maintainable Items

PROCESS SENSOR	
Sensor & electronics	Miscellaneous
• Sensing element • Electronics	• Isolation valve • Piping

(For all subunits the MIs "Unknown" and "Subunit" are included.

List of failure modes

ERO Erratic output
FTF Fail to function on demand
HIO High output
LOO Low output
SER Minor in-service problems
OTH Other
SPO Spurious operation

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Taxonomy no		Item									
4.2		Control and Safety Equipment Process sensors									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
209	4	**Calendar time** * 7.0700			**Operational time** † 6.0635						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**18***	**0.50**	**2.81**	**6.68**	**1.99**	**2.55**	**4.4**	**1.0**	**6.6**	**24.0**
		18†	**0.46**	**3.34**	**8.44**	**2.61**	**2.97**				
Erratic output		4*	0.02	1.90	6.16	2.24	0.57	7.0	2.0	8.5	12.0
		4†	0.02	1.91	6.42	2.36	0.66				
Fail to function on demand		7*	0.27	0.90	1.84	0.50	0.99	4.2	2.0	6.7	22.0
		7†	0.06	1.02	3.01	1.00	1.15				
Low output		1*	0.00	0.13	0.41	0.15	0.14	4.0	4.0	4.0	4.0
		1†	0.00	0.16	0.56	0.21	0.16				
Spurious operation		6*	0.33	0.80	1.44	0.35	0.85	2.8	1.0	5.8	24.0
		6†	0.14	0.92	2.27	0.69	0.99				
Degraded		**23***	**0.58**	**6.18**	**16.94**	**5.47**	**3.25**	**3.7**	**2.0**	**7.5**	**26.0**
		23†	**0.58**	**6.40**	**17.64**	**5.71**	**3.79**				
Erratic output		5*	0.06	0.84	2.41	0.79	0.71	3.4	2.0	5.0	8.0
		5†	0.11	0.86	2.20	0.68	0.82				
High output		4*	0.01	1.66	5.53	2.03	0.57	2.0	2.0	13.5	26.0
		4†	0.01	1.73	5.96	2.20	0.66				
Low output		6*	0.00	0.72	2.87	1.07	0.85	3.3	2.0	5.3	8.0
		6†	0.01	0.77	2.69	0.99	0.99				
Other		8*	0.04	2.94	9.33	3.36	1.13	5.3	2.0	7.7	16.0
		8†	0.04	3.11	10.01	3.63	1.32				
Incipient		**21***	**0.00**	**2.17**	**8.64**	**3.23**	**2.97**	**9.6**	**1.0**	**11.6**	**135.0**
		21†	**0.02**	**2.40**	**8.17**	**3.01**	**3.46**				
Erratic output		10*	0.00	1.09	4.95	1.97	1.41	4.4	2.0	7.0	24.0
		10†	0.00	1.15	4.92	1.90	1.65				
High output		1*	0.00	0.14	0.47	0.17	0.14	1.5	3.0	3.0	3.0
		1†	0.00	0.15	0.48	0.17	0.16				
Minor in-service problems		8*	0.11	1.00	2.64	0.83	1.13	18.8	1.0	20.0	135.0
		8†	0.16	1.15	2.87	0.88	1.32				
Other		2*	0.00	0.27	0.94	0.35	0.28	3.3	3.0	5.0	7.0
		2†	0.00	0.29	0.95	0.35	0.33				
Unknown		**1***	**0.00**	**0.45**	**1.75**	**0.65**	**0.14**	**-**	**28.0**	**28.0**	**28.0**
		1†	**0.00**	**0.47**	**1.87**	**0.70**	**0.16**				
Erratic output		1*	0.00	0.45	1.75	0.65	0.14	-	28.0	28.0	28.0
		1†	0.00	0.47	1.87	0.70	0.16				
All modes		**63***	**4.10**	**11.26**	**21.29**	**5.37**	**8.91**	**6.2**	**1.0**	**9.0**	**135.0**
		63†	**5.75**	**11.70**	**19.36**	**4.20**	**10.39**				
Comments											

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Maintainable item versus failure mode
Item: Process sensors

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	11.11	1.59	1.59	0.00	0.00	1.59	3.17	19.05
Isolation valve	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Other	7.94	3.17	1.59	7.94	6.35	4.76	3.17	34.92
Piping	0.00	0.00	0.00	0.00	3.17	0.00	0.00	3.17
Sensing element	6.35	3.17	4.76	1.59	0.00	3.17	3.17	22.22
Subunit	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Unknown	3.17	0.00	0.00	1.59	6.35	3.17	0.00	14.29
Total	31.75	11.11	7.94	11.11	15.87	12.70	9.52	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode
Item: Process sensors

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Blockage/plugged	0.00	1.59	0.00	0.00	1.59	0.00	1.59	4.76
Breakage	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
Clearance/ alignment failure	4.76	0.00	0.00	4.76	0.00	4.76	0.00	14.29
Corrosion	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
Electrical failure - general	1.59	1.59	0.00	0.00	0.00	0.00	0.00	3.17
Faulty signal/indication/alarm	22.22	3.17	6.35	3.17	0.00	1.59	1.59	38.10
Instrument failure - general	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Leakage	0.00	0.00	0.00	0.00	7.94	4.76	0.00	12.70
Mechanical Failure - general	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Misc. external influences	0.00	0.00	0.00	0.00	1.59	0.00	0.00	1.59
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	1.59	1.59
No signal/indication/alarm	0.00	1.59	0.00	0.00	0.00	0.00	1.59	3.17
Out of adjustment	3.17	0.00	1.59	1.59	0.00	0.00	0.00	6.35
Vibration	0.00	0.00	0.00	1.59	0.00	0.00	0.00	1.59
Wear	0.00	0.00	0.00	0.00	1.59	1.59	0.00	3.17
Total	31.75	11.11	7.94	11.11	15.87	12.70	9.52	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.2.1	Control and Safety Equipment Process sensors Flow

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
35	2	1.3416	1.2266	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**0.73**	**3.26**	**7.28**	**2.10**	**2.98**	**4.5**	**2.0**	**9.8**	**22.0**
	4†	**1.00**	**3.81**	**8.08**	**2.25**	**3.26**				
Erratic output	1*	0.01	0.68	2.11	0.75	0.75	6.0	12.0	12.0	12.0
	1†	0.01	0.74	2.30	0.82	0.82				
Fail to function on demand	3*	0.40	2.65	6.57	2.01	2.24	4.0	2.0	9.0	22.0
	3†	0.18	3.59	10.72	3.58	2.45				
Degraded	**6***	**0.27**	**3.69**	**10.54**	**3.47**	**4.47**	**4.3**	**2.0**	**6.3**	**16.0**
	6†	**0.71**	**4.14**	**9.90**	**2.97**	**4.89**				
Erratic output	3*	0.47	2.04	4.52	1.29	2.24	3.3	2.0	4.0	6.0
	3†	0.04	2.04	6.33	2.24	2.45				
High output	1*	0.01	0.68	2.11	0.75	0.75	2.0	2.0	2.0	2.0
	1†	0.01	0.74	2.30	0.82	0.82				
Other	2*	0.02	1.29	4.13	1.49	1.49	7.0	8.0	12.0	16.0
	2†	0.04	1.42	4.32	1.49	1.63				
Incipient	**6***	**1.99**	**4.52**	**7.88**	**1.83**	**4.47**	**2.3**	**1.0**	**4.2**	**8.0**
	6†	**2.26**	**5.11**	**8.88**	**2.05**	**4.89**				
Minor in-service problems	5*	1.57	3.84	6.93	1.67	3.73	2.1	1.0	3.6	8.0
	5†	1.12	4.56	9.92	2.80	4.08				
Other	1*	0.01	0.68	2.11	0.75	0.75	3.5	7.0	7.0	7.0
	1†	0.01	0.74	2.30	0.82	0.82				
All modes	**16***	**7.33**	**11.77**	**17.07**	**2.98**	**11.93**	**3.6**	**1.0**	**6.4**	**22.0**
	16†	**8.29**	**13.16**	**18.94**	**3.26**	**13.04**				

Comments

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Maintainable item versus failure mode
Item: Process sensors - Flow

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	18.75	0.00	6.25	0.00	0.00	6.25	0.00	31.25
Isolation valve	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Other	0.00	6.25	0.00	0.00	0.00	6.25	0.00	12.50
Piping	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Sensing element	0.00	0.00	0.00	0.00	0.00	6.25	0.00	6.25
Subunit	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Unknown	6.25	0.00	0.00	0.00	12.50	12.50	0.00	31.25
Total	25.00	18.75	6.25	0.00	18.75	31.25	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode
Item: Process sensors - Flow

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Breakage	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Clearance/ alignment failure	6.25	0.00	0.00	0.00	0.00	18.75	0.00	25.00
Corrosion	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Electrical failure - general	6.25	6.25	0.00	0.00	0.00	0.00	0.00	12.50
Faulty signal/indication/alarm	12.50	6.25	6.25	0.00	0.00	0.00	0.00	25.00
Leakage	0.00	0.00	0.00	0.00	0.00	12.50	0.00	12.50
Mechanical Failure - general	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25
Misc. external influences	0.00	0.00	0.00	0.00	6.25	0.00	0.00	6.25
Total	25.00	18.75	6.25	0.00	18.75	31.25	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.2.1.1	Control and Safety Equipment Process sensors Flow Electro-mechanical

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0701	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.55	13.62	5.01	0.00	-	-	-	-
	0†	0.02	4.62	17.76	6.54	0.00				

Comments

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Taxonomy no	Item
4.2.1.2	Control and Safety Equipment Process sensors Flow Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	2	1.2430	1.1565	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**1.15**	**3.63**	**7.26**	**1.92**	**3.22**	**4.5**	**2.0**	**9.8**	**22.0**
	4†	**0.54**	**4.95**	**13.11**	**4.16**	**3.46**				
Erratic output	1*	0.01	0.73	2.27	0.80	0.80	6.0	12.0	12.0	12.0
	1†	0.02	0.79	2.44	0.86	0.86				
Fail to function on demand	3*	0.21	3.42	9.98	3.31	2.41	4.0	2.0	9.0	22.0
	3†	0.08	4.71	14.83	5.31	2.59				
Degraded	**6***	**0.62**	**4.05**	**10.00**	**3.06**	**4.83**	**4.3**	**2.0**	**6.3**	**16.0**
	6†	**1.70**	**4.68**	**8.88**	**2.24**	**5.19**				
Erratic output	3*	0.04	2.01	6.29	2.24	2.41	3.3	2.0	4.0	6.0
	3†	0.09	2.19	6.60	2.24	2.59				
High output	1*	0.01	0.73	2.27	0.80	0.80	2.0	2.0	2.0	2.0
	1†	0.02	0.79	2.44	0.86	0.86				
Other	2*	0.04	1.40	4.28	1.49	1.61	7.0	8.0	12.0	16.0
	2†	0.09	1.52	4.50	1.49	1.73				
Incipient	**6***	**2.26**	**5.00**	**8.62**	**1.97**	**4.83**	**2.3**	**1.0**	**4.2**	**8.0**
	6†	**1.43**	**5.99**	**13.14**	**3.73**	**5.19**				
Minor in-service problems	5*	1.21	4.42	9.26	2.54	4.02	2.1	1.0	3.6	8.0
	5†	1.55	5.08	10.26	2.74	4.32				
Other	1*	0.01	0.73	2.27	0.80	0.80	3.5	7.0	7.0	7.0
	1†	0.02	0.79	2.44	0.86	0.86				
All modes	**16***	**8.13**	**12.93**	**18.64**	**3.22**	**12.87**	**3.6**	**1.0**	**6.4**	**22.0**
	16†	**8.01**	**14.50**	**22.56**	**4.48**	**13.84**				

Comments

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Taxonomy no	Item
4.2.2	Control and Safety Equipment Process sensors Level

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
76	4	2.0952	1.8624	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**8***	**1.62**	**3.99**	**7.23**	**1.75**	**3.82**	**5.0**	**1.0**	**7.6**	**24.0**
	8†	**1.48**	**4.65**	**9.26**	**2.44**	**4.30**				
Erratic output	3*	0.00	2.17	9.03	3.44	1.43	7.3	2.0	7.3	10.0
	3†	0.00	2.22	9.27	3.54	1.61				
Fail to function on demand	1*	0.00	0.46	1.72	0.63	0.48	-	-	-	-
	1†	0.00	0.56	2.33	0.89	0.54				
Low output	1*	0.00	0.46	1.72	0.63	0.48	4.0	4.0	4.0	4.0
	1†	0.00	0.56	2.33	0.89	0.54				
Spurious operation	3*	0.12	1.33	3.71	1.20	1.43	3.0	1.0	9.0	24.0
	3†	0.03	1.55	4.77	1.68	1.61				
Degraded	**13***	**1.46**	**14.24**	**38.26**	**12.23**	**6.20**	**3.2**	**2.0**	**8.5**	**26.0**
	13†	**1.43**	**14.86**	**40.45**	**13.02**	**6.98**				
Erratic output	2*	0.01	1.05	3.54	1.30	0.95	3.5	5.0	6.5	8.0
	2†	0.01	1.11	3.59	1.30	1.07				
High output	3*	0.59	9.93	29.21	9.70	1.43	-	12.0	17.3	26.0
	3†	0.47	10.44	31.34	10.54	1.61				
Low output	6*	0.01	2.28	8.98	3.34	2.86	3.3	2.0	5.3	8.0
	6†	0.01	2.43	8.57	3.16	3.22				
Other	2*	0.02	2.33	7.96	2.93	0.95	2.0	2.0	7.0	12.0
	2†	0.02	2.59	8.73	3.20	1.07				
Incipient	**15***	**0.00**	**5.22**	**21.89**	**8.38**	**7.16**	**12.5**	**2.0**	**14.5**	**135.0**
	15†	**0.01**	**5.55**	**21.91**	**8.16**	**8.05**				
Erratic output	10*	0.00	3.53	15.66	6.17	4.77	4.4	2.0	7.0	24.0
	10†	0.00	3.67	15.69	6.06	5.37				
High output	1*	0.00	0.44	1.54	0.57	0.48	1.5	3.0	3.0	3.0
	1†	0.01	0.48	1.57	0.57	0.54				
Minor in-service problems	3*	0.15	1.33	3.49	1.10	1.43	46.5	3.0	47.3	135.0
	3†	0.19	1.49	3.82	1.19	1.61				
Other	1*	0.00	0.44	1.54	0.57	0.48	3.0	3.0	3.0	3.0
	1†	0.01	0.48	1.57	0.57	0.54				
Unknown	**1***	**0.03**	**2.61**	**8.56**	**3.12**	**0.48**	**-**	**28.0**	**28.0**	**28.0**
	1†	**0.02**	**2.75**	**9.22**	**3.39**	**0.54**				
Erratic output	1*	0.03	2.61	8.56	3.12	0.48	-	28.0	28.0	28.0
	1†	0.02	2.75	9.22	3.39	0.54				
All modes	**37***	**5.38**	**23.81**	**53.01**	**15.21**	**17.66**	**8.1**	**1.0**	**11.4**	**135.0**
	37†	**6.31**	**24.70**	**53.01**	**14.84**	**19.87**				

Comments

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Maintainable item versus failure mode
Item: Process sensors - Level

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	10.81	0.00	0.00	0.00	0.00	0.00	0.00	10.81
Isolation valve	2.70	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Other	13.51	0.00	2.70	13.51	2.70	5.41	5.41	43.24
Piping	0.00	0.00	0.00	0.00	2.70	0.00	0.00	2.70
Sensing element	10.81	2.70	8.11	2.70	0.00	2.70	2.70	29.73
Subunit	2.70	0.00	0.00	0.00	0.00	0.00	0.00	2.70
Unknown	2.70	0.00	0.00	2.70	2.70	0.00	0.00	8.11
Total	43.24	2.70	10.81	18.92	8.11	8.11	8.11	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode
Item: Process sensors - Level

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Blockage/plugged	0.00	2.70	0.00	0.00	2.70	0.00	2.70	8.11
Clearance/ alignment failure	5.41	0.00	0.00	8.11	0.00	0.00	0.00	13.51
Faulty signal/indication/alarm	32.43	0.00	8.11	5.41	0.00	2.70	0.00	48.65
Leakage	0.00	0.00	0.00	0.00	2.70	2.70	0.00	5.41
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	2.70	2.70
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	2.70	2.70
Out of adjustment	5.41	0.00	2.70	2.70	0.00	0.00	0.00	10.81
Vibration	0.00	0.00	0.00	2.70	0.00	0.00	0.00	2.70
Wear	0.00	0.00	0.00	0.00	2.70	2.70	0.00	5.41
Total	43.24	2.70	10.81	18.92	8.11	8.11	8.11	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.2.2.1	Control and Safety Equipment Process sensors Level Capacitance

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0350	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**10.12**	**57.00**	**179.41**	**57.00**	**57.00**	**3.0**	**4.0**	**6.0**	**8.0**
	2†	**10.13**	**57.08**	**179.65**	**57.08**	**57.08**				
Low output	2*	10.12	57.00	179.41	57.00	57.00	3.0	4.0	6.0	8.0
	2†	10.13	57.08	179.65	57.08	57.08				
Incipient	**1***	**1.42**	**28.50**	**135.23**	**28.50**	**28.50**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**1.43**	**28.54**	**135.42**	**28.54**	**28.54**				
Other	1*	1.42	28.50	135.23	28.50	28.50	3.0	3.0	3.0	3.0
	1†	1.43	28.54	135.42	28.54	28.54				
All modes	**3***	**23.37**	**85.50**	**221.02**	**85.50**	**85.50**	**3.0**	**3.0**	**5.0**	**8.0**
	3†	**23.40**	**85.62**	**221.32**	**85.62**	**85.62**				

Comments

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Taxonomy no	Item
4.2.2.2	Control and Safety Equipment Process sensors Level Conductivity

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0350	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**2***	**10.12**	**57.00**	**179.41**	**57.00**	**57.00**	**68.3**	**4.0**	**69.5**	**135.0**
	2†	**10.13**	**57.08**	**179.65**	**57.08**	**57.08**				
Minor in-service problems	2*	10.12	57.00	179.41	57.00	57.00	68.3	4.0	69.5	135.0
	2†	10.13	57.08	179.65	57.08	57.08				
All modes	**2***	**10.12**	**57.00**	**179.41**	**57.00**	**57.00**	**68.3**	**4.0**	**69.5**	**135.0**
	2†	**10.13**	**57.08**	**179.65**	**57.08**	**57.08**				

Comments

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Taxonomy no	Item
4.2.2.3	Control and Safety Equipment Process sensors Level Displacement

Population	Installations	Aggregated time in service (10^6 hours)	
		Calendar time *	Operational time †
36	3	1.2810	1.1490

Failure mode	No of failures	Failure rate (per 10^6 hours).					No of demands	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Min	Mean	Max
Critical	**4***	**0.77**	**3.31**	**7.30**	**2.08**	**3.12**	**3.7**	**1.0**	**9.7**	**24.0**
	4†	**0.25**	**4.16**	**12.23**	**4.06**	**3.48**				
Fail to function on demand	1*	0.00	0.89	3.50	1.30	0.78	-	-	-	
	1†	0.07	1.05	3.07	1.01	0.87				
Low output	1*	0.00	0.89	3.50	1.30	0.78	4.0	4.0	4.0	4.0
	1†	0.07	1.05	3.07	1.01	0.87				
Spurious operation	2*	0.26	1.56	3.76	1.13	1.56	3.5	1.0	12.5	24.
	2†	0.17	1.82	4.95	1.59	1.74				
Degraded	**9***	**1.69**	**19.28**	**53.48**	**17.37**	**7.03**	**3.2**	**2.0**	**10.2**	**26**
	9†	**1.43**	**20.39**	**58.63**	**19.32**	**7.83**				
Erratic output	1*	0.01	0.71	2.21	0.78	0.78	2.0	8.0	8.0	8
	1†	0.01	0.78	2.44	0.87	0.87				
High output	3*	0.66	13.75	41.21	13.79	2.34	-	12.0	17.3	2(
	3†	0.38	14.59	44.62	15.55	2.61				
Low output	4*	0.68	2.81	6.14	1.74	3.12	3.5	2.0	5.0	
	4†	0.06	2.76	8.51	3.00	3.48				
Other	1*	0.05	3.80	12.22	4.42	0.78	-	12.0	12.0	1
	1†	0.04	4.10	13.59	4.97	0.87				
Incipient	**11***	**0.03**	**6.18**	**22.39**	**8.27**	**8.59**	**4.1**	**2.0**	**6.6**	
	11†	**0.08**	**6.66**	**21.40**	**7.75**	**9.57**				
Erratic output	10*	0.04	5.71	19.99	7.38	7.81	4.4	2.0	7.0	
	10†	0.12	6.20	19.27	6.83	8.70				
High output	1*	0.01	0.71	2.21	0.78	0.78	1.5	3.0	3.0	
	1†	0.01	0.78	2.44	0.87	0.87				
Unknown	**1***	**0.05**	**3.80**	**12.22**	**4.42**	**0.78**	**-**	**28.0**	**28.0**	
	1†	**0.04**	**4.10**	**13.59**	**4.97**	**0.87**				
Erratic output	1*	0.05	3.80	12.22	4.42	0.78	-	28.0	28.0	
	1†	0.04	4.10	13.59	4.97	0.87				
All modes	**25***	**5.91**	**28.97**	**66.42**	**19.42**	**19.52**	**3.8**	**1.0**	**9.3**	
	25†	**6.74**	**30.77**	**69.15**	**19.97**	**21.76**				

Comments

Taxonomy no	Item
4.2.2.4	Control and Safety Equipment Process sensors Level Magnetic

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.3449	0.2454	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.14**	**2.90**	**13.76**	**2.90**	**2.90**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.20**	**4.07**	**19.33**	**4.07**	**4.07**				
Spurious operation	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
Degraded	**1***	**0.14**	**2.90**	**13.76**	**2.90**	**2.90**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.20**	**4.07**	**19.33**	**4.07**	**4.07**				
Other	1*	0.14	2.90	13.76	2.90	2.90	2.0	2.0	2.0	2.0
	1†	0.20	4.07	19.33	4.07	4.07				
Incipient	**1***	**0.14**	**2.90**	**13.76**	**2.90**	**2.90**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.20**	**4.07**	**19.33**	**4.07**	**4.07**				
Minor in-service problems	1*	0.14	2.90	13.76	2.90	2.90	3.0	3.0	3.0	3.0
	1†	0.20	4.07	19.33	4.07	4.07				
All modes	**3***	**2.38**	**8.70**	**22.48**	**8.70**	**8.70**	**2.3**	**2.0**	**2.3**	**3.0**
	3†	**3.34**	**12.22**	**31.60**	**12.22**	**12.22**				

Comments

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Taxonomy no	Item
4.2.2.5	Control and Safety Equipment Process sensors Level Other

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0556	0.0554	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**0.90**	**17.99**	**85.37**	**17.99**	**17.99**	**5.0**	**5.0**	**5.0**	**5.0**
	1†	**0.90**	**18.04**	**85.62**	**18.04**	**18.04**				
Erratic output	1*	0.90	17.99	85.37	17.99	17.99	5.0	5.0	5.0	5.0
	1†	0.90	18.04	85.62	18.04	18.04				
All modes	**1***	**0.90**	**17.99**	**85.37**	**17.99**	**17.99**	**5.0**	**5.0**	**5.0**	**5.0**
	1†	**0.90**	**18.04**	**85.62**	**18.04**	**18.04**				

Comments

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Taxonomy no	Item
4.2.2.6	Control and Safety Equipment Process sensors Level Sonic

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	1	0.3084	0.3074	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**2.66**	**9.73**	**25.15**	**9.73**	**9.73**	**7.3**	**2.0**	**7.3**	**10.0**
	3†	**2.67**	**9.76**	**25.22**	**9.76**	**9.76**				
Erratic output	3*	2.66	9.73	25.15	9.73	9.73	7.3	2.0	7.3	10.0
	3†	2.67	9.76	25.22	9.76	9.76				
All modes	**3***	**2.66**	**9.73**	**25.15**	**9.73**	**9.73**	**7.3**	**2.0**	**7.3**	**10.0**
	3†	**2.67**	**9.76**	**25.22**	**9.76**	**9.76**				

Comments

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Taxonomy no	Item
4.2.2.7	Control and Safety Equipment Process sensors Level Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0350	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.04	8.91 9.04	34.23 34.73	12.61 12.79	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.2.3	Control and Safety Equipment Process sensors Pressure

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
55	2	1.9401	1.4675	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**4***	**0.02**	**5.30**	**20.47**	**7.55**	**2.06**	-	**2.0**	**5.3**	**12.0**
	4†	**0.02**	**5.55**	**21.35**	**7.87**	**2.73**				
Other	4*	0.02	5.30	20.47	7.55	2.06	-	2.0	5.3	12.0
	4†	0.02	5.55	21.35	7.87	2.73				
All modes	**4***	**0.02**	**5.30**	**20.47**	**7.55**	**2.06**	-	**2.0**	**5.3**	**12.0**
	4†	**0.02**	**5.55**	**21.35**	**7.87**	**2.73**				

Comments

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Maintainable item versus failure mode
Item: Process sensors - Pressure

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Other	0.00	0.00	0.00	0.00	75.00	0.00	0.00	75.00
Unknown	0.00	0.00	0.00	0.00	25.00	0.00	0.00	25.00
Total	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode
Item: Process sensors - Pressure

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Leakage	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	100.0	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.2.3.1	Control and Safety Equipment Process sensors Pressure Capacitance

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.3449	0.2454	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	1.14	4.37	1.61	0.00	-	-	-	-
	0†	0.01	1.49	5.72	2.11	0.00				

Comments

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Taxonomy no	Item
4.2.3.2	Control and Safety Equipment Process sensors Pressure Electro-mechanical

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
45	2	1.4836	1.1394	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**4***	**0.02**	**5.48**	**21.05**	**7.76**	**2.70**	-	**2.0**	**5.3**	**12.0**
	4†	**0.02**	**5.75**	**21.82**	**8.04**	**3.51**				
Other	4*	0.02	5.48	21.05	7.76	2.70	-	2.0	5.3	12.0
	4†	0.02	5.75	21.82	8.04	3.51				
All modes	**4***	**0.02**	**5.48**	**21.05**	**7.76**	**2.70**	-	**2.0**	**5.3**	**12.0**
	4†	**0.02**	**5.75**	**21.82**	**8.04**	**3.51**				

Comments

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Taxonomy no		Item
4.2.3.3		Control and Safety Equipment Process sensors Pressure Piezo-electric

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0351	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.48	13.38	4.93	0.00	-	-	-	-
	0†	0.02	4.00	15.35	5.65	0.00				

Comments

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Taxonomy no	Item
4.2.3.4	Control and Safety Equipment Process sensors Pressure Semiconductor strain

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0493	0.0351	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.48	13.38	4.93	0.00	-	-	-	-
	0†	0.02	4.00	15.35	5.65	0.00				

Comments

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Taxonomy no	Item
4.2.3.5	Control and Safety Equipment Process sensors Pressure Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0131	0.0125	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.66	17.88	6.58	0.00	-	-	-	-
	0†	0.02	4.88	18.73	6.90	0.00				

Comments

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Taxonomy no	Item
4.2.4	Control and Safety Equipment Process sensors Temperature

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
43	2	1.6932	1.5070	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.02**	**4.57**	**17.01**	**6.28**	**3.54**	**3.5**	**2.0**	**3.5**	**8.0**
	6†	**0.03**	**6.39**	**24.32**	**8.96**	**3.98**				
Fail to function on demand	3*	0.01	2.23	8.00	2.96	1.77	4.3	2.5	4.3	8.0
	3†	0.01	3.10	11.67	4.30	1.99				
Spurious operation	3*	0.01	2.23	8.00	2.96	1.77	2.7	2.0	2.7	3.0
	3†	0.01	3.10	11.67	4.30	1.99				
All modes	**6***	**0.02**	**4.57**	**17.01**	**6.28**	**3.54**	**3.5**	**2.0**	**3.5**	**8.0**
	6†	**0.03**	**6.39**	**24.32**	**8.96**	**3.98**				

Comments

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Maintainable item versus failure mode
Item: Process sensors - Temperature

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Electronics	0.00	16.67	0.00	0.00	0.00	0.00	33.33	50.00
Other	0.00	16.67	0.00	0.00	0.00	0.00	0.00	16.67
Sensing element	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
Total	0.00	50.00	0.00	0.00	0.00	0.00	50.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode
Item: Process sensors - Temperature

	ERO	FTF	HIO	LOO	OTH	SER	SPO	Sum
Faulty signal/indication/alarm	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
Instrument failure - general	0.00	16.67	0.00	0.00	0.00	0.00	16.67	33.33
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	16.67	16.67
No signal/indication/alarm	0.00	16.67	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	50.00	0.00	0.00	0.00	0.00	50.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.2.4.1	Control and Safety Equipment Process sensors Temperature Capillary

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.2949	0.2803	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	1.24	4.75	1.75	0.00	-	-	-	-
	0†	0.01	1.39	5.35	1.97	0.00				

Comments

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Taxonomy no	Item
4.2.4.2	Control and Safety Equipment Process sensors Temperature Resistance

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
19	2	0.6950	0.6658	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.05**	**14.62**	**56.60**	**20.93**	**4.32**	**4.7**	**3.0**	**4.7**	**8.0**
	3†	**0.07**	**20.73**	**80.21**	**29.65**	**4.51**				
Fail to function on demand	1*	0.01	4.47	17.61	6.56	1.44	8.0	8.0	8.0	8.0
	1†	0.02	6.47	25.45	9.47	1.50				
Spurious operation	2*	0.03	9.55	37.11	13.75	2.88	3.0	3.0	3.0	3.0
	2†	0.04	13.60	52.83	19.56	3.00				
All modes	**3***	**0.05**	**14.62**	**56.60**	**20.93**	**4.32**	**4.7**	**3.0**	**4.7**	**8.0**
	3†	**0.07**	**20.73**	**80.21**	**29.65**	**4.51**				

Comments

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Taxonomy no	Item
4.2.4.3	Control and Safety Equipment Process sensors Temperature Thermocouple

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	1	0.4927	0.3506	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**1.66**	**6.09**	**15.74**	**6.09**	**6.09**	**2.3**	**2.0**	**2.3**	**2.5**
	3†	**2.34**	**8.56**	**22.12**	**8.56**	**8.56**				
Fail to function on demand	2*	0.72	4.06	12.78	4.06	4.06	2.5	2.5	2.5	2.5
	2†	1.01	5.70	17.95	5.70	5.70				
Spurious operation	1*	0.10	2.03	9.63	2.03	2.03	2.0	2.0	2.0	2.0
	1†	0.14	2.85	13.53	2.85	2.85				
All modes	**3***	**1.66**	**6.09**	**15.74**	**6.09**	**6.09**	**2.3**	**2.0**	**2.3**	**2.5**
	3†	**2.34**	**8.56**	**22.12**	**8.56**	**8.56**				

Comments

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Taxonomy no	Item
4.2.4.4	Control and Safety Equipment Process sensors Temperature Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
6	1	0.2105	0.2102	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	1.56	6.00	2.21	0.00	-	-	-	-
	0†	0.01	1.73	6.66	2.45	0.00				

Comments

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Valves

Inventory description

The boundary definition is shown in Figure 22 and subdivision in. Maintainable Items are shown in Table 17.

The valve consists of the valve with housing, and the actuator. A valve includes the complete assembly of connector (i.e. inlet, outlet, and seals) connected to the piping.
The pilot (solenoid) valve for hydraulically/ pneumatically operated valves is included as a separate Maintainable Item within the subunit "Actuator". Hydraulic accumulators are not included within the boundary.

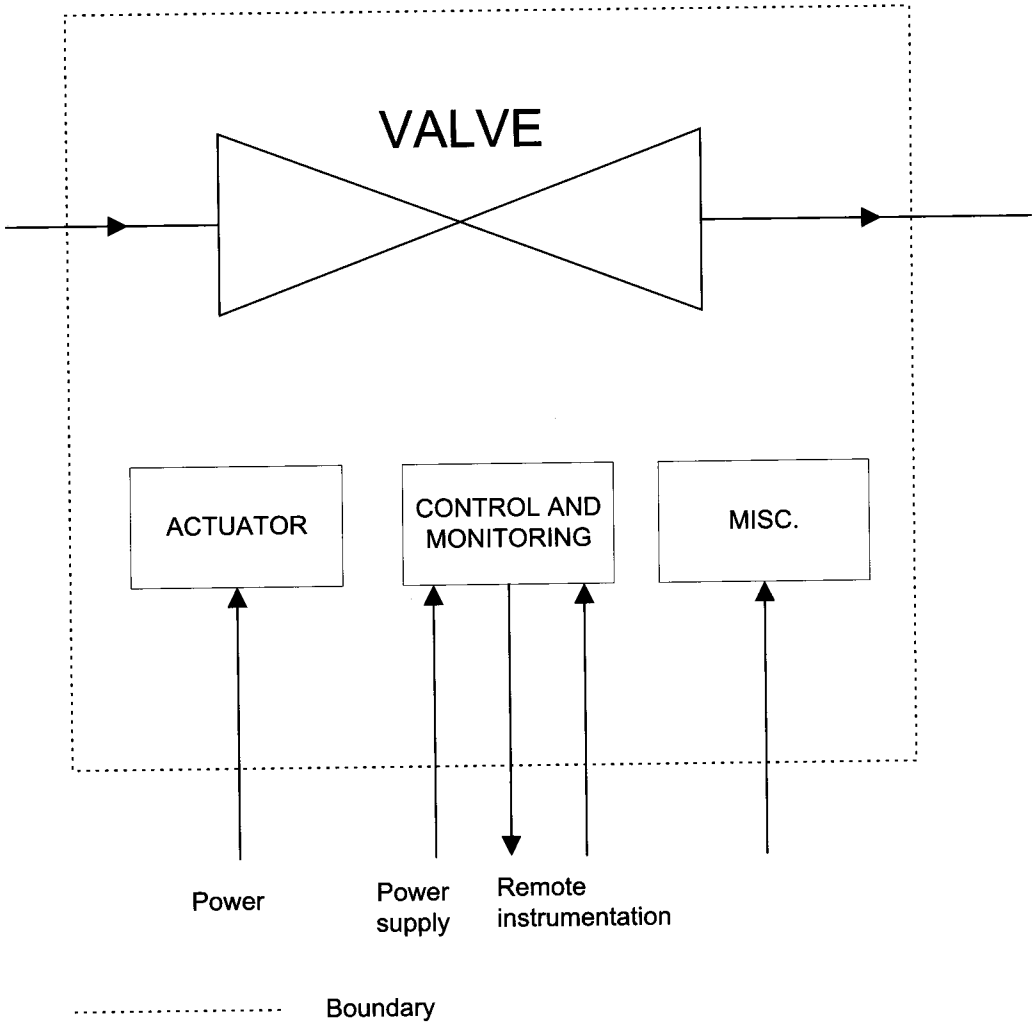

Figure 22 Valves, Boundary Definition

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Table 17 Valves, Subdivision in Maintainable Items

VALVES			
Valve	Actuator	Control and Monitoring	Miscellaneous
• Bonnet • Closure member[7] • Flange • Other valve components • Packing • Seals • Seat rings • Valve body w/internals	• Case • Diaphragm • Electric motor • Gear • Indicator • Instrument, position • Other actuator components • Pilot valve • Piston • Positioner • Seals (gaskets) • Spring • Stem	• Actuating device • Cabling & junction boxes • Control unit • Instrument • Monitoring • Internal power supply • Valves	• Other

(For all subunits the MIs "Unknown" and "Subunit" are included.)

List of failure modes

AIR Abnormal instrument reading
DOP Delayed operation
ELP External leakage - Process medium
ELU External leakage - Utility medium
FTC Fail to close on demand
FTO Fail to open on demand
FTR Fail to regulate
HIO High output
INL Internal leakage
LOO Low output
SER Minor in-service problems
OTH Other
PLU Plugged/Choked
SPO Spurious operation
STD Structural deficiency
UNK Unknown
LCP Valve leakage in closed position

[7] That part of the valve that is positioned in the flow stream to permit, obstruct or regulate flow (API Spec. 6D)

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Taxonomy no	Item
4.3	Control and Safety Equipment Valves

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1170	40	36.6612	31.6175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**358***	**0.01**	**6.79**	**28.28**	**10.78**	**9.77**	**9.1**	**0.5**	**12.0**	**113.0**
	358†	**3.00**	**25.97**	**67.80**	**21.31**	**11.32**				
Delayed operation	3*	0.00	0.11	0.55	0.24	0.08	32.0	28.0	64.0	113.0
	3†	0.00	0.15	0.71	0.29	0.09				
External leakage - Process medium	11*	0.00	0.24	0.82	0.30	0.30	11.0	1.0	13.5	54.0
	11†	0.00	0.29	1.16	0.44	0.35				
External leakage - Utility medium	2*	0.00	0.06	0.19	0.07	0.05	9.8	17.0	19.5	22.0
	2†	0.00	0.08	0.25	0.09	0.06				
Fail to close on demand	134*	0.00	2.31	13.11	7.48	3.66	8.2	1.0	11.3	78.0
	134†	0.00	5.09	22.77	9.01	4.24				
Fail to open on demand	84*	0.02	2.81	9.37	3.43	2.29	7.6	1.0	10.4	78.0
	84†	7.06	29.13	63.54	17.98	2.66				
Fail to regulate	72*	0.00	0.55	1.09	3.05	1.96	11.5	0.5	13.3	93.0
	72†	0.00	0.90	4.75	3.23	2.28				
High output	1*	0.00	0.03	0.08	0.03	0.03	6.0	6.0	6.0	6.0
	1†	0.00	0.03	0.09	0.03	0.03				
Internal leakage	3*	0.01	0.07	0.20	0.07	0.08	26.3	6.0	34.0	48.0
	3†	0.01	0.08	0.22	0.07	0.09				
Low output	1*	0.00	0.03	0.09	0.04	0.03	2.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Other	4*	0.00	0.13	0.45	0.17	0.11	8.3	1.0	16.7	37.0
	4†	0.00	0.16	0.54	0.20	0.13				
Spurious operation	23*	0.00	0.61	2.98	1.25	0.63	3.2	1.0	4.9	24.0
	23†	0.00	1.17	5.39	2.17	0.73				
Structural deficiency	7*	0.00	0.20	0.88	0.35	0.19	5.2	2.0	6.0	16.0
	7†	0.00	0.25	0.85	0.31	0.22				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	62.0	36.0	65.0	94.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	11*	0.03	0.25	0.66	0.21	0.30	8.6	6.0	10.2	35.0
	11†	0.05	0.30	0.74	0.22	0.35				
Degraded	**302***	**1.08**	**8.47**	**21.73**	**6.77**	**8.24**	**8.0**	**0.5**	**9.8**	**92.0**
	302†	**3.87**	**19.74**	**45.72**	**13.45**	**9.55**				
Abnormal instrument reading	6*	0.00	0.24	0.99	0.38	0.16	3.8	2.0	4.5	6.0
	6†	0.00	0.31	1.00	0.36	0.19				
Delayed operation	27*	0.01	1.00	3.34	1.23	0.74	5.8	1.0	10.5	36.0
	27†	0.13	1.59	4.47	1.46	0.85				
External leakage - Process medium	33*	0.02	2.13	7.17	2.63	0.90	8.7	1.0	10.8	45.0
	33†	5.52	20.42	43.00	11.87	1.04				
External leakage - Utility medium	38*	0.00	1.16	4.54	1.69	1.04	9.1	1.0	13.4	92.0
	38†	0.08	1.76	5.29	1.78	1.20				
Fail to open on demand	2*	0.00	0.06	0.18	0.07	0.05	3.3	0.5	3.3	6.0
	2†	0.00	0.07	0.22	0.08	0.06				

Comments

(cont.)

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Taxonomy no	Item
4.3	Control and Safety Equipment Valves

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1170	40	36.6612	31.6175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
High output	4*	0.00	0.10	0.32	0.11	0.11	4.1	2.0	4.4	9.0
	4†	0.00	0.13	0.41	0.15	0.13				
Internal leakage	18*	0.00	0.67	3.33	1.42	0.49	15.3	4.0	20.6	48.0
	18†	0.00	1.02	4.03	1.50	0.57				
Low output	14*	0.00	0.26	1.48	0.77	0.38	5.3	1.0	5.3	13.0
	14†	0.00	0.43	2.30	1.06	0.44				
Minor in-service problems	4*	0.00	0.10	0.38	0.14	0.11	4.0	4.0	4.0	4.0
	4†	0.00	0.12	0.38	0.14	0.13				
Other	44*	0.00	1.47	6.79	2.74	1.20	6.0	2.0	7.6	61.0
	44†	0.02	2.41	8.13	2.98	1.39				
Plugged/Choked	4*	0.00	0.15	0.77	0.35	0.11	2.0	2.0	2.0	2.0
	4†	0.00	0.21	0.93	0.36	0.13				
Spurious operation	74*	0.00	0.68	0.96	4.34	2.02	7.2	4.0	7.4	35.0
	74†	0.00	1.22	6.29	4.78	2.34				
Structural deficiency	3*	0.00	0.35	1.89	0.88	0.08	6.0	6.0	6.0	6.0
	3†	0.00	0.59	2.53	0.98	0.09				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	6.0	2.0	6.0	10.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	29*	0.00	0.47	1.99	0.77	0.79	12.6	2.0	13.0	70.0
	29†	0.01	0.66	2.05	0.73	0.92				
Incipient	**339***	**3.53**	**14.93**	**32.80**	**9.32**	**9.25**	**4.9**	**1.0**	**6.3**	**80.0**
	339†	**86.84**	**143.70**	**212.14**	**38.42**	**10.72**				
Abnormal instrument reading	111*	1.85	9.73	22.72	6.71	3.03	4.1	1.0	5.6	80.0
	111†	105.90	160.11	223.45	35.95	3.51				
Delayed operation	4*	0.00	0.34	1.50	0.59	0.11	2.5	1.0	4.3	8.0
	4†	0.43	3.58	9.25	2.89	0.13				
External leakage - Process medium	4*	0.00	0.18	0.74	0.28	0.11	4.0	1.0	3.7	7.0
	4†	0.00	0.22	0.76	0.28	0.13				
External leakage - Utility medium	30*	0.00	0.88	4.43	1.90	0.82	3.5	1.0	6.5	20.0
	30†	0.36	7.39	22.13	7.41	0.95				
Fail to regulate	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Internal leakage	3*	0.00	0.12	0.47	0.17	0.08	18.0	4.0	15.3	30.0
	3†	0.00	0.13	0.39	0.14	0.09				
Low output	2*	0.00	0.06	0.27	0.11	0.05	3.5	1.0	6.5	12.0
	2†	0.00	0.08	0.34	0.13	0.06				
Minor in-service problems	42*	0.00	2.02	8.34	3.17	1.15	3.0	1.0	3.7	10.0
	42†	0.13	3.34	10.05	3.41	1.33				
Other	28*	0.00	0.60	3.11	2.72	0.76	4.7	1.0	9.6	28.0
	28†	0.00	1.12	6.24	3.22	0.89				
Spurious operation	7*	0.00	0.32	1.45	0.58	0.19	4.8	1.0	8.7	16.0
	7†	0.00	0.61	2.33	0.86	0.22				

Comments

(cont.)

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Taxonomy no	Item
4.3	Control and Safety Equipment Valves

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1170	40	36.6612	31.6175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	3*	0.00	0.35	1.90	0.88	0.08	9.0	13.0	15.5	18.0
	3†	0.00	0.58	2.47	0.96	0.09				
Unknown	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Valve leakage in closed position	103*	0.00	0.74	0.81	6.85	2.81	6.5	2.0	6.5	14.0
	103†	0.00	1.26	2.07	7.57	3.26				
Unknown	**18***	**0.00**	**0.35**	**1.80**	**1.47**	**0.49**	**15.6**	**1.0**	**23.2**	**119.0**
	18†	**0.00**	**0.54**	**3.02**	**1.56**	**0.57**				
Unknown	18*	0.00	0.35	1.80	1.47	0.49	15.6	1.0	23.2	119.0
	18†	0.00	0.54	3.02	1.56	0.57				
All modes	**1017***	**7.74**	**31.05**	**67.14**	**18.89**	**27.74**	**7.5**	**0.5**	**9.7**	**119.0**
	1017†	**110.16**	**190.63**	**289.04**	**54.91**	**32.17**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.79	0.10	0.00	0.00	0.20	0.20	0.10	0.00	0.00
Bonnet	0.00	0.00	0.00	0.10	0.00	0.49	0.00	0.00	0.00
Cabling & junction boxes	0.39	0.10	0.00	0.00	0.00	0.39	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.10	0.00	0.00	0.20	0.10	0.00	0.00	0.00
Control unit	1.38	0.10	0.00	0.10	0.20	0.10	0.69	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flange	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Indicator	0.10	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.00
Instrument, general	0.88	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Monitoring	4.52	0.20	0.00	0.00	0.10	0.00	0.10	0.00	0.00
Other	0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.10
Other actuator components	0.00	0.29	0.00	1.08	0.39	0.10	0.10	0.00	0.00
Other valve components	0.00	0.00	0.59	0.20	0.20	0.44	0.20	0.00	0.20
Packing	0.00	0.00	0.44	0.29	0.21	0.00	0.00	0.00	0.10
Pilot valve	0.10	0.00	0.00	0.49	2.16	0.49	0.00	0.00	0.20
Piston(s)	0.00	0.00	0.00	0.20	0.29	0.29	0.33	0.00	0.00
Positioner	0.39	0.00	0.00	0.10	0.15	0.10	0.88	0.10	0.00
Seals	0.00	0.00	0.84	0.00	0.41	0.00	0.10	0.05	0.29
Seals (gaskets)	0.00	0.00	0.29	2.26	0.00	0.00	0.00	0.00	0.39
Seat rings	0.00	0.00	0.98	0.00	0.56	0.34	0.00	0.05	0.39
Spring	0.00	0.00	0.00	0.00	0.10	0.10	0.03	0.00	0.00
Stem	0.00	0.39	0.20	0.20	0.20	0.20	0.23	0.00	0.00
Subunit	0.10	0.59	0.20	0.49	2.26	1.47	2.36	0.10	0.49
Unknown	0.88	0.79	0.20	0.69	4.82	3.34	1.18	0.00	0.10
Valve body w/internals	0.00	0.69	0.59	0.10	0.59	0.10	0.39	0.20	0.10
Valves	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.20	0.69	0.00	0.10	1.08	0.00	0.00	3.44
Bonnet	0.00	0.00	0.00	0.00	0.10	0.00	0.15	0.00	0.84
Cabling & junction boxes	0.00	0.00	0.59	0.00	0.20	0.00	0.10	0.00	1.77
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.59
Control unit	0.00	0.00	0.00	0.00	0.29	0.29	0.00	0.10	3.24
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Electric motor (electric actuator)	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Indicator	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.54
Instrument, general	0.00	0.10	0.20	0.00	0.20	0.20	0.00	0.00	1.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.39
Monitoring	0.00	0.00	0.20	0.00	0.10	0.00	0.00	0.00	5.21
Other	0.10	0.00	1.08	0.00	0.10	0.00	0.00	0.00	1.77
Other actuator components	0.00	0.00	0.39	0.00	0.29	0.10	0.00	0.00	2.75
Other valve components	0.10	0.00	0.20	0.00	0.20	0.20	0.00	0.00	2.51
Packing	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Pilot valve	0.00	0.00	0.00	0.00	0.79	0.10	0.20	0.29	4.82
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.16
Positioner	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	1.92
Seals	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.00
Seat rings	1.08	0.00	0.10	0.00	0.10	0.10	0.00	0.00	3.70
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Stem	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	1.70
Subunit	1.77	0.00	3.05	0.00	0.39	0.39	0.10	0.79	14.55
Unknown	10.52	0.59	0.49	0.29	1.28	6.69	0.39	0.98	33.24
Valve body w/internals	0.10	0.79	0.00	0.00	0.00	0.88	0.25	0.00	4.77
Valves	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.29	0.00	0.00	0.00	1.87	1.57	0.49	0.20	0.10
Breakage	0.20	0.00	0.29	0.20	0.20	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.29	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.10
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Corrosion	0.39	0.20	0.10	0.20	0.20	0.20	0.39	0.00	0.00
Deformation	0.00	0.00	0.29	0.10	0.10	0.20	0.20	0.10	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Electrical failure - general	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.10	0.00	0.10	0.00	0.20	0.00	0.10
External influence - general	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.95	0.59	0.00	0.20	3.05	1.28	0.10	0.10	0.00
Leakage	0.00	0.20	2.06	4.23	0.39	0.10	0.10	0.00	0.49
Looseness	0.00	0.10	0.20	0.20	0.10	0.00	0.10	0.00	0.20
Material failure - general	0.10	0.00	0.29	0.49	0.39	1.57	0.00	0.00	0.20
Mechanical Failure - general	0.20	1.08	0.00	0.49	2.46	1.38	1.08	0.00	0.29
Misc. external influences	0.20	0.10	0.00	0.10	0.20	0.20	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.29	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Open circuit	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	4.52	0.29	0.00	0.20	0.98	0.29	3.05	0.00	0.10
Short circuiting	0.10	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.49	0.00	0.00	0.29	0.29	0.00	0.00	0.00
Unknown	0.00	0.29	0.29	0.10	0.69	0.49	0.20	0.10	0.10
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00
Wear	0.00	0.00	1.08	0.29	1.67	0.29	0.79	0.00	0.59
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	1.18	0.10	0.29	0.10	0.10	0.00	0.00	6.29
Breakage	0.00	0.00	0.10	0.00	0.00	0.20	0.00	0.00	1.18
Cavitation	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.20
Clearance/ alignment failure	0.20	0.00	0.00	0.00	0.00	0.10	0.00	0.10	1.38
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Corrosion	0.10	0.00	1.28	0.00	0.69	0.10	0.29	0.10	4.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Electrical failure - general	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.00	0.29
Erosion	0.20	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.79
External influence - general	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Faulty signal/indication/alarm	0.00	0.10	0.29	0.00	0.10	0.59	0.00	0.00	2.56
Instrument failure - general	0.10	0.00	0.39	0.00	0.69	0.88	0.20	0.59	11.11
Leakage	2.56	0.10	0.00	0.00	0.10	0.29	0.00	0.00	10.62
Looseness	0.20	0.00	0.20	0.00	0.69	0.10	0.00	0.00	2.06
Material failure - general	10.32	0.00	0.20	0.00	0.00	6.39	0.10	0.00	20.06
Mechanical Failure - general	0.20	0.10	0.29	0.00	0.39	0.49	0.29	0.39	9.14
Misc. external influences	0.00	0.00	0.29	0.00	0.49	0.00	0.10	0.00	1.67
Miscellaneous - general	0.00	0.00	0.10	0.00	0.10	0.29	0.00	0.00	0.59
No cause found	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.20
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Other	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.20
Out of adjustment	0.00	0.20	3.05	0.00	0.20	0.20	0.00	0.10	13.18
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.29
Software failure	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.20
Sticking	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	1.38
Unknown	0.10	0.00	0.29	0.10	0.29	0.29	0.00	0.98	4.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.49
Wear	0.10	0.00	0.20	0.00	0.00	0.00	0.10	0.00	5.11
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.1	Control and Safety Equipment Valves Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
316	18	9.7170	9.3247	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**123***	**0.00**	**10.06**	**43.64**	**16.95**	**12.66**	**6.3**	**1.0**	**10.7**	**113.0**
	123†	**0.00**	**10.47**	**45.13**	**17.49**	**13.19**				
Delayed operation	3*	0.00	0.28	1.13	0.43	0.31	32.0	28.0	64.0	113.0
	3†	0.00	0.30	1.30	0.50	0.32				
External leakage - Utility medium	2*	0.00	0.19	0.76	0.28	0.21	9.8	17.0	19.5	22.0
	2†	0.00	0.21	0.88	0.34	0.21				
Fail to close on demand	61*	0.00	5.73	30.99	14.39	6.28	6.3	1.0	9.9	60.0
	61†	0.00	5.85	31.72	14.76	6.54				
Fail to open on demand	35*	0.59	3.31	7.86	2.34	3.60	5.7	1.0	9.9	78.0
	35†	0.73	3.46	7.85	2.28	3.75				
Other	3*	0.00	0.28	1.13	0.43	0.31	8.3	1.0	16.7	37.0
	3†	0.00	0.30	1.30	0.50	0.32				
Spurious operation	17*	0.01	1.32	4.39	1.61	1.75	2.2	1.0	4.2	24.0
	17†	0.00	1.36	5.41	2.02	1.82				
Structural deficiency	2*	0.00	0.22	0.84	0.31	0.21	2.0	2.0	2.0	2.0
	2†	0.00	0.23	0.85	0.31	0.21				
Degraded	**85***	**2.70**	**16.37**	**39.61**	**11.96**	**8.75**	**9.3**	**1.0**	**14.2**	**92.0**
	85†	**2.79**	**17.00**	**41.22**	**12.47**	**9.12**				
Abnormal instrument reading	3*	0.00	0.50	2.05	0.78	0.31	3.5	2.0	4.3	6.0
	3†	0.00	0.51	2.07	0.78	0.32				
Delayed operation	18*	0.32	2.06	5.05	1.54	1.85	5.9	1.0	10.9	36.0
	18†	0.36	2.13	5.13	1.54	1.93				
External leakage - Process medium	10*	0.00	2.48	10.33	3.93	1.03	10.8	1.0	13.6	36.0
	10†	0.00	2.62	10.90	4.16	1.07				
External leakage - Utility medium	26*	0.18	2.82	8.24	2.73	2.68	8.4	1.0	14.7	92.0
	26†	0.21	2.94	8.44	2.78	2.79				
Fail to open on demand	1*	0.00	0.10	0.40	0.15	0.10	6.0	6.0	6.0	6.0
	1†	0.00	0.11	0.41	0.15	0.11				
Internal leakage	10*	0.01	1.96	7.59	2.81	1.03	12.8	4.0	24.6	48.0
	10†	0.01	1.98	7.69	2.85	1.07				
Other	11*	0.01	3.48	13.69	5.10	1.13	13.5	2.0	12.2	61.0
	11†	0.01	3.66	14.44	5.38	1.18				
Plugged/Choked	1*	0.00	0.37	1.87	0.81	0.10	-	-	-	-
	1†	0.00	0.37	1.90	0.82	0.11				
Spurious operation	1*	0.00	0.12	0.58	0.25	0.10	14.0	14.0	14.0	14.0
	1†	0.00	0.12	0.60	0.25	0.11				
Structural deficiency	2*	0.00	0.94	4.55	1.88	0.21	-	6.0	6.0	6.0
	2†	0.00	1.00	4.82	1.99	0.21				
Unknown	1*	0.00	0.12	0.58	0.25	0.10	2.0	2.0	2.0	2.0
	1†	0.00	0.12	0.60	0.25	0.11				

Comments

(cont.)

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Taxonomy no	Item
4.3.1	Control and Safety Equipment Valves Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
316	18	9.7170	9.3247	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Valve leakage in closed position	1*	0.00	0.12	0.58	0.25	0.10	58.0	70.0	70.0	70.0
	1†	0.00	0.12	0.60	0.25	0.11				
Incipient	**112***	**2.79**	**13.86**	**31.90**	**9.35**	**11.53**	**5.2**	**1.0**	**8.5**	**67.0**
	112†	**2.86**	**14.65**	**33.97**	**10.00**	**12.01**				
Abnormal instrument reading	29*	0.27	4.61	13.60	4.52	2.98	6.9	1.0	10.1	67.0
	29†	0.30	4.91	14.36	4.76	3.11				
External leakage - Process medium	3*	0.00	0.39	1.66	0.64	0.31	4.0	1.0	4.0	7.0
	3†	0.00	0.41	1.75	0.68	0.32				
External leakage - Utility medium	23*	0.00	1.04	5.73	2.68	2.37	3.8	2.0	7.7	20.0
	23†	0.00	1.10	5.84	2.66	2.47				
Internal leakage	2*	0.00	0.22	1.18	0.54	0.21	18.0	12.0	21.0	30.0
	2†	0.00	0.23	1.24	0.57	0.21				
Low output	1*	0.00	0.10	0.39	0.14	0.10	6.0	12.0	12.0	12.0
	1†	0.00	0.11	0.44	0.17	0.11				
Minor in-service problems	26*	0.12	5.48	16.91	5.95	2.68	2.6	1.0	3.6	10.0
	26†	0.12	5.57	17.21	6.06	2.79				
Other	24*	0.00	1.65	9.13	4.64	2.47	4.9	1.0	9.6	28.0
	24†	0.00	1.83	10.21	5.31	2.57				
Structural deficiency	3*	0.00	0.85	4.08	1.68	0.31	9.0	13.0	15.5	18.0
	3†	0.00	0.87	4.17	1.72	0.32				
Valve leakage in closed position	1*	0.00	0.14	0.60	0.23	0.10	7.0	7.0	7.0	7.0
	1†	0.00	0.15	0.64	0.25	0.11				
Unknown	**8***	**0.00**	**0.84**	**4.84**	**2.62**	**0.82**	**2.0**	**1.0**	**2.7**	**8.0**
	8†	**0.00**	**0.86**	**4.96**	**2.68**	**0.86**				
Unknown	8*	0.00	0.84	4.84	2.62	0.82	2.0	1.0	2.7	8.0
	8†	0.00	0.86	4.96	2.68	0.86				
All modes	**328***	**8.45**	**42.01**	**96.67**	**28.34**	**33.76**	**6.4**	**1.0**	**10.7**	**113.0**
	328†	**8.80**	**43.70**	**100.54**	**29.47**	**35.18**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Ball

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	2.13	0.00	0.00	0.00	0.61	0.30	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.30	0.00	0.00	0.00	0.91	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.30	0.00	0.00	0.30	0.30	0.00	0.00	0.00
Control unit	1.52	0.30	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Instrument, general	2.13	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.61	0.30	0.00	0.00	0.00	0.00	0.30
Other actuator components	0.00	0.30	0.00	1.83	0.61	0.30	0.00	0.00	0.00
Other valve components	0.00	0.00	0.91	0.00	0.00	0.30	0.00	0.00	0.61
Packing	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	1.22	3.05	1.52	0.00	0.00	0.61
Piston(s)	0.00	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Positioner	0.91	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.30	6.71	0.00	0.00	0.00	0.00	1.22
Seat rings	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
Stem	0.00	1.22	0.30	0.61	0.61	0.61	0.00	0.00	0.00
Subunit	0.00	0.91	0.00	0.00	2.44	2.13	0.00	0.00	0.00
Unknown	0.91	1.83	0.30	1.52	9.45	2.44	0.00	0.00	0.30
Valve body w/internals	0.00	0.61	0.30	0.30	0.61	0.30	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Total	9.76	6.40	3.96	15.55	18.60	10.98	0.00	0.00	3.66

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Ball

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.30	1.52	0.00	0.30	3.35	0.00	0.00	8.54
Bonnet	0.00	0.00	0.00	0.00	0.30	0.00	0.46	0.00	2.29
Cabling & junction boxes	0.00	0.00	1.83	0.00	0.30	0.00	0.00	0.00	3.35
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Control unit	0.00	0.00	0.00	0.00	0.30	0.30	0.00	0.00	3.05
Electric motor (electric actuator)	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.30
Indicator	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.91
Instrument, general	0.00	0.00	0.61	0.00	0.30	0.61	0.00	0.00	4.88
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83
Monitoring	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	1.22
Other	0.30	0.00	3.05	0.00	0.30	0.00	0.00	0.00	4.88
Other actuator components	0.00	0.00	1.22	0.00	0.91	0.00	0.00	0.00	5.18
Other valve components	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	2.13
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Pilot valve	0.00	0.00	0.00	0.00	0.91	0.30	0.00	0.61	8.23
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Positioner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.23
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Stem	0.00	0.00	0.00	0.00	0.30	0.30	0.30	0.00	4.27
Subunit	0.30	0.00	0.91	0.00	1.22	0.00	0.00	0.30	8.23
Unknown	0.00	0.00	0.61	0.30	2.13	0.61	1.22	1.83	23.48
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	2.29
Valves	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.22
Total	0.61	0.30	11.59	0.30	7.93	5.49	2.13	2.74	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Ball

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.61	0.00	0.00	0.00	2.13	0.30	0.00	0.00	0.30
Breakage	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Corrosion	0.91	0.61	0.30	0.00	0.61	0.61	0.00	0.00	0.00
Deformation	0.00	0.00	0.00	0.30	0.30	0.00	0.00	0.00	0.00
Electrical failure - general	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	3.66	1.83	0.00	0.61	6.10	3.35	0.00	0.00	0.00
Leakage	0.00	0.30	2.74	10.98	0.30	0.00	0.00	0.00	1.52
Looseness	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.30	0.00	0.91	1.22	0.30	0.00	0.00	0.00	0.61
Mechanical Failure - general	0.30	1.52	0.00	0.61	4.88	3.05	0.00	0.00	0.91
Misc. external influences	0.00	0.00	0.00	0.30	0.61	0.30	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.22	0.30	0.00	0.00	0.30	0.30	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
Sticking	0.00	1.22	0.00	0.00	0.91	0.61	0.00	0.00	0.00
Unknown	0.00	0.61	0.00	0.30	1.22	0.61	0.00	0.00	0.30
Wear	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Total	9.76	6.40	3.96	15.55	18.60	10.98	0.00	0.00	3.66

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Ball

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.66
Breakage	0.00	0.00	0.30	0.00	0.00	0.30	0.00	0.00	1.22
Cavitation	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.52
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Corrosion	0.00	0.00	3.66	0.00	0.61	0.00	0.91	0.00	8.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Electrical failure - general	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.61
External influence - general	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	1.22
Faulty signal/indication/alarm	0.00	0.30	0.91	0.00	0.00	1.52	0.00	0.00	4.88
Instrument failure - general	0.00	0.00	1.22	0.00	0.61	2.74	0.00	1.52	21.65
Leakage	0.61	0.00	0.00	0.00	0.30	0.00	0.00	0.00	16.77
Looseness	0.00	0.00	0.30	0.00	2.13	0.30	0.00	0.00	3.05
Material failure - general	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.66
Mechanical Failure - general	0.00	0.00	0.61	0.00	0.91	0.00	0.61	0.30	13.72
Misc. external influences	0.00	0.00	0.91	0.00	0.91	0.00	0.00	0.00	3.05
Miscellaneous - general	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.30
No cause found	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.30
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Other	0.00	0.00	0.00	0.00	0.30	0.00	0.30	0.00	0.61
Out of adjustment	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	2.44
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Sticking	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	3.66
Unknown	0.00	0.00	0.91	0.30	0.91	0.61	0.00	0.91	6.71
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.61
Total	0.61	0.30	11.59	0.30	7.93	5.49	2.13	2.74	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.1.1	Control and Safety Equipment Valves Ball Emergency shutdown (ESD)

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	1	0.5504	0.5554	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**25.56**	**38.15**	**54.94**	**38.15**	**38.15**	**6.8**	**1.0**	**14.6**	**55.0**
	21†	**25.34**	**37.81**	**54.45**	**37.81**	**37.81**				
Delayed operation	2*	0.64	3.63	11.44	3.63	3.63	19.8	28.0	39.5	51.0
	2†	0.64	3.60	11.33	3.60	3.60				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	8.5	17.0	17.0	17.0
	1†	0.09	1.80	8.54	1.80	1.80				
Fail to close on demand	3*	1.49	5.45	14.09	5.45	5.45	18.2	34.0	43.0	55.0
	3†	1.48	5.40	13.96	5.40	5.40				
Fail to open on demand	1*	0.09	1.82	8.62	1.82	1.82	3.5	7.0	7.0	7.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	3*	1.49	5.45	14.09	5.45	5.45	8.3	1.0	16.7	37.0
	3†	1.48	5.40	13.96	5.40	5.40				
Spurious operation	11*	11.21	19.98	33.08	19.98	19.98	1.1	1.0	2.2	14.0
	11†	11.11	19.81	32.79	19.81	19.81				
Degraded	**5***	**3.58**	**9.08**	**19.10**	**9.08**	**9.08**	**14.8**	**11.0**	**29.6**	**61.0**
	5†	**3.55**	**9.00**	**18.93**	**9.00**	**9.00**				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	20.0	40.0	40.0	40.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	4*	2.48	7.27	16.63	7.27	7.27	13.5	11.0	27.0	61.0
	4†	2.46	7.20	16.48	7.20	7.20				
Incipient	**24***	**30.06**	**43.60**	**61.32**	**43.60**	**43.60**	**5.4**	**1.0**	**10.7**	**29.0**
	24†	**29.80**	**43.21**	**60.77**	**43.21**	**43.21**				
Abnormal instrument reading	2*	0.64	3.63	11.44	3.63	3.63	12.0	19.0	24.0	29.0
	2†	0.64	3.60	11.33	3.60	3.60				
External leakage - Utility medium	1*	0.09	1.82	8.62	1.82	1.82	3.0	6.5	6.5	6.5
	1†	0.09	1.80	8.54	1.80	1.80				
Low output	1*	0.09	1.82	8.62	1.82	1.82	6.0	12.0	12.0	12.0
	1†	0.09	1.80	8.54	1.80	1.80				
Other	19*	22.60	34.52	50.65	34.52	34.52	4.5	1.0	8.9	28.0
	19†	22.40	34.21	50.20	34.21	34.21				
Structural deficiency	1*	0.09	1.82	8.62	1.82	1.82	9.0	18.0	18.0	18.0
	1†	0.09	1.80	8.54	1.80	1.80				
All modes	**50***	**70.79**	**90.84**	**114.98**	**90.84**	**90.84**	**7.0**	**1.0**	**14.4**	**61.0**
	50†	**70.16**	**90.03**	**113.95**	**90.03**	**90.03**				

Comments

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Taxonomy no	Item
4.3.1.2	Control and Safety Equipment Valves Ball Flare, vent & blow-down

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1462	0.1461	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**2.43**	**13.68**	**43.06**	**13.68**	**13.68**	**6.0**	**4.0**	**16.5**	**29.0**
	2†	**2.43**	**13.69**	**43.08**	**13.69**	**13.69**				
Fail to open on demand	2*	2.43	13.68	43.06	13.68	13.68	6.0	4.0	16.5	29.0
	2†	2.43	13.69	43.08	13.69	13.69				
Degraded	**2***	**2.43**	**13.68**	**43.06**	**13.68**	**13.68**	**8.0**	**10.0**	**17.5**	**25.0**
	2†	**2.43**	**13.69**	**43.08**	**13.69**	**13.69**				
Delayed operation	2*	2.43	13.68	43.06	13.68	13.68	8.0	10.0	17.5	25.0
	2†	2.43	13.69	43.08	13.69	13.69				
All modes	**4***	**9.34**	**27.36**	**62.62**	**27.36**	**27.36**	**7.0**	**4.0**	**17.0**	**29.0**
	4†	**9.34**	**27.37**	**62.65**	**27.37**	**27.37**				

Comments

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Taxonomy no	Item
4.3.1.3	Control and Safety Equipment Valves Ball Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
224	17	6.5555	6.3474	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**87***	**0.00**	**10.40**	**50.64**	**21.10**	**13.27**	**5.8**	**1.0**	**9.0**	**113.0**
	87†	**0.00**	**10.90**	**52.34**	**21.57**	**13.71**				
Delayed operation	1*	0.00	0.18	0.93	0.42	0.15	56.5	113.0	113.0	113.0
	1†	0.00	0.21	1.16	0.54	0.16				
Fail to close on demand	52*	0.00	5.86	33.01	17.44	7.93	5.2	1.0	7.1	46.0
	52†	0.00	6.00	33.78	17.83	8.19				
Fail to open on demand	26*	0.48	3.83	9.84	3.07	3.97	5.3	1.0	9.2	78.0
	26†	0.46	3.98	10.36	3.25	4.10				
Spurious operation	6*	0.09	0.78	2.05	0.65	0.92	4.3	2.0	7.8	24.0
	6†	0.10	0.81	2.08	0.65	0.95				
Structural deficiency	2*	0.00	0.29	0.95	0.35	0.31	2.0	2.0	2.0	2.0
	2†	0.00	0.30	0.97	0.35	0.32				
Degraded	**65***	**2.48**	**18.42**	**46.72**	**14.48**	**9.92**	**9.7**	**1.0**	**13.6**	**92.0**
	65†	**2.63**	**19.29**	**48.76**	**15.09**	**10.24**				
Abnormal instrument reading	3*	0.00	0.57	1.94	0.71	0.46	3.5	2.0	4.3	6.0
	3†	0.01	0.58	1.92	0.70	0.47				
Delayed operation	14*	0.22	2.34	6.40	2.06	2.14	5.5	1.0	9.5	36.0
	14†	0.16	2.45	7.11	2.35	2.21				
External leakage - Process medium	10*	0.00	2.80	11.82	4.54	1.53	10.8	1.0	13.6	36.0
	10†	0.00	2.96	12.48	4.79	1.58				
External leakage - Utility medium	17*	0.10	3.33	10.13	3.51	2.59	9.0	1.0	15.2	92.0
	17†	0.13	3.52	10.62	3.63	2.68				
Internal leakage	10*	0.01	2.27	8.52	3.14	1.53	12.8	4.0	24.6	48.0
	10†	0.01	2.31	8.59	3.17	1.58				
Other	7*	0.00	3.66	15.78	6.12	1.07	-	2.0	2.3	4.0
	7†	0.00	3.83	16.55	6.42	1.10				
Plugged/Choked	1*	0.00	0.40	2.07	0.90	0.15	-	-	-	-
	1†	0.00	0.41	2.10	0.91	0.16				
Structural deficiency	2*	0.00	1.04	5.18	2.21	0.31	-	6.0	6.0	6.0
	2†	0.00	1.10	5.48	2.33	0.32				
Valve leakage in closed position	1*	0.00	0.17	0.88	0.38	0.15	58.0	70.0	70.0	70.0
	1†	0.00	0.18	0.91	0.39	0.16				
Incipient	**69***	**1.35**	**12.18**	**32.12**	**10.16**	**10.53**	**5.3**	**1.0**	**7.8**	**67.0**
	69†	**1.50**	**12.62**	**32.78**	**10.27**	**10.87**				
Abnormal instrument reading	19*	0.11	3.31	10.01	3.43	2.90	8.1	1.0	11.5	67.0
	19†	0.13	3.51	10.59	3.61	2.99				
External leakage - Process medium	2*	0.00	0.42	1.98	0.81	0.31	4.0	1.0	4.0	7.0
	2†	0.00	0.44	2.09	0.86	0.32				
External leakage - Utility medium	18*	0.00	1.37	7.55	3.81	2.75	3.7	2.0	7.4	20.0
	18†	0.00	1.44	7.90	3.82	2.84				

Comments

(cont.)

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Taxonomy no	Item
4.3.1.3	Control and Safety Equipment Valves Ball Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
224	17	6.5555	6.3474	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Internal leakage	1*	0.00	0.21	1.14	0.55	0.15	30.0	30.0	30.0	30.0
	1†	0.00	0.22	1.20	0.58	0.16				
Minor in-service problems	25*	0.12	6.20	19.25	6.82	3.81	2.6	1.0	3.6	10.0
	25†	0.13	6.31	19.56	6.91	3.94				
Other	1*	0.00	0.14	0.43	0.15	0.15	2.0	3.0	3.0	3.0
	1†	0.00	0.14	0.45	0.16	0.16				
Structural deficiency	2*	0.00	0.93	4.74	2.04	0.31	-	13.0	13.0	13.0
	2†	0.00	0.95	4.81	2.07	0.32				
Valve leakage in closed position	1*	0.00	0.21	1.14	0.55	0.15	7.0	7.0	7.0	7.0
	1†	0.00	0.22	1.20	0.58	0.16				
Unknown	**6***	**0.00**	**0.82**	**4.52**	**2.19**	**0.92**	**2.2**	**1.0**	**2.8**	**8.0**
	6†	**0.00**	**0.85**	**4.65**	**2.23**	**0.95**				
Unknown	6*	0.00	0.82	4.52	2.19	0.92	2.2	1.0	2.8	8.0
	6†	0.00	0.85	4.65	2.23	0.95				
All modes	**227***	**4.96**	**42.23**	**109.81**	**34.42**	**34.63**	**6.3**	**1.0**	**9.7**	**113.0**
	227†	**5.62**	**43.97**	**112.62**	**35.07**	**35.76**				

Comments

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Taxonomy no		Item
4.3.1.4		Control and Safety Equipment Valves Ball Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.03	7.76 7.98	29.79 30.64	10.97 11.29	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.3.1.5	Control and Safety Equipment Valves Ball Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
48	6	1.7460	1.5593	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**10***	**3.22**	**5.85**	**9.11**	**1.81**	**5.73**	**9.1**	**3.0**	**15.9**	**60.0**
	10†	**0.75**	**6.78**	**17.89**	**5.66**	**6.41**				
External leakage - Utility medium	1*	0.00	0.52	2.09	0.78	0.57	11.0	22.0	22.0	22.0
	1†	0.00	0.61	2.63	1.02	0.64				
Fail to close on demand	3*	0.08	2.86	8.71	3.02	1.72	11.8	3.0	22.7	60.0
	3†	0.12	2.98	8.98	3.05	1.92				
Fail to open on demand	6*	0.65	3.26	7.53	2.21	3.44	7.5	3.0	11.5	16.0
	6†	1.53	3.68	6.59	1.57	3.85				
Degraded	**11***	**2.72**	**6.35**	**11.22**	**2.64**	**6.30**	**6.5**	**2.0**	**10.1**	**16.0**
	11†	**3.95**	**7.05**	**10.87**	**2.13**	**7.05**				
Delayed operation	2*	0.19	1.19	2.90	0.88	1.15	6.5	10.0	13.0	16.0
	2†	0.24	1.31	3.06	0.91	1.28				
External leakage - Utility medium	7*	0.23	3.64	10.63	3.52	4.01	6.0	4.0	9.8	13.0
	7†	0.35	4.06	11.31	3.68	4.49				
Spurious operation	1*	0.01	0.65	2.12	0.77	0.57	14.0	14.0	14.0	14.0
	1†	0.05	0.69	1.97	0.65	0.64				
Unknown	1*	0.01	0.65	2.12	0.77	0.57	2.0	2.0	2.0	2.0
	1†	0.05	0.69	1.97	0.65	0.64				
Incipient	**16***	**2.04**	**10.75**	**25.09**	**7.41**	**9.16**	**4.8**	**2.0**	**8.0**	**28.0**
	16†	**2.63**	**11.88**	**26.61**	**7.66**	**10.26**				
Abnormal instrument reading	8*	0.13	7.56	23.71	8.47	4.58	3.4	2.0	3.8	8.0
	8†	0.16	8.35	25.97	9.21	5.13				
External leakage - Process medium	1*	0.00	0.51	1.89	0.70	0.57	-	-	-	-
	1†	0.00	0.57	1.90	0.70	0.64				
External leakage - Utility medium	2*	0.00	0.95	3.75	1.40	1.15	7.0	12.0	14.0	16.0
	2†	0.01	1.04	3.78	1.40	1.28				
Minor in-service problems	1*	0.00	0.52	2.09	0.78	0.57	2.5	5.0	5.0	5.0
	1†	0.00	0.61	2.63	1.02	0.64				
Other	4*	0.01	2.22	8.01	2.96	2.29	7.1	4.0	14.3	28.0
	4†	0.02	2.53	8.69	3.20	2.57				
Unknown	**2***	**0.00**	**3.84**	**15.97**	**6.08**	**1.15**	**1.0**	**2.0**	**2.0**	**2.0**
	2†	**0.00**	**3.93**	**16.70**	**6.44**	**1.28**				
Unknown	2*	0.00	3.84	15.97	6.08	1.15	1.0	2.0	2.0	2.0
	2†	0.00	3.93	16.70	6.44	1.28				
All modes	**39***	**10.07**	**25.94**	**47.80**	**11.76**	**22.34**	**6.4**	**2.0**	**10.6**	**60.0**
	39†	**13.50**	**27.59**	**45.74**	**9.95**	**25.01**				

Comments

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Taxonomy no	Item
4.3.1.6	Control and Safety Equipment Valves Ball Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
13	3	0.6356	0.6347	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.24**	**5.46**	**16.39**	**5.51**	**4.72**	**6.0**	**2.0**	**11.3**	**20.0**
	3†	**0.25**	**5.47**	**16.43**	**5.52**	**4.73**				
Fail to close on demand	3*	0.24	5.46	16.39	5.51	4.72	6.0	2.0	11.3	20.0
	3†	0.25	5.47	16.43	5.52	4.73				
Degraded	**2***	**0.90**	**3.65**	**7.90**	**2.22**	**3.15**	**6.0**	**6.0**	**9.0**	**12.0**
	2†	**0.91**	**3.65**	**7.91**	**2.23**	**3.15**				
External leakage - Utility medium	1*	0.02	1.41	4.41	1.57	1.57	6.0	12.0	12.0	12.0
	1†	0.02	1.41	4.42	1.58	1.58				
Fail to open on demand	1*	0.01	3.69	14.80	5.55	1.57	6.0	6.0	6.0	6.0
	1†	0.01	3.71	14.85	5.56	1.58				
Incipient	**3***	**0.46**	**4.05**	**10.62**	**3.35**	**4.72**	**3.7**	**4.0**	**7.3**	**12.0**
	3†	**0.46**	**4.06**	**10.63**	**3.35**	**4.73**				
External leakage - Utility medium	2*	0.37	2.82	7.18	2.23	3.15	2.5	4.0	5.0	6.0
	2†	0.37	2.83	7.19	2.23	3.15				
Internal leakage	1*	0.02	1.41	4.41	1.57	1.57	6.0	12.0	12.0	12.0
	1†	0.02	1.41	4.42	1.58	1.58				
All modes	**8***	**1.51**	**13.21**	**34.58**	**10.88**	**12.59**	**5.1**	**2.0**	**9.3**	**20.0**
	8†	**1.52**	**13.26**	**34.64**	**10.89**	**12.60**				

Comments

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Taxonomy no	Item
4.3.1.7	Control and Safety Equipment Valves Ball Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.05	11.75	45.12	16.62	0.00	-	-	-	-
	0†	0.05	11.89	45.64	16.81	0.00				

Comments

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Taxonomy no	Item
4.3.2	Control and Safety Equipment Valves Butterfly

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	3	0.6974	0.6451	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**4.02**	**9.26**	**16.25**	**3.79**	**10.04**	**4.6**	**2.0**	**4.6**	**8.0**
	7†	**1.22**	**9.27**	**23.59**	**7.32**	**10.85**				
External leakage - Process medium	1*	0.02	1.26	3.99	1.43	1.43	2.0	2.0	2.0	2.0
	1†	0.02	1.36	4.31	1.55	1.55				
Fail to close on demand	2*	0.03	2.36	7.51	2.70	2.87	5.0	4.0	5.0	6.0
	2†	0.06	2.57	7.91	2.78	3.10				
Fail to regulate	4*	0.82	5.32	13.06	3.98	5.74	5.0	2.0	5.0	8.0
	4†	0.64	5.84	15.43	4.89	6.20				
Degraded	**8***	**4.62**	**10.47**	**18.22**	**4.21**	**11.47**	**7.3**	**1.0**	**7.3**	**28.0**
	8†	**5.29**	**11.43**	**19.46**	**4.38**	**12.40**				
External leakage - Process medium	5*	0.70	5.77	14.93	4.67	7.17	9.0	1.0	9.0	28.0
	5†	1.43	6.50	14.58	4.21	7.75				
External leakage - Utility medium	1*	0.01	1.91	6.86	2.54	1.43	4.0	4.0	4.0	4.0
	1†	0.01	2.53	9.99	3.72	1.55				
Internal leakage	1*	0.02	1.26	3.99	1.43	1.43	5.0	5.0	5.0	5.0
	1†	0.02	1.36	4.31	1.55	1.55				
Low output	1*	0.02	1.26	3.99	1.43	1.43	4.0	4.0	4.0	4.0
	1†	0.02	1.36	4.31	1.55	1.55				
Unknown	**1***	**0.02**	**1.26**	**3.99**	**1.43**	**1.43**	**67.0**	**114.0**	**114.0**	**114.0**
	1†	**0.02**	**1.36**	**4.31**	**1.55**	**1.55**				
Unknown	1*	0.02	1.26	3.99	1.43	1.43	67.0	114.0	114.0	114.0
	1†	0.02	1.36	4.31	1.55	1.55				
All modes	**16***	**2.61**	**17.99**	**44.92**	**13.81**	**22.94**	**9.8**	**1.0**	**12.8**	**114.0**
	16†	**3.97**	**20.11**	**46.49**	**13.66**	**24.80**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Butterfly

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.00	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	6.25	0.00	0.00
Packing	0.00	0.00	3.13	0.00	0.00	0.00	0.00	0.00	6.25
Seat rings	0.00	0.00	9.38	0.00	0.00	0.00	0.00	0.00	0.00
Spring	0.00	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	6.25	0.00	0.00	12.50	0.00	0.00
Valve body w/internals	0.00	0.00	25.00	0.00	0.00	0.00	6.25	0.00	0.00
Total	0.00	0.00	37.50	6.25	12.50	0.00	25.00	0.00	6.25

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Butterfly

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.38
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	25.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.25
Total	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Butterfly

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	6.25	0.00	6.25
Mechanical Failure - general	0.00	0.00	0.00	6.25	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	6.25	0.00	6.25	0.00	0.00
Unknown	0.00	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	31.25	0.00	6.25	0.00	0.00	0.00	0.00
Total	0.00	0.00	37.50	6.25	12.50	0.00	25.00	0.00	6.25

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Butterfly

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25
Out of adjustment	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	18.75
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25	12.50
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.50
Total	0.00	6.25	0.00	0.00	0.00	0.00	0.00	6.25	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.2.1	Control and Safety Equipment Valves Butterfly Cooling systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.1840	0.1793	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.27**	**5.44**	**25.79**	**5.44**	**5.44**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**0.28**	**5.58**	**26.47**	**5.58**	**5.58**				
Fail to regulate	1*	0.27	5.44	25.79	5.44	5.44	4.0	4.0	4.0	4.0
	1†	0.28	5.58	26.47	5.58	5.58				
Degraded	**1***	**0.27**	**5.44**	**25.79**	**5.44**	**5.44**	**5.0**	**5.0**	**5.0**	**5.0**
	1†	**0.28**	**5.58**	**26.47**	**5.58**	**5.58**				
Internal leakage	1*	0.27	5.44	25.79	5.44	5.44	5.0	5.0	5.0	5.0
	1†	0.28	5.58	26.47	5.58	5.58				
All modes	**2***	**1.93**	**10.87**	**34.22**	**10.87**	**10.87**	**4.5**	**4.0**	**4.5**	**5.0**
	2†	**1.98**	**11.16**	**35.12**	**11.16**	**11.16**				

Comments

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Taxonomy no		Item
4.3.2.2		Control and Safety Equipment Valves Butterfly Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1719	0.1583	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.50	9.62	3.54	0.00	-	-	-	-
	0†	0.01	2.73	10.48	3.86	0.00				

Comments

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Taxonomy no	Item
4.3.2.3	Control and Safety Equipment Valves Butterfly Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.51**	**10.15**	**48.15**	**10.15**	**10.15**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.70**	**13.96**	**66.26**	**13.96**	**13.96**				
Fail to regulate	1*	0.51	10.15	48.15	10.15	10.15	2.0	2.0	2.0	2.0
	1†	0.70	13.96	66.26	13.96	13.96				
Degraded	**1***	**0.51**	**10.15**	**48.15**	**10.15**	**10.15**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**0.70**	**13.96**	**66.26**	**13.96**	**13.96**				
External leakage - Utility medium	1*	0.51	10.15	48.15	10.15	10.15	4.0	4.0	4.0	4.0
	1†	0.70	13.96	66.26	13.96	13.96				
All modes	**2***	**3.60**	**20.30**	**63.88**	**20.30**	**20.30**	**3.0**	**2.0**	**3.0**	**4.0**
	2†	**4.96**	**27.93**	**87.90**	**27.93**	**27.93**				

Comments

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Taxonomy no	Item
4.3.2.4	Control and Safety Equipment Valves Butterfly Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.0854	0.0823	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**1***	**0.59**	**11.71**	**55.57**	**11.71**	**11.71**	**67.0**	**114.0**	**114.0**	**114.0**
	1†	**0.61**	**12.15**	**57.66**	**12.15**	**12.15**				
Unknown	1*	0.59	11.71	55.57	11.71	11.71	67.0	114.0	114.0	114.0
	1†	0.61	12.15	57.66	12.15	12.15				
All modes	**1***	**0.59**	**11.71**	**55.57**	**11.71**	**11.71**	**67.0**	**114.0**	**114.0**	**114.0**
	1†	**0.61**	**12.15**	**57.66**	**12.15**	**12.15**				

Comments

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Taxonomy no	Item
4.3.2.5	Control and Safety Equipment Valves Butterfly Sea water lift

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**	**5.0**	**4.0**	**5.0**	**6.0**
	2†	**6.93**	**39.05**	**122.91**	**39.05**	**39.05**				
Fail to close on demand	2*	6.75	38.05	119.77	38.05	38.05	5.0	4.0	5.0	6.0
	2†	6.93	39.05	122.91	39.05	39.05				
All modes	**2***	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**	**5.0**	**4.0**	**5.0**	**6.0**
	2†	**6.93**	**39.05**	**122.91**	**39.05**	**39.05**				

Comments

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Taxonomy no	Item
4.3.2.6	Control and Safety Equipment Valves Butterfly Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**15.60**	**57.08**	**147.55**	**57.08**	**57.08**	**5.3**	**2.0**	**5.3**	**8.0**
	3†	**16.01**	**58.58**	**151.42**	**58.58**	**58.58**				
External leakage - Process medium	1*	0.95	19.03	90.28	19.03	19.03	2.0	2.0	2.0	2.0
	1†	0.98	19.53	92.65	19.53	19.53				
Fail to regulate	2*	6.75	38.05	119.77	38.05	38.05	7.0	6.0	7.0	8.0
	2†	6.93	39.05	122.91	39.05	39.05				
Degraded	**3***	**15.60**	**57.08**	**147.55**	**57.08**	**57.08**	**5.0**	**1.0**	**5.0**	**13.0**
	3†	**16.01**	**58.58**	**151.42**	**58.58**	**58.58**				
External leakage - Process medium	3*	15.60	57.08	147.55	57.08	57.08	5.0	1.0	5.0	13.0
	3†	16.01	58.58	151.42	58.58	58.58				
All modes	**6***	**49.75**	**114.16**	**225.27**	**114.16**	**114.16**	**5.2**	**1.0**	**5.2**	**13.0**
	6†	**51.06**	**117.15**	**231.18**	**117.15**	**117.15**				

Comments

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Taxonomy no	Item
4.3.2.7	Control and Safety Equipment Valves Butterfly Well servicing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0512	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**3***	**15.60**	**57.08**	**147.55**	**57.08**	**57.08**	**11.3**	**2.0**	**11.3**	**28.0**
	3†	**16.01**	**58.58**	**151.42**	**58.58**	**58.58**				
External leakage - Process medium	2*	6.75	38.05	119.77	38.05	38.05	15.0	2.0	15.0	28.0
	2†	6.93	39.05	122.91	39.05	39.05				
Low output	1*	0.95	19.03	90.28	19.03	19.03	4.0	4.0	4.0	4.0
	1†	0.98	19.53	92.65	19.53	19.53				
All modes	**3***	**15.60**	**57.08**	**147.55**	**57.08**	**57.08**	**11.3**	**2.0**	**11.3**	**28.0**
	3†	**16.01**	**58.58**	**151.42**	**58.58**	**58.58**				

Comments

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Taxonomy no		Item
4.3.3		Control and Safety Equipment Valves Check

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
46	2	1.3664	1.3115	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.00 0.00	0.36 0.38	1.39 1.46	0.51 0.54	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.3.3.1	Control and Safety Equipment Valves Check Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	1	0.4176	0.4172	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	0.28	1.07	0.39	0.00	-	-	-	-
	0†	0.00	0.29	1.11	0.41	0.00				

Comments

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Taxonomy no	Item
4.3.3.2	Control and Safety Equipment Valves Check Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
16	2	0.4883	0.4610	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.00 0.00	0.27 0.28	1.03 1.08	0.38 0.40	0.00 0.00	-	-	-	-

Comments

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Taxonomy no		Item
4.3.3.3		Control and Safety Equipment Valves Check Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	0.34	1.30	0.48	0.00	-	-	-	-
	0†	0.00	0.36	1.39	0.51	0.00				

Comments

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Taxonomy no	Item
4.3.3.4	Control and Safety Equipment Valves Check Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
13	1	0.3619	0.3616	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	0.29	1.10	0.41	0.00	-	-	-	-
	0†	0.00	0.30	1.15	0.42	0.00				

Comments

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Taxonomy no		Item
4.3.4		Control and Safety Equipment Valves Diaphragm

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**36.0**	**36.0**	**36.0**	**36.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**7.0**	**5.0**	**7.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**3***	**31.20**	**114.16**	**295.09**	**114.16**	**114.16**	**16.7**	**5.0**	**16.7**	**36.0**
	3†	**32.02**	**117.15**	**302.84**	**117.15**	**117.15**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Diaphragm

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00
Subunit	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33	0.00

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Diaphragm

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	66.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Diaphragm

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Diaphragm

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	33.33
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.4.1	Control and Safety Equipment Valves Diaphragm Well servicing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**36.0**	**36.0**	**36.0**	**36.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**7.0**	**5.0**	**7.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**3***	**31.20**	**114.16**	**295.09**	**114.16**	**114.16**	**16.7**	**5.0**	**16.7**	**36.0**
	3†	**32.02**	**117.15**	**302.84**	**117.15**	**117.15**				

Comments

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Taxonomy no	Item
4.3.5	Control and Safety Equipment Valves Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
177	28	6.6856	3.8523	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**70***	**0.01**	**7.67**	**31.30**	**11.84**	**10.47**	**6.9**	**1.0**	**9.9**	**66.0**
	70†	**8.46**	**69.57**	**179.79**	**56.22**	**18.17**				
External leakage - Process medium	1*	0.00	0.14	0.42	0.15	0.15	2.0	2.0	2.0	2.0
	1†	0.01	0.24	0.74	0.26	0.26				
Fail to close on demand	34*	0.00	3.03	15.85	7.10	5.09	5.7	1.0	9.7	66.0
	34†	0.03	9.62	37.19	13.74	8.83				
Fail to open on demand	24*	0.00	3.81	16.47	6.39	3.59	8.8	1.0	12.0	60.0
	24†	7.51	66.05	173.11	54.53	6.23				
Other	1*	0.00	0.21	1.16	0.55	0.15	-	-	-	-
	1†	0.00	0.56	2.73	1.13	0.26				
Spurious operation	4*	0.00	0.52	2.29	0.89	0.60	6.3	3.0	6.3	8.0
	4†	0.00	2.17	10.47	4.32	1.04				
Structural deficiency	4*	0.00	0.45	1.72	0.63	0.60	4.3	2.0	4.5	9.0
	4†	0.19	0.95	2.19	0.64	1.04				
Valve leakage in closed position	2*	0.00	0.25	0.83	0.30	0.30	12.5	10.0	12.5	15.0
	2†	0.07	0.48	1.20	0.37	0.52				
Degraded	**76***	**0.00**	**6.52**	**34.27**	**15.48**	**11.37**	**7.5**	**1.0**	**8.1**	**62.0**
	76†	**0.41**	**33.00**	**106.11**	**38.43**	**19.73**				
Abnormal instrument reading	3*	0.00	0.41	2.12	0.92	0.45	4.0	4.0	4.7	6.0
	3†	0.00	1.20	6.51	3.03	0.78				
Delayed operation	4*	0.00	0.61	3.36	1.62	0.60	8.0	12.0	13.5	15.0
	4†	0.02	1.44	4.53	1.62	1.04				
External leakage - Process medium	8*	0.00	2.06	10.10	4.24	1.20	7.3	3.0	8.3	30.0
	8†	4.55	42.37	112.63	35.78	2.08				
External leakage - Utility medium	6*	0.00	0.71	4.08	2.27	0.90	13.8	1.0	15.8	62.0
	6†	0.01	1.79	6.17	2.27	1.56				
Minor in-service problems	1*	0.00	0.21	1.16	0.55	0.15	4.0	4.0	4.0	4.0
	1†	0.00	0.56	2.73	1.13	0.26				
Other	31*	0.00	1.68	5.59	8.24	4.64	4.5	2.0	5.4	23.0
	31†	0.00	4.55	21.68	8.90	8.05				
Spurious operation	2*	0.00	0.25	0.83	0.30	0.30	21.0	7.0	21.0	35.0
	2†	0.07	0.48	1.20	0.37	0.52				
Structural deficiency	1*	0.00	0.14	0.44	0.16	0.15	6.0	6.0	6.0	6.0
	1†	0.01	0.24	0.75	0.26	0.26				
Valve leakage in closed position	20*	0.00	0.93	1.64	5.40	2.99	9.4	2.0	9.4	24.0
	20†	0.00	2.84	13.14	5.30	5.19				
Incipient	**86***	**3.31**	**17.93**	**42.16**	**12.50**	**12.86**	**2.3**	**1.0**	**3.2**	**80.0**
	86†	**130.23**	**288.98**	**498.36**	**114.01**	**22.32**				
Abnormal instrument reading	66*	1.46	14.25	38.28	12.23	9.87	2.3	1.0	3.4	80.0
	66†	112.64	262.36	462.84	108.65	17.13				

Comments

(cont.)

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Taxonomy no	Item
4.3.5	Control and Safety Equipment Valves Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
177	28	6.6856	3.8523	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Delayed operation	2*	0.00	0.35	1.15	0.42	0.30	1.0	1.0	1.0	1.0
	2†	0.06	6.97	23.22	8.51	0.52				
External leakage - Process medium	1*	0.00	0.22	1.20	0.60	0.15	-	3.0	3.0	3.0
	1†	0.00	0.59	2.86	1.20	0.26				
External leakage - Utility medium	7*	0.00	1.59	7.90	3.36	1.05	2.0	1.0	2.6	4.0
	7†	0.26	19.29	61.56	22.21	1.82				
Internal leakage	1*	0.00	0.22	1.20	0.60	0.15	-	4.0	4.0	4.0
	1†	0.00	0.59	2.86	1.20	0.26				
Minor in-service problems	7*	0.44	0.99	1.72	0.40	1.05	2.8	2.0	2.8	3.0
	7†	0.17	1.68	4.55	1.46	1.82				
Other	2*	0.00	0.99	5.45	2.67	0.30	3.0	3.0	3.0	3.0
	2†	0.00	2.20	9.25	3.54	0.52				
Unknown	**8***	**0.01**	**0.86**	**2.73**	**0.99**	**1.20**	**12.2**	**1.0**	**17.8**	**64.0**
	8†	**0.58**	**1.87**	**3.76**	**1.00**	**2.08**				
Unknown	8*	0.01	0.86	2.73	0.99	1.20	12.2	1.0	17.8	64.0
	8†	0.58	1.87	3.76	1.00	2.08				
All modes	**240***	**7.46**	**32.77**	**72.77**	**20.84**	**35.90**	**5.7**	**1.0**	**7.2**	**80.0**
	240†	**185.60**	**401.99**	**685.32**	**154.65**	**62.30**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Gate

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.67	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Control unit	1.25	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Instrument, general	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	4.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.83	0.00	2.08	0.83	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.42	0.83	0.42	1.46	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.00
Pilot valve	0.42	0.00	0.00	0.42	5.00	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Seals (gaskets)	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	2.92	0.00	0.42	1.46	0.00	0.00	0.00
Subunit	0.00	0.42	0.42	0.00	0.83	2.92	0.00	0.00	0.00
Unknown	1.67	0.83	0.42	0.83	5.42	2.92	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Total	28.75	2.50	4.17	5.42	14.17	10.00	0.00	0.00	0.42

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Gate

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	1.25
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.42	0.00	0.42	0.00	2.92
Control unit	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	2.50
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.58
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.83
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.50
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	4.17
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Pilot valve	0.00	0.00	0.00	0.00	2.08	0.00	0.83	0.42	9.17
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Seals	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Seat rings	3.75	0.00	0.42	0.00	0.00	0.00	0.00	0.00	8.96
Subunit	5.00	0.00	11.67	0.00	0.00	0.83	0.42	1.67	24.17
Unknown	0.00	0.00	1.25	0.00	0.83	0.00	0.00	1.25	15.42
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.83
Total	9.17	0.00	14.17	0.00	3.33	2.50	2.08	3.33	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Gate

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.42	0.00	0.00	0.00	2.92	5.83	0.00	0.00	0.00
Breakage	0.83	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00
Clearance/ alignment failure	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	6.67	0.00	0.00	0.00	4.58	0.42	0.00	0.00	0.00
Leakage	0.00	0.42	4.17	2.92	0.42	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.42
Material failure - general	0.00	0.00	0.00	0.42	0.00	0.42	0.00	0.00	0.00
Mechanical Failure - general	0.42	0.42	0.00	0.83	3.75	1.67	0.00	0.00	0.00
Misc. external influences	0.83	0.42	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Open circuit	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	14.17	0.42	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Short circuiting	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.42	0.00	0.00	0.83	0.42	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
Total	28.75	2.50	4.17	5.42	14.17	10.00	0.00	0.00	0.42

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Gate

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.17
Breakage	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	2.08
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	1.67
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Corrosion	0.00	0.00	0.42	0.00	1.25	0.42	0.00	0.00	2.92
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Electrical failure - general	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.42
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	2.92
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.42	12.92
Leakage	9.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.08
Looseness	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	1.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	1.25
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.42	0.00	0.42	0.83	8.75
Misc. external influences	0.00	0.00	0.00	0.00	0.83	0.00	0.42	0.00	2.92
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83
Out of adjustment	0.00	0.00	12.50	0.00	0.42	0.83	0.00	0.00	28.75
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.83
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	3.33
Wear	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	1.25
Total	9.17	0.00	14.17	0.00	3.33	2.50	2.08	3.33	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.5.1	Control and Safety Equipment Valves Gate Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.05 0.07	12.04 18.62	46.22 71.50	17.02 26.33	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.3.5.2	Control and Safety Equipment Valves Gate Emergency shutdown (ESD)

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0219	0.0219	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**2.28**	**45.64**	**216.55**	**45.64**	**45.64**	-	-	-	-
	1†	**2.28**	**45.69**	**216.79**	**45.69**	**45.69**				
Other	1*	2.28	45.64	216.55	45.64	45.64	-	-	-	-
	1†	2.28	45.69	216.79	45.69	45.69				
All modes	**1***	**2.28**	**45.64**	**216.55**	**45.64**	**45.64**	-	-	-	-
	1†	**2.28**	**45.69**	**216.79**	**45.69**	**45.69**				

Comments

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Taxonomy no		Item
4.3.5.3		Control and Safety Equipment Valves Gate Flare, vent & blow-down
Population	**Installations**	**Aggregated time in service (10^6 hours)**
42	19	**Calendar time *** 2.9787 / **Operational time †** 0.1988

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**13***	**0.00**	**5.40**	**22.91**	**8.82**	**4.36**	**9.8**	**1.0**	**14.2**	**60.0**
	13†	**0.17**	**134.65**	**552.13**	**209.19**	**65.41**				
Fail to close on demand	2*	0.00	0.71	2.66	0.98	0.67	1.5	2.0	2.0	2.0
	2†	0.00	18.50	94.35	40.76	10.06				
Fail to open on demand	10*	0.00	4.49	22.02	9.26	3.36	11.6	1.0	17.2	60.0
	10†	0.00	110.09	516.04	210.03	50.31				
Spurious operation	1*	0.00	0.29	1.51	0.68	0.34	8.0	8.0	8.0	8.0
	1†	0.00	5.52	31.87	17.29	5.03				
Degraded	**7***	**0.00**	**2.59**	**12.95**	**5.53**	**2.35**	**7.3**	**3.0**	**9.0**	**30.0**
	7†	**0.00**	**65.22**	**316.42**	**131.21**	**35.22**				
External leakage - Process medium	7*	0.00	2.59	12.95	5.53	2.35	7.3	3.0	9.0	30.0
	7†	0.00	65.22	316.42	131.21	35.22				
Incipient	**54***	**4.28**	**19.77**	**44.57**	**12.89**	**18.13**	**2.1**	**1.0**	**3.3**	**80.0**
	54†	**60.05**	**441.15**	**1115.90**	**345.50**	**271.70**				
Abnormal instrument reading	48*	2.70	18.26	45.39	13.93	16.11	2.2	1.0	3.5	80.0
	48†	41.79	400.92	1073.00	342.26	241.51				
Delayed operation	2*	0.00	0.63	3.38	1.56	0.67	1.0	1.0	1.0	1.0
	2†	0.37	11.68	35.43	12.20	10.06				
External leakage - Utility medium	4*	0.00	1.21	5.31	2.07	1.34	1.5	1.0	1.5	3.0
	4†	0.00	29.96	163.71	76.52	20.13				
All modes	**74***	**6.31**	**27.84**	**61.91**	**17.74**	**24.84**	**4.0**	**1.0**	**5.8**	**80.0**
	74†	**93.03**	**652.14**	**1633.42**	**503.23**	**372.32**				

Comments

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Taxonomy no	Item
4.3.5.4	Control and Safety Equipment Valves Gate Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
92	8	2.5419	2.5059	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**51***	**1.23**	**14.97**	**42.02**	**13.72**	**20.06**	**5.8**	**1.0**	**8.8**	**66.0**
	51†	**1.27**	**15.17**	**42.42**	**13.83**	**20.35**				
Fail to close on demand	29*	0.11	8.52	27.20	9.82	11.41	5.3	1.0	10.0	66.0
	29†	0.12	8.63	27.51	9.92	11.57				
Fail to open on demand	14*	0.49	4.29	11.23	3.53	5.51	6.6	1.0	7.6	30.0
	14†	0.50	4.35	11.37	3.57	5.59				
Other	1*	0.00	0.74	3.23	1.26	0.39	-	-	-	-
	1†	0.00	0.74	3.23	1.26	0.40				
Spurious operation	2*	0.00	1.19	5.20	2.03	0.79	4.5	3.0	4.5	6.0
	2†	0.00	1.19	5.21	2.03	0.80				
Structural deficiency	4*	0.04	1.22	3.68	1.26	1.57	4.3	2.0	4.5	9.0
	4†	0.04	1.23	3.73	1.28	1.60				
Valve leakage in closed position	1*	0.00	0.39	1.35	0.50	0.39	15.0	15.0	15.0	15.0
	1†	0.00	0.39	1.39	0.51	0.40				
Degraded	**50***	**0.17**	**18.06**	**59.62**	**21.79**	**19.67**	**7.4**	**1.0**	**7.9**	**62.0**
	50†	**0.16**	**18.34**	**61.00**	**22.35**	**19.95**				
Abnormal instrument reading	3*	0.00	1.38	5.34	1.97	1.18	4.0	4.0	4.7	6.0
	3†	0.00	1.42	5.58	2.08	1.20				
Delayed operation	3*	0.29	1.35	3.06	0.89	1.18	-	15.0	15.0	15.0
	3†	0.32	1.35	2.97	0.84	1.20				
External leakage - Process medium	1*	0.00	0.77	3.40	1.33	0.39	-	3.0	3.0	3.0
	1†	0.00	0.78	3.41	1.33	0.40				
External leakage - Utility medium	6*	0.85	2.64	5.24	1.38	2.36	13.8	1.0	15.8	62.0
	6†	0.90	2.66	5.17	1.34	2.39				
Minor in-service problems	1*	0.00	0.74	3.23	1.26	0.39	4.0	4.0	4.0	4.0
	1†	0.00	0.74	3.23	1.26	0.40				
Other	24*	0.00	6.91	34.84	14.96	9.44	4.3	2.0	5.2	23.0
	24†	0.00	7.03	35.60	15.32	9.58				
Spurious operation	2*	0.00	0.75	2.70	1.00	0.79	21.0	7.0	21.0	35.0
	2†	0.00	0.76	2.77	1.02	0.80				
Structural deficiency	1*	0.01	0.35	1.10	0.39	0.39	6.0	6.0	6.0	6.0
	1†	0.01	0.35	1.11	0.40	0.40				
Valve leakage in closed position	9*	0.00	2.50	12.94	5.66	3.54	9.3	2.0	9.3	22.0
	9†	0.00	2.56	13.22	5.81	3.59				
Incipient	**29***	**1.65**	**12.06**	**30.46**	**9.42**	**11.41**	**2.7**	**1.0**	**3.1**	**12.0**
	29†	**1.67**	**12.20**	**30.82**	**9.54**	**11.57**				
Abnormal instrument reading	17*	0.44	5.42	15.23	4.98	6.69	2.6	1.0	3.1	12.0
	17†	0.46	5.48	15.34	5.00	6.78				
External leakage - Process medium	1*	0.00	0.77	3.40	1.33	0.39	-	3.0	3.0	3.0
	1†	0.00	0.78	3.41	1.33	0.40				

Comments

(cont.)

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Taxonomy no	Item
4.3.5.4	Control and Safety Equipment Valves Gate Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
92	8	2.5419	2.5059	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
External leakage - Utility medium	2*	0.00	3.52	14.44	5.48	0.79	-	4.0	4.0	4.0
	2†	0.01	3.67	14.97	5.66	0.80				
Internal leakage	1*	0.00	0.77	3.40	1.33	0.39	-	4.0	4.0	4.0
	1†	0.00	0.78	3.41	1.33	0.40				
Minor in-service problems	7*	0.02	2.19	7.20	2.63	2.75	2.8	2.0	2.8	3.0
	7†	0.02	2.21	7.25	2.64	2.79				
Other	1*	0.00	0.74	3.23	1.26	0.39	3.0	3.0	3.0	3.0
	1†	0.00	0.74	3.23	1.26	0.40				
Unknown	**7***	**0.19**	**2.12**	**5.83**	**1.89**	**2.75**	**8.9**	**1.0**	**11.1**	**51.0**
	7†	**0.20**	**2.15**	**5.90**	**1.91**	**2.79**				
Unknown	7*	0.19	2.12	5.83	1.89	2.75	8.9	1.0	11.1	51.0
	7†	0.20	2.15	5.90	1.91	2.79				
All modes	**137***	**24.33**	**48.73**	**79.97**	**17.16**	**53.90**	**6.0**	**1.0**	**7.5**	**66.0**
	137†	**24.44**	**49.37**	**81.37**	**17.57**	**54.67**				

Comments

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Taxonomy no	Item
4.3.5.5	Control and Safety Equipment Valves Gate Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
24	2	0.6175	0.6066	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**2.23**	**6.50**	**12.58**	**3.24**	**6.48**	**7.5**	**2.0**	**7.5**	**10.0**
	4†	**2.27**	**6.61**	**12.80**	**3.30**	**6.59**				
External leakage - Process medium	1*	0.01	1.55	5.60	2.07	1.62	2.0	2.0	2.0	2.0
	1†	0.01	1.59	5.78	2.14	1.65				
Fail to close on demand	1*	0.11	1.68	4.89	1.62	1.62	10.0	10.0	10.0	10.0
	1†	0.11	1.70	4.98	1.65	1.65				
Spurious operation	1*	0.11	1.68	4.89	1.62	1.62	8.0	8.0	8.0	8.0
	1†	0.11	1.70	4.98	1.65	1.65				
Valve leakage in closed position	1*	0.01	1.55	5.60	2.07	1.62	10.0	10.0	10.0	10.0
	1†	0.01	1.59	5.78	2.14	1.65				
Degraded	**7***	**0.08**	**10.44**	**35.69**	**13.14**	**11.34**	**3.7**	**2.0**	**4.4**	**13.0**
	7†	**0.07**	**10.74**	**36.94**	**13.61**	**11.54**				
Other	4*	0.09	6.05	19.15	6.88	6.48	4.0	2.0	5.3	13.0
	4†	0.08	6.21	19.81	7.15	6.59				
Valve leakage in closed position	3*	0.16	4.58	13.87	4.76	4.86	3.3	2.0	3.3	5.0
	3†	0.13	4.70	14.32	4.96	4.95				
Unknown	**1***	**0.01**	**1.55**	**5.60**	**2.07**	**1.62**	**35.0**	**64.0**	**64.0**	**64.0**
	1†	**0.01**	**1.59**	**5.78**	**2.14**	**1.65**				
Unknown	1*	0.01	1.55	5.60	2.07	1.62	35.0	64.0	64.0	64.0
	1†	0.01	1.59	5.78	2.14	1.65				
All modes	**12***	**3.17**	**18.57**	**44.52**	**13.37**	**19.43**	**7.6**	**2.0**	**10.4**	**64.0**
	12†	**3.04**	**19.00**	**46.34**	**14.06**	**19.78**				

Comments

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Taxonomy no	Item
4.3.5.6	Control and Safety Equipment Valves Gate Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	3	0.3416	0.3399	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.11**	**6.58**	**20.60**	**7.34**	**5.85**	**12.5**	**1.0**	**12.5**	**24.0**
	2†	**0.11**	**6.64**	**20.84**	**7.44**	**5.88**				
Fail to close on demand	2*	0.11	6.58	20.60	7.34	5.85	12.5	1.0	12.5	24.0
	2†	0.11	6.64	20.84	7.44	5.88				
Degraded	**1***	**0.04**	**2.58**	**8.16**	**2.93**	**2.93**	**8.0**	**12.0**	**12.0**	**12.0**
	1†	**0.04**	**2.60**	**8.20**	**2.94**	**2.94**				
Delayed operation	1*	0.04	2.58	8.16	2.93	2.93	8.0	12.0	12.0	12.0
	1†	0.04	2.60	8.20	2.94	2.94				
Incipient	**2***	**0.11**	**6.58**	**20.60**	**7.34**	**5.85**	**3.0**	**2.0**	**3.0**	**4.0**
	2†	**0.11**	**6.64**	**20.84**	**7.44**	**5.88**				
Abnormal instrument reading	1*	0.02	4.54	16.40	6.06	2.93	2.0	2.0	2.0	2.0
	1†	0.02	4.60	16.70	6.17	2.94				
External leakage - Utility medium	1*	0.04	2.58	8.16	2.93	2.93	4.0	4.0	4.0	4.0
	1†	0.04	2.60	8.20	2.94	2.94				
All modes	**5***	**1.17**	**15.34**	**43.60**	**14.31**	**14.64**	**7.8**	**1.0**	**8.6**	**24.0**
	5†	**1.16**	**15.48**	**44.11**	**14.49**	**14.71**				

Comments

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Taxonomy no		Item									
4.3.5.7		Control and Safety Equipment Valves Gate Sea water lift									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
6	1	**Calendar time *** 0.1577			**Operational time †** 0.1536						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Degraded		**11***	**39.13**	**69.76**	**115.49**	**69.76**	**69.76**	**10.5**	**2.0**	**10.5**	**24.0**
		11†	**40.16**	**71.59**	**118.52**	**71.59**	**71.59**				
Other		3*	5.20	19.03	49.18	19.03	19.03	6.7	2.0	6.7	14.0
		3†	5.34	19.53	50.47	19.53	19.53				
Valve leakage in closed position		8*	25.24	50.74	91.55	50.74	50.74	11.9	4.0	11.9	24.0
		8†	25.90	52.07	93.95	52.07	52.07				
All modes		**11***	**39.13**	**69.76**	**115.49**	**69.76**	**69.76**	**10.5**	**2.0**	**10.5**	**24.0**
		11†	**40.16**	**71.59**	**118.52**	**71.59**	**71.59**				

Comments

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Taxonomy no	Item
4.3.6	Control and Safety Equipment Valves Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
255	3	8.0172	7.1701	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**115***	**0.09**	**10.52**	**35.34**	**12.97**	**14.34**	**14.2**	**1.0**	**15.8**	**94.0**
	115†	**0.13**	**11.11**	**35.83**	**12.99**	**16.04**				
External leakage - Process medium	7*	0.17	0.91	2.11	0.62	0.87	13.0	1.0	15.1	54.0
	7†	0.30	0.97	1.94	0.52	0.98				
Fail to close on demand	31*	0.00	2.51	10.45	3.99	3.87	15.0	2.0	15.2	78.0
	31†	0.00	2.68	10.81	4.07	4.32				
Fail to open on demand	8*	0.23	1.20	2.80	0.83	1.00	14.9	1.5	15.9	48.0
	8†	0.33	1.27	2.71	0.76	1.12				
Fail to regulate	59*	0.00	4.64	19.98	7.74	7.36	12.5	2.0	14.3	93.0
	59†	0.00	4.93	20.73	7.94	8.23				
High output	1*	0.00	0.11	0.36	0.13	0.12	6.0	6.0	6.0	6.0
	1†	0.00	0.12	0.39	0.14	0.14				
Internal leakage	3*	0.08	0.34	0.75	0.22	0.37	26.3	6.0	34.0	48.0
	3†	0.00	0.33	1.09	0.40	0.42				
Spurious operation	1*	0.00	0.25	1.01	0.38	0.12	8.0	8.0	8.0	8.0
	1†	0.00	0.26	1.05	0.39	0.14				
Structural deficiency	1*	0.00	0.11	0.36	0.13	0.12	12.0	16.0	16.0	16.0
	1†	0.00	0.12	0.39	0.14	0.14				
Unknown	1*	0.00	0.11	0.36	0.13	0.12	88.0	94.0	94.0	94.0
	1†	0.00	0.12	0.39	0.14	0.14				
Valve leakage in closed position	3*	0.07	0.36	0.83	0.24	0.37	11.3	6.0	17.0	35.0
	3†	0.07	0.40	0.97	0.29	0.42				
Degraded	**48***	**2.90**	**7.22**	**13.11**	**3.18**	**5.99**	**10.3**	**0.5**	**11.4**	**46.0**
	48†	**2.78**	**8.38**	**16.43**	**4.28**	**6.69**				
Delayed operation	1*	0.00	0.25	1.01	0.38	0.12	4.0	8.0	8.0	8.0
	1†	0.00	0.26	1.05	0.39	0.14				
External leakage - Process medium	9*	0.10	1.86	5.53	1.84	1.12	9.3	1.0	12.7	45.0
	9†	0.11	1.94	5.73	1.91	1.26				
External leakage - Utility medium	4*	0.05	0.42	1.11	0.35	0.50	7.8	2.0	7.8	14.0
	4†	0.13	0.49	1.05	0.29	0.56				
Fail to open on demand	1*	0.01	0.13	0.38	0.12	0.12	0.5	0.5	0.5	0.5
	1†	0.00	0.16	0.51	0.18	0.14				
High output	3*	0.05	0.48	1.27	0.40	0.37	2.5	2.0	2.8	3.5
	3†	0.05	0.59	1.63	0.53	0.42				
Internal leakage	7*	0.19	0.81	1.77	0.50	0.87	18.1	4.0	18.1	42.0
	7†	0.41	0.92	1.60	0.37	0.98				
Low output	11*	0.00	1.49	6.54	2.56	1.37	6.1	1.5	6.1	13.0
	11†	0.00	2.00	8.74	3.41	1.53				
Other	2*	0.03	0.25	0.63	0.20	0.25	20.0	32.0	32.0	32.0
	2†	0.02	0.28	0.82	0.27	0.28				

Comments

(cont.)

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Taxonomy no	Item
4.3.6	Control and Safety Equipment Valves Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
255	3	8.0172	7.1701	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Plugged/Choked	2*	0.00	0.28	0.97	0.36	0.25	-	-	-	-
	2†	0.00	0.36	1.40	0.52	0.28				
Spurious operation	1*	0.00	0.11	0.36	0.13	0.12	11.0	11.0	11.0	11.0
	1†	0.00	0.12	0.39	0.14	0.14				
Unknown	1*	0.00	0.11	0.36	0.13	0.12	10.0	10.0	10.0	10.0
	1†	0.00	0.12	0.39	0.14	0.14				
Valve leakage in closed position	6*	0.10	1.16	3.22	1.04	0.75	17.0	4.0	17.0	46.0
	6†	0.13	1.28	3.47	1.11	0.84				
Incipient	**26***	**2.28**	**3.25**	**4.36**	**0.64**	**3.24**	**5.4**	**1.0**	**5.6**	**19.0**
	26†	**2.21**	**3.70**	**5.50**	**1.01**	**3.63**				
Abnormal instrument reading	14*	0.02	1.27	4.08	1.48	1.75	7.2	3.0	7.2	19.0
	14†	0.06	1.41	4.25	1.44	1.95				
Low output	1*	0.01	0.13	0.38	0.12	0.12	1.0	1.0	1.0	1.0
	1†	0.00	0.16	0.51	0.18	0.14				
Minor in-service problems	9*	0.17	1.44	3.72	1.16	1.12	3.8	2.0	4.2	8.0
	9†	0.15	1.76	4.90	1.60	1.26				
Other	1*	0.00	0.25	1.01	0.38	0.12	3.0	3.0	3.0	3.0
	1†	0.00	0.26	1.05	0.39	0.14				
Valve leakage in closed position	1*	0.01	0.13	0.38	0.12	0.12	2.0	2.0	2.0	2.0
	1†	0.00	0.16	0.51	0.18	0.14				
Unknown	**1***	**0.00**	**0.11**	**0.36**	**0.13**	**0.12**	**87.0**	**119.0**	**119.0**	**119.0**
	1†	**0.00**	**0.12**	**0.39**	**0.14**	**0.14**				
Unknown	1*	0.00	0.11	0.36	0.13	0.12	87.0	119.0	119.0	119.0
	1†	0.00	0.12	0.39	0.14	0.14				
All modes	**190***	**8.51**	**21.50**	**39.29**	**9.58**	**23.70**	**12.5**	**0.5**	**13.9**	**119.0**
	190†	**13.43**	**23.91**	**36.85**	**7.20**	**26.50**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Globe

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.53	0.00	0.00	0.00	0.00	0.53	0.53	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00
Control unit	3.16	0.00	0.00	0.00	0.00	0.53	3.68	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.53	0.53	0.00	0.00
Flange	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.26	0.00	1.05	0.00	0.00
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.53	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Monitoring	2.11	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.53	0.00	0.53	0.00	1.05	0.00	0.00
Packing	0.00	0.00	2.11	0.00	0.61	0.00	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.53	1.05	0.53	1.75	0.00	0.00
Positioner	0.53	0.00	0.00	0.00	0.79	0.53	4.74	0.53	0.00
Seals	0.00	0.00	2.37	0.00	2.19	0.00	0.53	0.00	1.05
Seals (gaskets)	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.26	0.00	2.46	0.00	0.00	0.00	1.05
Spring	0.00	0.00	0.00	0.00	0.00	0.53	0.18	0.00	0.00
Stem	0.00	0.00	0.53	0.00	0.00	0.00	1.23	0.00	0.00
Subunit	0.53	0.53	0.53	1.58	6.32	0.53	11.58	0.53	2.63
Unknown	0.00	0.00	0.00	0.00	0.00	1.05	1.05	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	1.58	0.00	1.58	1.05	0.53
Total	7.37	0.53	8.42	2.11	16.32	4.74	31.05	2.11	5.26

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Globe

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.53	0.53	0.00	0.00	0.00	0.00	1.58
Control unit	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.53	8.95
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Instrument, general	0.00	0.53	0.00	0.00	0.53	0.00	0.00	0.00	1.05
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Monitoring	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	3.16
Other	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.53
Other valve components	0.00	0.00	0.53	0.00	0.53	0.00	0.00	0.00	3.16
Packing	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	4.12
Positioner	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	8.16
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.14
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.32
Seat rings	1.05	0.00	0.00	0.00	0.53	0.00	0.00	0.00	5.35
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75
Subunit	1.58	0.00	0.00	0.00	0.00	0.53	0.00	0.53	27.37
Unknown	1.05	1.58	0.00	0.53	0.53	0.53	0.00	0.00	6.32
Valve body w/internals	0.00	4.21	0.00	0.00	0.00	0.00	0.53	0.00	9.47
Total	5.26	6.32	1.58	1.05	4.74	1.05	0.53	1.58	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Globe

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	2.11	0.00	1.58	1.05	0.00
Breakage	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Control failure	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.53	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00
Deformation	0.00	0.00	1.58	0.00	0.00	1.05	1.05	0.00	0.00
Erosion	0.00	0.00	0.53	0.00	0.53	0.00	1.05	0.00	0.53
Faulty signal/indication/alarm	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.53	0.53	0.53	0.00
Leakage	0.00	0.00	0.00	0.00	0.53	0.53	0.53	0.00	0.00
Looseness	0.00	0.53	1.05	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	1.05	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00
Out of adjustment	4.21	0.00	0.00	1.05	4.21	0.53	15.79	0.00	0.53
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Unknown	0.00	0.00	1.05	0.00	0.53	0.00	1.05	0.53	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00
Wear	0.00	0.00	3.16	1.05	8.42	0.53	4.21	0.00	3.16
Total	7.37	0.53	8.42	2.11	16.32	4.74	31.05	2.11	5.26

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Globe

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	6.32	0.00	1.05	0.53	0.53	0.00	0.00	13.16
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Clearance/ alignment failure	1.05	0.00	0.00	0.00	0.00	0.53	0.00	0.00	2.63
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Corrosion	0.53	0.00	0.00	0.00	1.05	0.00	0.00	0.53	4.74
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
Erosion	1.05	0.00	0.53	0.00	0.00	0.00	0.00	0.00	4.21
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	1.58
Instrument failure - general	0.53	0.00	0.00	0.00	1.05	0.00	0.00	0.00	3.16
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Looseness	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Material failure - general	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	1.05
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Miscellaneous - general	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.53
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58
Out of adjustment	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.53	27.37
Software failure	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	1.05
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Unknown	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.53	4.21
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	2.63
Wear	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.05
Total	5.26	6.32	1.58	1.05	4.74	1.05	0.53	1.58	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.6.1	Control and Safety Equipment Valves Globe Chemical injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	2	0.3581	0.3123	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**8***	**0.15**	**19.62**	**66.37**	**24.40**	**22.34**	**14.3**	**5.0**	**14.3**	**28.0**
	8†	**0.29**	**20.98**	**66.84**	**24.10**	**25.62**				
External leakage - Process medium	2*	0.84	5.31	12.99	3.95	5.59	6.5	6.0	6.5	7.0
	2†	0.87	5.93	14.75	4.53	6.40				
Fail to close on demand	6*	0.16	14.86	48.42	17.63	16.76	16.8	5.0	16.8	28.0
	6†	0.43	16.10	49.17	17.10	19.21				
Degraded	**3***	**1.53**	**8.72**	**20.76**	**6.20**	**8.38**	**11.3**	**3.5**	**11.3**	**19.0**
	3†	**3.14**	**10.27**	**20.76**	**5.55**	**9.61**				
High output	1*	0.22	2.99	8.50	2.79	2.79	3.5	3.5	3.5	3.5
	1†	0.05	3.89	12.53	4.54	3.20				
Internal leakage	1*	0.02	2.62	9.12	3.36	2.79	19.0	19.0	19.0	19.0
	1†	0.03	2.94	9.51	3.45	3.20				
Other	1*	0.22	2.99	8.50	2.79	2.79	-	-	-	-
	1†	0.05	3.89	12.53	4.54	3.20				
Incipient	**1***	**0.22**	**2.99**	**8.50**	**2.79**	**2.79**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.05**	**3.89**	**12.53**	**4.54**	**3.20**				
Minor in-service problems	1*	0.22	2.99	8.50	2.79	2.79	3.0	3.0	3.0	3.0
	1†	0.05	3.89	12.53	4.54	3.20				
All modes	**12***	**18.73**	**32.87**	**50.23**	**9.67**	**33.51**	**12.7**	**3.0**	**12.7**	**28.0**
	12†	**21.14**	**37.63**	**57.96**	**11.32**	**38.43**				

Comments

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Taxonomy no	Item
4.3.6.2	Control and Safety Equipment Valves Globe Combined function

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1051	0.1024	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.02 0.02	3.89 4.05	14.96 15.57	5.51 5.73	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.3.6.3	Control and Safety Equipment Valves Globe Compressed air

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	1	0.8935	0.8707	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**15***	**10.35**	**16.79**	**25.85**	**16.79**	**16.79**	**10.5**	**2.0**	**10.5**	**24.0**
	15†	**10.62**	**17.23**	**26.53**	**17.23**	**17.23**				
Fail to close on demand	2*	0.40	2.24	7.05	2.24	2.24	10.5	9.0	10.5	12.0
	2†	0.41	2.30	7.23	2.30	2.30				
Fail to regulate	12*	7.75	13.43	21.76	13.43	13.43	10.8	2.0	10.8	24.0
	12†	7.95	13.78	22.33	13.78	13.78				
Valve leakage in closed position	1*	0.06	1.12	5.31	1.12	1.12	6.0	6.0	6.0	6.0
	1†	0.06	1.15	5.45	1.15	1.15				
Degraded	**4***	**1.53**	**4.48**	**10.25**	**4.48**	**4.48**	**7.8**	**2.0**	**7.8**	**14.0**
	4†	**1.57**	**4.59**	**10.51**	**4.59**	**4.59**				
External leakage - Utility medium	4*	1.53	4.48	10.25	4.48	4.48	7.8	2.0	7.8	14.0
	4†	1.57	4.59	10.51	4.59	4.59				
Incipient	**7***	**3.68**	**7.83**	**14.72**	**7.83**	**7.83**	**5.7**	**4.0**	**5.7**	**8.0**
	7†	**3.77**	**8.04**	**15.10**	**8.04**	**8.04**				
Abnormal instrument reading	7*	3.68	7.83	14.72	7.83	7.83	5.7	4.0	5.7	8.0
	7†	3.77	8.04	15.10	8.04	8.04				
All modes	**26***	**20.39**	**29.10**	**40.37**	**29.10**	**29.10**	**8.8**	**2.0**	**8.8**	**24.0**
	26†	**20.92**	**29.86**	**41.43**	**29.86**	**29.86**				

Comments

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Taxonomy no	Item
4.3.6.4	Control and Safety Equipment Valves Globe Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**9.0**	**9.0**	**9.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				
Fail to close on demand	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
Fail to regulate	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**9.0**	**9.0**	**9.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				

Comments

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Taxonomy no	Item
4.3.6.5	Control and Safety Equipment Valves Globe Cooling systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
19	1	0.4993	0.4866	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.10**	**2.00**	**9.50**	**2.00**	**2.00**	**7.0**	**7.0**	**7.0**	**7.0**
	1†	**0.10**	**2.06**	**9.75**	**2.06**	**2.06**				
Fail to regulate	1*	0.10	2.00	9.50	2.00	2.00	7.0	7.0	7.0	7.0
	1†	0.10	2.06	9.75	2.06	2.06				
All modes	**1***	**0.10**	**2.00**	**9.50**	**2.00**	**2.00**	**7.0**	**7.0**	**7.0**	**7.0**
	1†	**0.10**	**2.06**	**9.75**	**2.06**	**2.06**				

Comments

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Taxonomy no	Item
4.3.6.6	Control and Safety Equipment Valves Globe Essential power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.04 0.04	10.09 10.75	38.76 41.28	14.27 15.20	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.3.6.7	Control and Safety Equipment Valves Globe Flare, vent & blow-down

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
14	1	0.3679	0.3585	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**2.23**	**8.15**	**21.08**	**8.15**	**8.15**	**11.7**	**6.0**	**11.7**	**20.0**
	3†	**2.29**	**8.37**	**21.63**	**8.37**	**8.37**				
Fail to close on demand	2*	0.96	5.44	17.11	5.44	5.44	7.5	6.0	7.5	9.0
	2†	0.99	5.58	17.56	5.58	5.58				
Fail to open on demand	1*	0.14	2.72	12.90	2.72	2.72	20.0	20.0	20.0	20.0
	1†	0.14	2.79	13.24	2.79	2.79				
Degraded	**1***	**0.14**	**2.72**	**12.90**	**2.72**	**2.72**	**11.0**	**11.0**	**11.0**	**11.0**
	1†	**0.14**	**2.79**	**13.24**	**2.79**	**2.79**				
Spurious operation	1*	0.14	2.72	12.90	2.72	2.72	11.0	11.0	11.0	11.0
	1†	0.14	2.79	13.24	2.79	2.79				
Incipient	**1***	**0.14**	**2.72**	**12.90**	**2.72**	**2.72**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**0.14**	**2.79**	**13.24**	**2.79**	**2.79**				
Abnormal instrument reading	1*	0.14	2.72	12.90	2.72	2.72	8.0	8.0	8.0	8.0
	1†	0.14	2.79	13.24	2.79	2.79				
All modes	**5***	**5.35**	**13.59**	**28.58**	**13.59**	**13.59**	**10.8**	**6.0**	**10.8**	**20.0**
	5†	**5.49**	**13.95**	**29.33**	**13.95**	**13.95**				

Comments

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Taxonomy no	Item
4.3.6.8	Control and Safety Equipment Valves Globe Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
85	3	3.1270	2.6771	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**39***	**0.14**	**16.46**	**55.28**	**20.30**	**12.47**	**11.1**	**1.0**	**12.0**	**54.0**
	39†	**0.15**	**16.99**	**56.51**	**20.70**	**14.57**				
External leakage - Process medium	4*	0.22	1.54	3.86	1.19	1.28	17.5	1.0	21.3	54.0
	4†	0.41	1.60	3.43	0.96	1.49				
Fail to close on demand	12*	0.00	5.18	21.79	8.35	3.84	9.2	4.0	9.5	18.0
	12†	0.00	5.33	22.56	8.67	4.48				
Fail to open on demand	6*	0.26	2.41	6.43	2.05	1.92	16.3	2.0	17.7	48.0
	6†	0.40	2.48	6.05	1.83	2.24				
Fail to regulate	15*	0.01	6.27	25.32	9.53	4.80	9.1	3.0	9.6	29.0
	15†	0.01	6.51	26.23	9.86	5.60				
Spurious operation	1*	0.01	0.36	1.16	0.42	0.32	8.0	8.0	8.0	8.0
	1†	0.03	0.39	1.13	0.37	0.37				
Valve leakage in closed position	1*	0.00	0.28	0.98	0.36	0.32	10.0	10.0	10.0	10.0
	1†	0.00	0.34	1.33	0.50	0.37				
Degraded	**22***	**1.07**	**6.87**	**16.85**	**5.13**	**7.04**	**6.4**	**1.0**	**8.1**	**45.0**
	22†	**1.33**	**7.86**	**18.89**	**5.68**	**8.22**				
Delayed operation	1*	0.01	0.36	1.16	0.42	0.32	4.0	8.0	8.0	8.0
	1†	0.03	0.39	1.13	0.37	0.37				
External leakage - Process medium	6*	0.01	2.30	8.17	3.02	1.92	6.9	1.0	12.0	45.0
	6†	0.02	2.41	8.09	2.97	2.24				
High output	2*	0.03	0.64	1.92	0.65	0.64	2.0	2.0	2.5	3.0
	2†	0.07	0.74	2.04	0.66	0.75				
Low output	7*	0.01	1.66	6.35	2.34	2.24	4.1	1.5	4.1	8.0
	7†	0.00	2.13	8.65	3.26	2.61				
Plugged/Choked	1*	0.00	0.28	0.98	0.36	0.32	-	-	-	-
	1†	0.00	0.34	1.33	0.50	0.37				
Valve leakage in closed position	5*	0.26	1.66	4.07	1.24	1.60	11.2	4.0	11.2	24.0
	5†	0.51	1.87	3.93	1.08	1.87				
Incipient	**8***	**1.19**	**2.64**	**4.56**	**1.04**	**2.56**	**6.9**	**1.0**	**6.9**	**19.0**
	8†	**1.51**	**3.01**	**4.93**	**1.06**	**2.99**				
Abnormal instrument reading	4*	0.03	1.45	4.46	1.57	1.28	10.4	6.0	10.4	19.0
	4†	0.10	1.58	4.58	1.52	1.49				
Low output	1*	0.00	0.28	0.98	0.36	0.32	1.0	1.0	1.0	1.0
	1†	0.00	0.34	1.33	0.50	0.37				
Minor in-service problems	2*	0.03	0.64	1.92	0.65	0.64	5.0	2.0	5.0	8.0
	2†	0.07	0.74	2.04	0.66	0.75				
Other	1*	0.01	0.36	1.16	0.42	0.32	3.0	3.0	3.0	3.0
	1†	0.03	0.39	1.13	0.37	0.37				
All modes	**69***	**5.66**	**25.94**	**58.36**	**16.86**	**22.07**	**9.2**	**1.0**	**10.2**	**54.0**
	69†	**8.37**	**27.69**	**56.17**	**15.06**	**25.77**				

Comments

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Taxonomy no	Item
4.3.6.9	Control and Safety Equipment Valves Globe Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0788	0.0768	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.90	18.81	6.93	0.00	-	-	-	-
	0†	0.02	5.12	19.65	7.24	0.00				

Comments

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Taxonomy no	Item
4.3.6.10	Control and Safety Equipment Valves Globe Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
33	3	1.1979	0.9880	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**0.07**	**14.61**	**53.17**	**19.64**	**10.85**	**17.2**	**1.5**	**21.0**	**93.0**
	13†	**0.10**	**15.57**	**53.99**	**19.91**	**13.16**				
Fail to close on demand	1*	0.01	0.73	2.32	0.83	0.83	2.0	2.0	2.0	2.0
	1†	0.01	0.90	2.94	1.07	1.01				
Fail to open on demand	1*	0.01	0.73	2.32	0.83	0.83	1.5	1.5	1.5	1.5
	1†	0.01	0.90	2.94	1.07	1.01				
Fail to regulate	10*	0.02	12.37	49.69	18.66	8.35	20.8	2.0	25.3	93.0
	10†	0.03	12.93	51.28	19.14	10.12				
Structural deficiency	1*	0.01	1.13	4.13	1.53	0.83	12.0	16.0	16.0	16.0
	1†	0.01	1.18	3.79	1.37	1.01				
Degraded	**9***	**3.80**	**7.39**	**11.93**	**2.50**	**7.51**	**17.3**	**0.5**	**18.8**	**42.0**
	9†	**4.28**	**8.82**	**14.68**	**3.21**	**9.11**				
Fail to open on demand	1*	0.01	0.73	2.32	0.83	0.83	0.5	0.5	0.5	0.5
	1†	0.01	0.90	2.94	1.07	1.01				
Internal leakage	2*	0.28	2.23	5.74	1.79	1.67	39.5	37.0	39.5	42.0
	2†	0.53	2.28	5.02	1.43	2.02				
Low output	4*	0.83	2.94	6.11	1.67	3.34	9.8	6.0	9.8	13.0
	4†	0.28	3.33	9.34	3.05	4.05				
Other	1*	0.01	1.13	4.13	1.53	0.83	20.0	32.0	32.0	32.0
	1†	0.01	1.18	3.79	1.37	1.01				
Plugged/Choked	1*	0.01	0.73	2.32	0.83	0.83	-	-	-	-
	1†	0.01	0.90	2.94	1.07	1.01				
Incipient	**6***	**0.58**	**4.39**	**11.18**	**3.47**	**5.01**	**2.5**	**2.0**	**3.2**	**8.0**
	6†	**2.31**	**5.69**	**10.28**	**2.48**	**6.07**				
Minor in-service problems	5*	0.52	3.78	9.54	2.95	4.17	2.6	2.0	3.4	8.0
	5†	0.51	4.54	11.94	3.77	5.06				
Valve leakage in closed position	1*	0.01	0.73	2.32	0.83	0.83	2.0	2.0	2.0	2.0
	1†	0.01	0.90	2.94	1.07	1.01				
Unknown	**1***	**0.01**	**1.13**	**4.13**	**1.53**	**0.83**	**87.0**	**119.0**	**119.0**	**119.0**
	1†	**0.01**	**1.18**	**3.79**	**1.37**	**1.01**				
Unknown	1*	0.01	1.13	4.13	1.53	0.83	87.0	119.0	119.0	119.0
	1†	0.01	1.18	3.79	1.37	1.01				
All modes	**29***	**5.29**	**26.70**	**61.66**	**18.11**	**24.21**	**16.6**	**0.5**	**20.0**	**119.0**
	29†	**8.18**	**29.90**	**62.72**	**17.25**	**29.35**				

Comments

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Taxonomy no	Item
4.3.6.11	Control and Safety Equipment Valves Globe Oily water treatment

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
13	2	0.3646	0.2991	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**4.47**	**28.02**	**68.39**	**20.77**	**35.65**	**11.8**	**4.0**	**15.1**	**48.0**
	13†	**7.66**	**35.31**	**79.57**	**23.02**	**43.47**				
Fail to close on demand	3*	0.51	7.12	20.43	6.73	8.23	9.3	4.0	9.3	16.0
	3†	0.71	8.78	24.67	8.06	10.03				
Fail to regulate	7*	7.65	17.66	31.04	7.26	19.20	11.0	5.0	11.3	20.0
	7†	0.76	18.47	55.58	18.80	23.41				
High output	1*	0.06	2.52	7.79	2.74	2.74	6.0	6.0	6.0	6.0
	1†	0.07	3.09	9.52	3.34	3.34				
Internal leakage	1*	0.06	2.52	7.79	2.74	2.74	25.0	48.0	48.0	48.0
	1†	0.07	3.09	9.52	3.34	3.34				
Valve leakage in closed position	1*	0.06	2.52	7.79	2.74	2.74	18.0	35.0	35.0	35.0
	1†	0.07	3.09	9.52	3.34	3.34				
Degraded	**1***	**0.06**	**2.52**	**7.79**	**2.74**	**2.74**	**46.0**	**46.0**	**46.0**	**46.0**
	1†	**0.07**	**3.09**	**9.52**	**3.34**	**3.34**				
Valve leakage in closed position	1*	0.06	2.52	7.79	2.74	2.74	46.0	46.0	46.0	46.0
	1†	0.07	3.09	9.52	3.34	3.34				
Incipient	**3***	**0.51**	**7.12**	**20.43**	**6.73**	**8.23**	**6.3**	**3.0**	**6.3**	**8.0**
	3†	**0.71**	**8.78**	**24.67**	**8.06**	**10.03**				
Abnormal instrument reading	2*	0.42	4.93	13.77	4.48	5.48	5.5	3.0	5.5	8.0
	2†	0.57	6.07	16.63	5.37	6.69				
Minor in-service problems	1*	0.06	2.52	7.79	2.74	2.74	8.0	8.0	8.0	8.0
	1†	0.07	3.09	9.52	3.34	3.34				
All modes	**17***	**3.32**	**34.36**	**93.51**	**30.10**	**46.62**	**12.9**	**3.0**	**15.4**	**48.0**
	17†	**5.38**	**42.91**	**110.28**	**34.40**	**56.84**				

Comments

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Taxonomy no	Item
4.3.6.12	Control and Safety Equipment Valves Globe Sea water lift

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.3154	0.3073	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**8***	**12.62**	**25.37**	**45.77**	**25.37**	**25.37**	**20.9**	**3.0**	**20.9**	**78.0**
	8†	**12.95**	**26.03**	**46.97**	**26.03**	**26.03**				
External leakage - Process medium	1*	0.16	3.17	15.05	3.17	3.17	8.0	8.0	8.0	8.0
	1†	0.16	3.25	15.44	3.25	3.25				
Fail to close on demand	1*	0.16	3.17	15.05	3.17	3.17	78.0	78.0	78.0	78.0
	1†	0.16	3.25	15.44	3.25	3.25				
Fail to regulate	4*	4.33	12.68	29.03	12.68	12.68	6.8	3.0	6.8	17.0
	4†	4.44	13.02	29.79	13.02	13.02				
Internal leakage	2*	1.13	6.34	19.96	6.34	6.34	27.0	6.0	27.0	48.0
	2†	1.16	6.51	20.49	6.51	6.51				
Degraded	**7***	**10.42**	**22.20**	**41.70**	**22.20**	**22.20**	**10.1**	**3.0**	**10.1**	**36.0**
	7†	**10.69**	**22.78**	**42.79**	**22.78**	**22.78**				
External leakage - Process medium	3*	2.60	9.51	24.59	9.51	9.51	14.0	3.0	14.0	36.0
	3†	2.67	9.76	25.24	9.76	9.76				
Internal leakage	4*	4.33	12.68	29.03	12.68	12.68	7.3	4.0	7.3	11.0
	4†	4.44	13.02	29.79	13.02	13.02				
All modes	**15***	**29.32**	**47.56**	**73.23**	**47.56**	**47.56**	**15.9**	**3.0**	**15.9**	**78.0**
	15†	**30.08**	**48.81**	**75.15**	**48.81**	**48.81**				

Comments

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Taxonomy no		Item
4.3.6.13		Control and Safety Equipment Valves Globe Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	1	0.1314	0.1280	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**19.90**	**45.66**	**90.11**	**45.66**	**45.66**	**40.7**	**10.0**	**50.5**	**94.0**
	6†	**20.42**	**46.86**	**92.47**	**46.86**	**46.86**				
Fail to close on demand	1*	0.38	7.61	36.11	7.61	7.61	47.0	47.0	47.0	47.0
	1†	0.39	7.81	37.06	7.81	7.81				
Fail to regulate	4*	10.39	30.44	69.67	30.44	30.44	27.3	10.0	40.5	69.0
	4†	10.66	31.24	71.50	31.24	31.24				
Unknown	1*	0.38	7.61	36.11	7.61	7.61	88.0	94.0	94.0	94.0
	1†	0.39	7.81	37.06	7.81	7.81				
All modes	**6***	**19.90**	**45.66**	**90.11**	**45.66**	**45.66**	**40.7**	**10.0**	**50.5**	**94.0**
	6†	**20.42**	**46.86**	**92.47**	**46.86**	**46.86**				

Comments

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Taxonomy no	Item
4.3.6.14	Control and Safety Equipment Valves Globe Well servicing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	1	0.5256	0.5122	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**6.25**	**13.32**	**25.02**	**13.32**	**13.32**	**12.1**	**4.0**	**12.3**	**49.0**
	7†	**6.41**	**13.67**	**25.68**	**13.67**	**13.67**				
Fail to close on demand	2*	0.68	3.81	11.98	3.81	3.81	27.0	6.0	27.5	49.0
	2†	0.69	3.91	12.29	3.91	3.91				
Fail to regulate	5*	3.75	9.51	20.01	9.51	9.51	6.2	4.0	6.2	9.0
	5†	3.85	9.76	20.53	9.76	9.76				
Degraded	**1***	**0.10**	**1.90**	**9.03**	**1.90**	**1.90**	**10.0**	**10.0**	**10.0**	**10.0**
	1†	**0.10**	**1.95**	**9.26**	**1.95**	**1.95**				
Unknown	1*	0.10	1.90	9.03	1.90	1.90	10.0	10.0	10.0	10.0
	1†	0.10	1.95	9.26	1.95	1.95				
All modes	**8***	**7.57**	**15.22**	**27.46**	**15.22**	**15.22**	**11.9**	**4.0**	**12.0**	**49.0**
	8†	**7.77**	**15.62**	**28.18**	**15.62**	**15.62**				

Comments

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Taxonomy no		Item									
4.3.7		Control and Safety Equipment Valves PSV - Conventional									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
170	2	**Calendar time *** 5.1485			**Operational time †** 4.8847						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	**n/τ**		**Min**	**Mean**	**Max**
Critical		**23***	**0.42**	**3.84**	**10.15**	**3.21**	**4.47**	**6.3**	**5.0**	**6.3**	**11.0**
		23†	**0.45**	**4.05**	**10.70**	**3.39**	**4.71**				
Fail to close on demand		3*	0.09	0.57	1.38	0.42	0.58	6.0	6.0	6.0	6.0
		3†	0.10	0.60	1.46	0.44	0.61				
Fail to open on demand		14*	0.32	2.46	6.29	1.96	2.72	6.5	5.0	6.5	11.0
		14†	0.33	2.59	6.63	2.06	2.87				
Valve leakage in closed position		6*	0.17	1.11	2.74	0.84	1.17	6.0	6.0	6.0	6.0
		6†	0.18	1.17	2.89	0.88	1.23				
Degraded		**65***	**7.43**	**11.94**	**17.31**	**3.03**	**12.63**	**6.6**	**4.0**	**6.6**	**16.0**
		65†	**7.80**	**12.57**	**18.27**	**3.21**	**13.31**				
Spurious operation		65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0
		65†	7.80	12.57	18.27	3.21	13.31				
Incipient		**99***	**4.11**	**15.29**	**32.29**	**8.93**	**19.23**	**6.6**	**2.0**	**6.6**	**14.0**
		99†	**4.32**	**16.11**	**34.04**	**9.42**	**20.27**				
Valve leakage in closed position		99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0
		99†	4.32	16.11	34.04	9.42	20.27				
All modes		**187***	**2.06**	**23.99**	**66.77**	**21.72**	**36.32**	**6.5**	**2.0**	**6.5**	**16.0**
		187†	**2.17**	**25.28**	**70.38**	**22.90**	**38.28**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Conventional

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Conventional

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0
Total	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Conventional

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Material failure - general	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00
Total	0.00	0.00	0.00	0.00	1.60	7.49	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Conventional

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Material failure - general	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0
Total	56.15	0.00	0.00	0.00	0.00	34.76	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.7.1	Control and Safety Equipment Valves PSV - Conventional Crude oil handling

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
13	1	0.3987	0.3783	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	4*	**3.42**	**10.03**	**22.96**	**10.03**	**10.03**	**6.8**	**6.0**	**6.8**	**8.0**
	4†	**3.61**	**10.57**	**24.20**	**10.57**	**10.57**				
Fail to open on demand	3*	2.06	7.52	19.45	7.52	7.52	7.0	6.0	7.0	8.0
	3†	2.17	7.93	20.50	7.93	7.93				
Valve leakage in closed position	1*	0.13	2.51	11.90	2.51	2.51	6.0	6.0	6.0	6.0
	1†	0.13	2.64	12.54	2.64	2.64				
Degraded	2*	**0.89**	**5.02**	**15.79**	**5.02**	**5.02**	**9.5**	**7.0**	**9.5**	**12.0**
	2†	**0.94**	**5.29**	**16.64**	**5.29**	**5.29**				
Spurious operation	2*	0.89	5.02	15.79	5.02	5.02	9.5	7.0	9.5	12.0
	2†	0.94	5.29	16.64	5.29	5.29				
Incipient	2*	**0.89**	**5.02**	**15.79**	**5.02**	**5.02**	**9.0**	**6.0**	**9.0**	**12.0**
	2†	**0.94**	**5.29**	**16.64**	**5.29**	**5.29**				
Valve leakage in closed position	2*	0.89	5.02	15.79	5.02	5.02	9.0	6.0	9.0	12.0
	2†	0.94	5.29	16.64	5.29	5.29				
All modes	8*	**9.98**	**20.06**	**36.20**	**20.06**	**20.06**	**8.0**	**6.0**	**8.0**	**12.0**
	8†	**10.52**	**21.15**	**38.16**	**21.15**	**21.15**				

Comments

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Taxonomy no	Item
4.3.7.2	Control and Safety Equipment Valves PSV - Conventional Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
83	2	2.4800	2.3530	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**0.24**	**1.87**	**4.76**	**1.48**	**2.02**	**7.0**	**6.0**	**7.0**	**11.0**
	5†	**0.26**	**1.97**	**5.01**	**1.56**	**2.12**				
Fail to open on demand	2*	0.12	0.78	1.93	0.59	0.81	8.5	6.0	8.5	11.0
	2†	0.12	0.82	2.04	0.62	0.85				
Valve leakage in closed position	3*	0.17	1.15	2.88	0.89	1.21	6.0	6.0	6.0	6.0
	3†	0.17	1.21	3.04	0.93	1.27				
Degraded	**36***	**5.60**	**12.83**	**22.46**	**5.23**	**14.52**	**6.7**	**4.0**	**6.7**	**16.0**
	36†	**5.89**	**13.51**	**23.69**	**5.52**	**15.30**				
Spurious operation	36*	5.60	12.83	22.46	5.23	14.52	6.7	4.0	6.7	16.0
	36†	5.89	13.51	23.69	5.52	15.30				
Incipient	**50***	**3.63**	**15.75**	**34.86**	**9.96**	**20.16**	**6.7**	**4.0**	**6.7**	**14.0**
	50†	**3.82**	**16.60**	**36.75**	**10.50**	**21.25**				
Valve leakage in closed position	50*	3.63	15.75	34.86	9.96	20.16	6.7	4.0	6.7	14.0
	50†	3.82	16.60	36.75	10.50	21.25				
All modes	**91***	**1.92**	**24.32**	**68.73**	**22.50**	**36.69**	**6.7**	**4.0**	**6.7**	**16.0**
	91†	**2.02**	**25.63**	**72.45**	**23.72**	**38.67**				

Comments

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Taxonomy no	Item
4.3.7.3	Control and Safety Equipment Valves PSV - Conventional Main power

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
51	1	1.5643	1.4841	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**3.94**	**7.03**	**11.64**	**7.03**	**7.03**	**5.9**	**5.0**	**5.9**	**6.0**
	11†	**4.16**	**7.41**	**12.27**	**7.41**	**7.41**				
Fail to close on demand	3*	0.52	1.92	4.96	1.92	1.92	6.0	6.0	6.0	6.0
	3†	0.55	2.02	5.23	2.02	2.02				
Fail to open on demand	7*	2.10	4.47	8.41	4.47	4.47	5.9	5.0	5.9	6.0
	7†	2.21	4.72	8.86	4.72	4.72				
Valve leakage in closed position	1*	0.03	0.64	3.03	0.64	0.64	6.0	6.0	6.0	6.0
	1†	0.03	0.67	3.20	0.67	0.67				
Degraded	**21***	**9.00**	**13.42**	**19.33**	**13.42**	**13.42**	**6.2**	**4.0**	**6.2**	**10.0**
	21†	**9.48**	**14.15**	**20.38**	**14.15**	**14.15**				
Spurious operation	21*	9.00	13.42	19.33	13.42	13.42	6.2	4.0	6.2	10.0
	21†	9.48	14.15	20.38	14.15	14.15				
Incipient	**34***	**15.99**	**21.74**	**28.94**	**21.74**	**21.74**	**5.9**	**2.0**	**5.9**	**7.0**
	34†	**16.85**	**22.91**	**30.50**	**22.91**	**22.91**				
Valve leakage in closed position	34*	15.99	21.74	28.94	21.74	21.74	5.9	2.0	5.9	7.0
	34†	16.85	22.91	30.50	22.91	22.91				
All modes	**66***	**34.03**	**42.19**	**51.79**	**42.19**	**42.19**	**6.0**	**2.0**	**6.0**	**10.0**
	66†	**35.87**	**44.47**	**54.58**	**44.47**	**44.47**				

Comments

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Taxonomy no	Item
4.3.7.4	Control and Safety Equipment Valves PSV - Conventional Water fire fighting

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	1	0.3374	0.3201	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**1.05**	**5.93**	**18.66**	**5.93**	**5.93**	**6.0**	**6.0**	**6.0**	**6.0**
	2†	**1.11**	**6.25**	**19.67**	**6.25**	**6.25**				
Fail to open on demand	2*	1.05	5.93	18.66	5.93	5.93	6.0	6.0	6.0	6.0
	2†	1.11	6.25	19.67	6.25	6.25				
Degraded	**1***	**0.15**	**2.96**	**14.06**	**2.96**	**2.96**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.16**	**3.12**	**14.82**	**3.12**	**3.12**				
Spurious operation	1*	0.15	2.96	14.06	2.96	2.96	6.0	6.0	6.0	6.0
	1†	0.16	3.12	14.82	3.12	3.12				
Incipient	**5***	**5.84**	**14.82**	**31.17**	**14.82**	**14.82**	**7.4**	**6.0**	**7.4**	**9.0**
	5†	**6.15**	**15.62**	**32.85**	**15.62**	**15.62**				
Valve leakage in closed position	5*	5.84	14.82	31.17	14.82	14.82	7.4	6.0	7.4	9.0
	5†	6.15	15.62	32.85	15.62	15.62				
All modes	**8***	**11.80**	**23.71**	**42.78**	**23.71**	**23.71**	**6.9**	**6.0**	**6.9**	**9.0**
	8†	**12.43**	**24.99**	**45.10**	**24.99**	**24.99**				

Comments

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Taxonomy no	Item
4.3.7.5	Control and Safety Equipment Valves PSV - Conventional Water injection

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.3681	0.3492	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.14**	**2.72**	**12.89**	**2.72**	**2.72**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.14**	**2.86**	**13.59**	**2.86**	**2.86**				
Valve leakage in closed position	1*	0.14	2.72	12.89	2.72	2.72	6.0	6.0	6.0	6.0
	1†	0.14	2.86	13.59	2.86	2.86				
Degraded	**5***	**5.35**	**13.58**	**28.57**	**13.58**	**13.58**	**6.0**	**6.0**	**6.0**	**6.0**
	5†	**5.64**	**14.32**	**30.11**	**14.32**	**14.32**				
Spurious operation	5*	5.35	13.58	28.57	13.58	13.58	6.0	6.0	6.0	6.0
	5†	5.64	14.32	30.11	14.32	14.32				
Incipient	**8***	**10.81**	**21.74**	**39.22**	**21.74**	**21.74**	**7.4**	**6.0**	**7.4**	**12.0**
	8†	**11.40**	**22.91**	**41.34**	**22.91**	**22.91**				
Valve leakage in closed position	8*	10.81	21.74	39.22	21.74	21.74	7.4	6.0	7.4	12.0
	8†	11.40	22.91	41.34	22.91	22.91				
All modes	**14***	**22.99**	**38.04**	**59.46**	**38.04**	**38.04**	**6.8**	**6.0**	**6.8**	**12.0**
	14†	**24.23**	**40.09**	**62.67**	**40.09**	**40.09**				

Comments

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Taxonomy no	Item
4.3.8	Control and Safety Equipment Valves PSV - Conventional w/bellows

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	2	0.6747	0.4284	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.03**	**1.35**	**4.19**	**1.48**	**1.48**	**15.0**	**30.0**	**30.0**	**30.0**
	1†	**0.02**	**2.17**	**7.34**	**2.70**	**2.33**				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
Degraded	**7***	**0.71**	**8.38**	**23.41**	**7.63**	**10.38**	**5.4**	**2.0**	**10.6**	**30.0**
	7†	**0.15**	**14.03**	**45.69**	**16.63**	**16.34**				
Delayed operation	3*	0.92	4.05	8.97	2.57	4.45	4.7	5.0	9.0	14.0
	3†	0.62	6.40	17.36	5.58	7.00				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	1.0	2.0	2.0	2.0
	1†	0.02	2.17	7.34	2.70	2.33				
Spurious operation	2*	0.05	2.57	7.98	2.83	2.96	9.5	7.0	18.5	30.0
	2†	0.68	4.39	10.82	3.30	4.67				
Valve leakage in closed position	1*	0.03	1.35	4.19	1.48	1.48	4.0	8.0	8.0	8.0
	1†	0.02	2.17	7.34	2.70	2.33				
Incipient	**5***	**1.06**	**6.38**	**15.39**	**4.64**	**7.41**	**5.2**	**6.0**	**10.2**	**16.0**
	5†	**0.21**	**10.21**	**31.62**	**11.17**	**11.67**				
Delayed operation	2*	0.05	2.57	7.98	2.83	2.96	4.0	7.0	7.5	8.0
	2†	0.68	4.39	10.82	3.30	4.67				
Spurious operation	3*	0.92	4.05	8.97	2.57	4.45	6.0	6.0	12.0	16.0
	3†	0.62	6.40	17.36	5.58	7.00				
All modes	**13***	**0.22**	**14.39**	**45.37**	**16.26**	**19.27**	**6.1**	**2.0**	**11.9**	**30.0**
	13†	**0.16**	**25.48**	**89.11**	**32.89**	**30.35**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Seals	0.00	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	38.46	7.69	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	38.46	15.38	0.00	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Subunit	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	38.46	0.00	0.00	84.62
Total	7.69	0.00	0.00	0.00	0.00	38.46	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Leakage	0.00	0.00	15.38	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	30.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	38.46	15.38	0.00	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Conventional w/bellows

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Leakage	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.08
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	30.77	0.00	0.00	61.54
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Unknown	0.00	0.00	0.00	0.00	0.00	7.69	0.00	0.00	7.69
Total	7.69	0.00	0.00	0.00	0.00	38.46	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.3.8.1	Control and Safety Equipment Valves PSV - Conventional w/bellows Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0701	0.0666	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.77	18.31	6.74	0.00	-	-	-	-
	0†	0.02	5.80	22.28	8.20	0.00				

Comments

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Taxonomy no	Item
4.3.8.2	Control and Safety Equipment Valves PSV - Conventional w/bellows Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
21	2	0.4457	0.2728	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**4***	**2.42**	**8.15**	**16.65**	**4.49**	**8.98**	**4.5**	**5.0**	**8.5**	**14.0**
	4†	**0.88**	**12.90**	**37.28**	**12.31**	**14.66**				
Delayed operation	3*	0.10	5.61	17.52	6.23	6.73	4.7	5.0	9.0	14.0
	3†	1.29	10.01	25.61	7.97	11.00				
Spurious operation	1*	0.04	2.04	6.33	2.24	2.24	4.0	7.0	7.0	7.0
	1†	0.03	3.38	11.18	4.09	3.67				
Incipient	**4***	**2.42**	**8.15**	**16.65**	**4.49**	**8.98**	**5.5**	**6.0**	**11.0**	**16.0**
	4†	**0.88**	**12.90**	**37.28**	**12.31**	**14.66**				
Delayed operation	1*	0.04	2.04	6.33	2.24	2.24	4.0	8.0	8.0	8.0
	1†	0.03	3.38	11.18	4.09	3.67				
Spurious operation	3*	0.10	5.61	17.52	6.23	6.73	6.0	6.0	12.0	16.0
	3†	1.29	10.01	25.61	7.97	11.00				
All modes	**8***	**1.26**	**14.26**	**39.48**	**12.81**	**17.95**	**5.0**	**5.0**	**9.8**	**16.0**
	8†	**0.27**	**24.46**	**79.55**	**28.94**	**29.32**				

Comments

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Taxonomy no	Item
4.3.8.3	Control and Safety Equipment Valves PSV - Conventional w/bellows Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.1589	0.0890	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.31**	**6.29**	**29.86**	**6.29**	**6.29**	**15.0**	**30.0**	**30.0**	**30.0**
	1†	**0.56**	**11.24**	**53.31**	**11.24**	**11.24**				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
Degraded	**3***	**5.16**	**18.88**	**48.80**	**18.88**	**18.88**	**6.7**	**2.0**	**13.3**	**30.0**
	3†	**9.21**	**33.71**	**87.13**	**33.71**	**33.71**				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	1.0	2.0	2.0	2.0
	1†	0.56	11.24	53.31	11.24	11.24				
Spurious operation	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
Valve leakage in closed position	1*	0.31	6.29	29.86	6.29	6.29	4.0	8.0	8.0	8.0
	1†	0.56	11.24	53.31	11.24	11.24				
Incipient	**1***	**0.31**	**6.29**	**29.86**	**6.29**	**6.29**	**4.0**	**7.0**	**7.0**	**7.0**
	1†	**0.56**	**11.24**	**53.31**	**11.24**	**11.24**				
Delayed operation	1*	0.31	6.29	29.86	6.29	6.29	4.0	7.0	7.0	7.0
	1†	0.56	11.24	53.31	11.24	11.24				
All modes	**5***	**12.40**	**31.46**	**66.16**	**31.46**	**31.46**	**7.8**	**2.0**	**15.4**	**30.0**
	5†	**22.13**	**56.18**	**118.15**	**56.18**	**56.18**				

Comments

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Taxonomy no	Item
4.3.9	Control and Safety Equipment Valves PSV - Pilot operated

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	3	1.1545	0.8041	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.19**	**2.27**	**6.35**	**2.07**	**2.60**	-	**4.0**	**6.7**	**8.0**
	3†	**0.07**	**3.28**	**10.16**	**3.60**	**3.73**				
External leakage - Process medium	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Fail to close on demand	1*	0.00	0.77	2.80	1.03	0.87	-	4.0	4.0	4.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Degraded	**5***	**0.02**	**3.44**	**12.07**	**4.46**	**4.33**	**3.0**	**4.0**	**6.6**	**10.0**
	5†	**0.02**	**5.15**	**19.53**	**7.20**	**6.22**				
Delayed operation	1*	0.00	0.77	2.80	1.03	0.87	-	6.0	6.0	6.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	3*	0.19	2.27	6.35	2.07	2.60	3.0	4.0	6.3	10.0
	3†	0.07	3.28	10.16	3.60	3.73				
Valve leakage in closed position	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Incipient	**7***	**0.66**	**5.26**	**13.50**	**4.21**	**6.06**	**2.0**	**1.0**	**8.0**	**24.0**
	7†	**0.56**	**7.79**	**22.35**	**7.36**	**8.71**				
Other	1*	0.00	0.77	2.80	1.03	0.87	-	24.0	24.0	24.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	4*	0.33	3.16	8.45	2.69	3.46	1.0	1.0	6.3	14.0
	4†	1.59	4.83	9.51	2.49	4.97				
Valve leakage in closed position	2*	0.23	1.59	3.98	1.22	1.73	3.0	2.0	3.5	5.0
	2†	0.35	2.33	5.75	1.76	2.49				
All modes	**15***	**0.05**	**9.89**	**36.61**	**13.52**	**12.99**	**2.3**	**1.0**	**7.3**	**24.0**
	15†	**0.06**	**15.29**	**58.36**	**21.51**	**18.65**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Pilot operated

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Other valve components	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	6.67	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	6.67	6.67	0.00	6.67	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Pilot operated

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Other valve components	6.67	0.00	6.67	0.00	0.00	13.33	0.00	0.00	33.33
Seat rings	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	6.67
Subunit	6.67	0.00	0.00	0.00	0.00	6.67	0.00	0.00	26.67
Valve body w/internals	6.67	0.00	0.00	0.00	0.00	26.67	0.00	0.00	33.33
Total	20.00	0.00	6.67	0.00	0.00	53.33	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - PSV - Pilot operated

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Breakage	0.00	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	6.67	6.67	0.00	6.67	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - PSV - Pilot operated

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
Leakage	6.67	0.00	0.00	0.00	0.00	20.00	0.00	0.00	33.33
Mechanical Failure - general	13.33	0.00	6.67	0.00	0.00	6.67	0.00	0.00	33.33
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	20.00
No cause found	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	6.67
Total	20.00	0.00	6.67	0.00	0.00	53.33	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no		Item
4.3.9.1		Control and Safety Equipment Valves PSV - Pilot operated Condensate processing

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.1402	0.1331	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.62	10.07	3.71	0.00	-	-	-	-
	0†	0.01	3.02	11.58	4.26	0.00				

Comments

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Taxonomy no	Item
4.3.9.2	Control and Safety Equipment Valves PSV - Pilot operated Gas systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.1226	0.1165	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.89	11.09	4.08	0.00	-	-	-	-
	0†	0.01	3.35	12.87	4.74	0.00				

Comments

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Taxonomy no	Item
4.3.9.3	Control and Safety Equipment Valves PSV - Pilot operated Oil systems

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
19	2	0.8917	0.5545	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.35**	**3.07**	**8.02**	**2.52**	**3.36**	-	**4.0**	**6.7**	**8.0**
	3†	**0.69**	**4.93**	**12.40**	**3.83**	**5.41**				
External leakage - Process medium	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0
	1†	0.02	1.66	5.46	1.99	1.80				
Fail to close on demand	1*	0.01	1.04	3.46	1.27	1.12	-	4.0	4.0	4.0
	1†	0.02	1.66	5.46	1.99	1.80				
Spurious operation	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0
	1†	0.02	1.66	5.46	1.99	1.80				
Degraded	**5***	**0.13**	**4.86**	**14.84**	**5.16**	**5.61**	**3.0**	**4.0**	**6.6**	**10.0**
	5†	**0.27**	**7.75**	**23.43**	**8.01**	**9.02**				
Delayed operation	1*	0.01	1.04	3.46	1.27	1.12	-	6.0	6.0	6.0
	1†	0.02	1.66	5.46	1.99	1.80				
Spurious operation	3*	0.35	3.07	8.02	2.52	3.36	3.0	4.0	6.3	10.0
	3†	0.69	4.93	12.40	3.83	5.41				
Valve leakage in closed position	1*	0.01	1.04	3.46	1.27	1.12	-	8.0	8.0	8.0
	1†	0.02	1.66	5.46	1.99	1.80				
Incipient	**7***	**2.95**	**7.49**	**13.70**	**3.35**	**7.85**	**2.0**	**1.0**	**8.0**	**24.0**
	7†	**5.46**	**12.10**	**20.86**	**4.77**	**12.62**				
Other	1*	0.01	1.04	3.46	1.27	1.12	-	24.0	24.0	24.0
	1†	0.02	1.66	5.46	1.99	1.80				
Spurious operation	4*	1.46	4.39	8.61	2.24	4.49	1.0	1.0	6.3	14.0
	4†	2.34	7.06	13.84	3.61	7.21				
Valve leakage in closed position	2*	0.32	2.10	5.19	1.59	2.24	3.0	2.0	3.5	5.0
	2†	0.50	3.36	8.33	2.55	3.61				
All modes	**15***	**0.82**	**14.50**	**42.86**	**14.26**	**16.82**	**2.3**	**1.0**	**7.3**	**24.0**
	15†	**1.54**	**23.10**	**66.92**	**22.12**	**27.05**				

Comments

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Taxonomy no	Item
4.3.10	Control and Safety Equipment Valves Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
114	1	3.1738	3.1710	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**15***	**2.91**	**4.73**	**7.28**	**4.73**	**4.73**	**2.7**	**0.5**	**12.1**	**50.0**
	15†	**2.92**	**4.73**	**7.28**	**4.73**	**4.73**				
Fail to close on demand	2*	0.11	0.63	1.98	0.63	0.63	4.0	50.0	50.0	50.0
	2†	0.11	0.63	1.99	0.63	0.63				
Fail to open on demand	3*	0.26	0.95	2.44	0.95	0.95	4.0	4.0	4.0	4.0
	3†	0.26	0.95	2.45	0.95	0.95				
Fail to regulate	9*	1.48	2.84	4.95	2.84	2.84	1.7	0.5	1.8	3.0
	9†	1.48	2.84	4.95	2.84	2.84				
Low output	1*	0.02	0.32	1.50	0.32	0.32	2.0	3.0	3.0	3.0
	1†	0.02	0.32	1.50	0.32	0.32				
Degraded	**6***	**0.82**	**1.89**	**3.73**	**1.89**	**1.89**	**1.3**	**1.0**	**1.3**	**2.0**
	6†	**0.82**	**1.89**	**3.73**	**1.89**	**1.89**				
Low output	2*	0.11	0.63	1.98	0.63	0.63	1.0	1.0	1.0	1.0
	2†	0.11	0.63	1.99	0.63	0.63				
Minor in-service problems	3*	0.26	0.95	2.44	0.95	0.95	-	-	-	-
	3†	0.26	0.95	2.45	0.95	0.95				
Plugged/Choked	1*	0.02	0.32	1.50	0.32	0.32	2.0	2.0	2.0	2.0
	1†	0.02	0.32	1.50	0.32	0.32				
Incipient	**4***	**0.43**	**1.26**	**2.88**	**1.26**	**1.26**	**3.0**	**3.0**	**3.0**	**3.0**
	4†	**0.43**	**1.26**	**2.89**	**1.26**	**1.26**				
Abnormal instrument reading	2*	0.11	0.63	1.98	0.63	0.63	-	-	-	-
	2†	0.11	0.63	1.99	0.63	0.63				
Fail to regulate	1*	0.02	0.32	1.50	0.32	0.32	3.0	3.0	3.0	3.0
	1†	0.02	0.32	1.50	0.32	0.32				
Unknown	1*	0.02	0.32	1.50	0.32	0.32	3.0	3.0	3.0	3.0
	1†	0.02	0.32	1.50	0.32	0.32				
All modes	**25***	**5.48**	**7.88**	**11.00**	**7.88**	**7.88**	**2.4**	**0.5**	**7.1**	**50.0**
	25†	**5.48**	**7.88**	**11.01**	**7.88**	**7.88**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by taxonomy code - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00
Total	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by taxonomy code - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0
Total	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by taxonomy code - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	4.00	4.00	0.00	0.00	0.00
Instrument failure - general	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00
Total	8.00	0.00	0.00	0.00	8.00	12.00	40.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by taxonomy code - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	12.00
Instrument failure - general	0.00	0.00	0.00	0.00	12.00	0.00	0.00	0.00	20.00
Leakage	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Mechanical Failure - general	0.00	4.00	0.00	0.00	0.00	0.00	0.00	4.00	48.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Out of adjustment	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
Total	0.00	12.00	0.00	4.00	12.00	0.00	0.00	4.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4	Control and Safety Equipment Valves

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1170	40	36.6612	31.6175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**358***	**0.01**	**6.79**	**28.28**	**10.78**	**9.77**	**9.1**	**0.5**	**12.0**	**113.0**
	358†	**3.00**	**25.97**	**67.80**	**21.31**	**11.32**				
Delayed operation	3*	0.00	0.11	0.55	0.24	0.08	32.0	28.0	64.0	113.0
	3†	0.00	0.15	0.71	0.29	0.09				
External leakage - Process medium	11*	0.00	0.24	0.82	0.30	0.30	11.0	1.0	13.5	54.0
	11†	0.00	0.29	1.16	0.44	0.35				
External leakage - Utility medium	2*	0.00	0.06	0.19	0.07	0.05	9.8	17.0	19.5	22.0
	2†	0.00	0.08	0.25	0.09	0.06				
Fail to close on demand	134*	0.00	2.31	13.11	7.48	3.66	8.2	1.0	11.3	78.0
	134†	0.00	5.09	22.77	9.01	4.24				
Fail to open on demand	84*	0.02	2.81	9.37	3.43	2.29	7.6	1.0	10.4	78.0
	84†	7.06	29.13	63.54	17.98	2.66				
Fail to regulate	72*	0.00	0.55	1.09	3.05	1.96	11.5	0.5	13.3	93.0
	72†	0.00	0.90	4.75	3.23	2.28				
High output	1*	0.00	0.03	0.08	0.03	0.03	6.0	6.0	6.0	6.0
	1†	0.00	0.03	0.09	0.03	0.03				
Internal leakage	3*	0.01	0.07	0.20	0.07	0.08	26.3	6.0	34.0	48.0
	3†	0.01	0.08	0.22	0.07	0.09				
Low output	1*	0.00	0.03	0.09	0.04	0.03	2.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Other	4*	0.00	0.13	0.45	0.17	0.11	8.3	1.0	16.7	37.0
	4†	0.00	0.16	0.54	0.20	0.13				
Spurious operation	23*	0.00	0.61	2.98	1.25	0.63	3.2	1.0	4.9	24.0
	23†	0.00	1.17	5.39	2.17	0.73				
Structural deficiency	7*	0.00	0.20	0.88	0.35	0.19	5.2	2.0	6.0	16.0
	7†	0.00	0.25	0.85	0.31	0.22				
Unknown	2*	0.00	0.05	0.14	0.04	0.05	62.0	36.0	65.0	94.0
	2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position	11*	0.03	0.25	0.66	0.21	0.30	8.6	6.0	10.2	35.0
	11†	0.05	0.30	0.74	0.22	0.35				
Degraded	**302***	**1.08**	**8.47**	**21.73**	**6.77**	**8.24**	**8.0**	**0.5**	**9.8**	**92.0**
	302†	**3.87**	**19.74**	**45.72**	**13.45**	**9.55**				
Abnormal instrument reading	6*	0.00	0.24	0.99	0.38	0.16	3.8	2.0	4.5	6.0
	6†	0.00	0.31	1.00	0.36	0.19				
Delayed operation	27*	0.01	1.00	3.34	1.23	0.74	5.8	1.0	10.5	36.0
	27†	0.13	1.59	4.47	1.46	0.85				
External leakage - Process medium	33*	0.02	2.13	7.17	2.63	0.90	8.7	1.0	10.8	45.0
	33†	5.52	20.42	43.00	11.87	1.04				
External leakage - Utility medium	38*	0.00	1.16	4.54	1.69	1.04	9.1	1.0	13.4	92.0
	38†	0.08	1.76	5.29	1.78	1.20				
Fail to open on demand	2*	0.00	0.06	0.18	0.07	0.05	3.3	0.5	3.3	6.0
	2†	0.00	0.07	0.22	0.08	0.06				

Comments

(cont.)

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Taxonomy no		Item									
4.4		Control and Safety Equipment Valves									
Population	Installations	Aggregated time in service (10^6 hours)						No of demands			
1170	40	Calendar time * 36.6612			Operational time † 31.6175						
Failure mode		No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
			Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
High output		4*	0.00	0.10	0.32	0.11	0.11	4.1	2.0	4.4	9.0
		4†	0.00	0.13	0.41	0.15	0.13				
Internal leakage		18*	0.00	0.67	3.33	1.42	0.49	15.3	4.0	20.6	48.0
		18†	0.00	1.02	4.03	1.50	0.57				
Low output		14*	0.00	0.26	1.48	0.77	0.38	5.3	1.0	5.3	13.0
		14†	0.00	0.43	2.30	1.06	0.44				
Minor in-service problems		4*	0.00	0.10	0.38	0.14	0.11	4.0	4.0	4.0	4.0
		4†	0.00	0.12	0.38	0.14	0.13				
Other		44*	0.00	1.47	6.79	2.74	1.20	6.0	2.0	7.6	61.0
		44†	0.02	2.41	8.13	2.98	1.39				
Plugged/Choked		4*	0.00	0.15	0.77	0.35	0.11	2.0	2.0	2.0	2.0
		4†	0.00	0.21	0.93	0.36	0.13				
Spurious operation		74*	0.00	0.68	0.96	4.34	2.02	7.2	4.0	7.4	35.0
		74†	0.00	1.22	6.29	4.78	2.34				
Structural deficiency		3*	0.00	0.35	1.89	0.88	0.08	6.0	6.0	6.0	6.0
		3†	0.00	0.59	2.53	0.98	0.09				
Unknown		2*	0.00	0.05	0.14	0.04	0.05	6.0	2.0	6.0	10.0
		2†	0.01	0.06	0.15	0.05	0.06				
Valve leakage in closed position		29*	0.00	0.47	1.99	0.77	0.79	12.6	2.0	13.0	70.0
		29†	0.01	0.66	2.05	0.73	0.92				
Incipient		**339***	**3.53**	**14.93**	**32.80**	**9.32**	**9.25**	**4.9**	**1.0**	**6.3**	**80.0**
		339†	**86.84**	**143.70**	**212.14**	**38.42**	**10.72**				
Abnormal instrument reading		111*	1.85	9.73	22.72	6.71	3.03	4.1	1.0	5.6	80.0
		111†	105.90	160.11	223.45	35.95	3.51				
Delayed operation		4*	0.00	0.34	1.50	0.59	0.11	2.5	1.0	4.3	8.0
		4†	0.43	3.58	9.25	2.89	0.13				
External leakage - Process medium		4*	0.00	0.18	0.74	0.28	0.11	4.0	1.0	3.7	7.0
		4†	0.00	0.22	0.76	0.28	0.13				
External leakage - Utility medium		30*	0.00	0.88	4.43	1.90	0.82	3.5	1.0	6.5	20.0
		30†	0.36	7.39	22.13	7.41	0.95				
Fail to regulate		1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
		1†	0.00	0.03	0.10	0.04	0.03				
Internal leakage		3*	0.00	0.12	0.47	0.17	0.08	18.0	4.0	15.3	30.0
		3†	0.00	0.13	0.39	0.14	0.09				
Low output		2*	0.00	0.06	0.27	0.11	0.05	3.5	1.0	6.5	12.0
		2†	0.00	0.08	0.34	0.13	0.06				
Minor in-service problems		42*	0.00	2.02	8.34	3.17	1.15	3.0	1.0	3.7	10.0
		42†	0.13	3.34	10.05	3.41	1.33				
Other		28*	0.00	0.60	3.11	2.72	0.76	4.7	1.0	9.6	28.0
		28†	0.00	1.12	6.24	3.22	0.89				
Spurious operation		7*	0.00	0.32	1.45	0.58	0.19	4.8	1.0	8.7	16.0
		7†	0.00	0.61	2.33	0.86	0.22				
Comments											

(cont.)

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Taxonomy no	Item
4.4	Control and Safety Equipment Valves

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1170	40	36.6612	31.6175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Structural deficiency	3*	0.00	0.35	1.90	0.88	0.08	9.0	13.0	15.5	18.0
	3†	0.00	0.58	2.47	0.96	0.09				
Unknown	1*	0.00	0.03	0.09	0.04	0.03	3.0	3.0	3.0	3.0
	1†	0.00	0.03	0.10	0.04	0.03				
Valve leakage in closed position	103*	0.00	0.74	0.81	6.85	2.81	6.5	2.0	6.5	14.0
	103†	0.00	1.26	2.07	7.57	3.26				
Unknown	**18***	**0.00**	**0.35**	**1.80**	**1.47**	**0.49**	**15.6**	**1.0**	**23.2**	**119.0**
	18†	**0.00**	**0.54**	**3.02**	**1.56**	**0.57**				
Unknown	18*	0.00	0.35	1.80	1.47	0.49	15.6	1.0	23.2	119.0
	18†	0.00	0.54	3.02	1.56	0.57				
All modes	**1017***	**7.74**	**31.05**	**67.14**	**18.89**	**27.74**	**7.5**	**0.5**	**9.7**	**119.0**
	1017†	**110.16**	**190.63**	**289.04**	**54.91**	**32.17**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.79	0.10	0.00	0.00	0.20	0.20	0.10	0.00	0.00
Bonnet	0.00	0.00	0.00	0.10	0.00	0.49	0.00	0.00	0.00
Cabling & junction boxes	0.39	0.10	0.00	0.00	0.00	0.39	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.10	0.00	0.00	0.20	0.10	0.00	0.00	0.00
Control unit	1.38	0.10	0.00	0.10	0.20	0.10	0.69	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flange	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Indicator	0.10	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.00
Instrument, general	0.88	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.20	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Monitoring	4.52	0.20	0.00	0.00	0.10	0.00	0.10	0.00	0.00
Other	0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.10
Other actuator components	0.00	0.29	0.00	1.08	0.39	0.10	0.10	0.00	0.00
Other valve components	0.00	0.00	0.59	0.20	0.20	0.44	0.20	0.00	0.20
Packing	0.00	0.00	0.44	0.29	0.21	0.00	0.00	0.00	0.10
Pilot valve	0.10	0.00	0.00	0.49	2.16	0.49	0.00	0.00	0.20
Piston(s)	0.00	0.00	0.00	0.20	0.29	0.29	0.33	0.00	0.00
Positioner	0.39	0.00	0.00	0.10	0.15	0.10	0.88	0.10	0.00
Seals	0.00	0.00	0.84	0.00	0.41	0.00	0.10	0.05	0.29
Seals (gaskets)	0.00	0.00	0.29	2.26	0.00	0.00	0.00	0.00	0.39
Seat rings	0.00	0.00	0.98	0.00	0.56	0.34	0.00	0.05	0.39
Spring	0.00	0.00	0.00	0.00	0.10	0.10	0.03	0.00	0.00
Stem	0.00	0.39	0.20	0.20	0.20	0.20	0.23	0.00	0.00
Subunit	0.10	0.59	0.20	0.49	2.26	1.47	2.36	0.10	0.49
Unknown	0.88	0.79	0.20	0.69	4.82	3.34	1.18	0.00	0.10
Valve body w/internals	0.00	0.69	0.59	0.10	0.59	0.10	0.39	0.20	0.10
Valves	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by application

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.20	0.69	0.00	0.10	1.08	0.00	0.00	3.44
Bonnet	0.00	0.00	0.00	0.00	0.10	0.00	0.15	0.00	0.84
Cabling & junction boxes	0.00	0.00	0.59	0.00	0.20	0.00	0.10	0.00	1.77
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.59
Control unit	0.00	0.00	0.00	0.00	0.29	0.29	0.00	0.10	3.24
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Electric motor (electric actuator)	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Indicator	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.54
Instrument, general	0.00	0.10	0.20	0.00	0.20	0.20	0.00	0.00	1.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.39
Monitoring	0.00	0.00	0.20	0.00	0.10	0.00	0.00	0.00	5.21
Other	0.10	0.00	1.08	0.00	0.10	0.00	0.00	0.00	1.77
Other actuator components	0.00	0.00	0.39	0.00	0.29	0.10	0.00	0.00	2.75
Other valve components	0.10	0.00	0.20	0.00	0.20	0.20	0.00	0.00	2.51
Packing	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Pilot valve	0.00	0.00	0.00	0.00	0.79	0.10	0.20	0.29	4.82
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.16
Positioner	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	1.92
Seals	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.00
Seat rings	1.08	0.00	0.10	0.00	0.10	0.10	0.00	0.00	3.70
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Stem	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	1.70
Subunit	1.77	0.00	3.05	0.00	0.39	0.39	0.10	0.79	14.55
Unknown	10.52	0.59	0.49	0.29	1.28	6.69	0.39	0.98	33.24
Valve body w/internals	0.10	0.79	0.00	0.00	0.00	0.88	0.25	0.00	4.77
Valves	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.29	0.00	0.00	0.00	1.87	1.57	0.49	0.20	0.10
Breakage	0.20	0.00	0.29	0.20	0.20	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.29	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.10
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Corrosion	0.39	0.20	0.10	0.20	0.20	0.20	0.39	0.00	0.00
Deformation	0.00	0.00	0.29	0.10	0.10	0.20	0.20	0.10	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Electrical failure - general	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.10	0.00	0.10	0.00	0.20	0.00	0.10
External influence - general	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	2.95	0.59	0.00	0.20	3.05	1.28	0.10	0.10	0.00
Leakage	0.00	0.20	2.06	4.23	0.39	0.10	0.10	0.00	0.49
Looseness	0.00	0.10	0.20	0.20	0.10	0.00	0.10	0.00	0.20
Material failure - general	0.10	0.00	0.29	0.49	0.39	1.57	0.00	0.00	0.20
Mechanical Failure - general	0.20	1.08	0.00	0.49	2.46	1.38	1.08	0.00	0.29
Misc. external influences	0.20	0.10	0.00	0.10	0.20	0.20	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.29	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
Open circuit	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	4.52	0.29	0.00	0.20	0.98	0.29	3.05	0.00	0.10
Short circuiting	0.10	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.49	0.00	0.00	0.29	0.29	0.00	0.00	0.00
Unknown	0.00	0.29	0.29	0.10	0.69	0.49	0.20	0.10	0.10
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00
Wear	0.00	0.00	1.08	0.29	1.67	0.29	0.79	0.00	0.59
Total	11.50	3.34	4.72	6.88	13.18	8.46	7.18	0.49	2.36

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by application

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	1.18	0.10	0.29	0.10	0.10	0.00	0.00	6.29
Breakage	0.00	0.00	0.10	0.00	0.00	0.20	0.00	0.00	1.18
Cavitation	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.20
Clearance/ alignment failure	0.20	0.00	0.00	0.00	0.00	0.10	0.00	0.10	1.38
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Corrosion	0.10	0.00	1.28	0.00	0.69	0.10	0.29	0.10	4.23
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Electrical failure - general	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.00	0.29
Erosion	0.20	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.79
External influence - general	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.39
Faulty signal/indication/alarm	0.00	0.10	0.29	0.00	0.10	0.59	0.00	0.00	2.56
Instrument failure - general	0.10	0.00	0.39	0.00	0.69	0.88	0.20	0.59	11.11
Leakage	2.56	0.10	0.00	0.00	0.10	0.29	0.00	0.00	10.62
Looseness	0.20	0.00	0.20	0.00	0.69	0.10	0.00	0.00	2.06
Material failure - general	10.32	0.00	0.20	0.00	0.00	6.39	0.10	0.00	20.06
Mechanical Failure - general	0.20	0.10	0.29	0.00	0.39	0.49	0.29	0.39	9.14
Misc. external influences	0.00	0.00	0.29	0.00	0.49	0.00	0.10	0.00	1.67
Miscellaneous - general	0.00	0.00	0.10	0.00	0.10	0.29	0.00	0.00	0.59
No cause found	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.20
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Other	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00	0.20
Out of adjustment	0.00	0.20	3.05	0.00	0.20	0.20	0.00	0.10	13.18
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.29
Software failure	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.20
Sticking	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	1.38
Unknown	0.10	0.00	0.29	0.10	0.29	0.29	0.00	0.98	4.33
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.49
Wear	0.10	0.00	0.20	0.00	0.00	0.00	0.10	0.00	5.11
Total	14.06	1.67	7.47	0.39	4.52	10.23	1.28	2.26	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.1	Control and Safety Equipment Valves Blowdown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
94	24	4.5502	1.7378	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**29***	**0.01**	**5.61**	**23.25**	**8.84**	**6.37**	**6.5**	**1.0**	**10.9**	**60.0**
	29†	**9.83**	**97.36**	**262.40**	**84.03**	**16.69**				
Fail to close on demand	3*	0.05	0.69	2.00	0.66	0.66	2.0	2.0	2.3	3.0
	3†	0.06	13.70	50.67	18.71	1.73				
Fail to open on demand	25*	0.00	4.66	22.67	9.43	5.49	7.0	1.0	12.1	60.0
	25†	2.69	79.21	239.75	82.19	14.39				
Spurious operation	1*	0.00	0.20	1.15	0.61	0.22	8.0	8.0	8.0	8.0
	1†	0.00	3.41	16.67	6.98	0.58				
Degraded	**20***	**0.02**	**3.73**	**13.69**	**5.06**	**4.40**	**7.8**	**1.0**	**12.2**	**36.0**
	20†	**0.70**	**46.23**	**146.10**	**52.42**	**11.51**				
Delayed operation	8*	0.00	1.14	6.15	2.86	1.76	7.0	6.0	16.0	36.0
	8†	0.02	3.60	13.42	4.96	4.60				
External leakage - Process medium	10*	0.00	2.44	11.44	4.66	2.20	9.3	1.0	10.5	36.0
	10†	1.08	49.44	152.55	53.70	5.75				
External leakage - Utility medium	2*	0.00	0.35	1.46	0.56	0.44	3.0	1.0	5.5	10.0
	2†	0.13	1.02	2.61	0.81	1.15				
Incipient	**68***	**3.96**	**18.07**	**40.61**	**11.72**	**14.94**	**2.9**	**1.0**	**3.9**	**80.0**
	68†	**122.85**	**348.03**	**666.40**	**170.02**	**39.13**				
Abnormal instrument reading	51*	1.47	15.59	42.64	13.76	11.21	2.4	1.0	3.6	80.0
	51†	104.93	318.45	625.94	163.45	29.35				
Delayed operation	2*	0.00	0.48	2.67	1.40	0.44	1.0	1.0	1.0	1.0
	2†	0.03	8.69	33.80	12.52	1.15				
External leakage - Process medium	2*	0.00	0.36	1.98	0.93	0.44	4.0	1.0	4.0	7.0
	2†	0.13	1.17	3.09	0.98	1.15				
External leakage - Utility medium	4*	0.00	0.90	4.67	2.05	0.88	1.5	1.0	1.5	3.0
	4†	0.06	22.50	88.67	33.02	2.30				
Internal leakage	1*	0.00	0.20	1.03	0.47	0.22	30.0	30.0	30.0	30.0
	1†	0.03	0.58	1.73	0.58	0.58				
Minor in-service problems	6*	0.00	0.96	4.12	1.60	1.32	3.7	2.0	4.0	6.0
	6†	1.05	3.22	6.35	1.66	3.45				
Other	1*	0.00	0.59	3.22	1.99	0.22	2.0	4.0	4.0	4.0
	1†	0.00	1.61	6.88	2.66	0.58				
Valve leakage in closed position	1*	0.00	0.20	1.03	0.47	0.22	7.0	7.0	7.0	7.0
	1†	0.03	0.58	1.73	0.58	0.58				
All modes	**117***	**8.36**	**27.30**	**55.13**	**14.72**	**25.71**	**4.6**	**1.0**	**7.1**	**80.0**
	117†	**194.65**	**509.72**	**945.93**	**234.27**	**67.33**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Blowdown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00
Cabling & junction boxes	1.71	0.85	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Control unit	3.42	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	35.04	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.85
Other actuator components	0.00	1.71	0.00	2.56	1.71	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.00	0.00	0.00	3.85	0.00	0.00	0.00
Piston(s)	0.00	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Seals	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	5.98	0.00	0.00	2.99	0.00	0.00	0.00
Stem	0.00	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Subunit	0.00	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.85	2.56	0.00	0.00	0.00
Valve body w/internals	0.00	0.85	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	43.59	8.55	10.26	5.13	2.56	21.37	0.00	0.00	0.85

Maintainable item versus failure mode, continued
Item: Valves described by application - Blowdown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	1.71
Bonnet	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	5.13
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27
Control unit	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	5.13
Indicator	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.85
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Monitoring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.90
Other	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Other actuator components	0.00	0.00	0.00	0.00	1.71	0.85	0.00	0.00	8.55
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.97
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Valves	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.85
Total	0.85	0.00	0.85	0.00	5.13	0.85	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Blowdown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	7.69	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00
Faulty signal/indication/alarm	5.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	8.55	1.71	0.00	0.00	0.00	1.71	0.00	0.00	0.00
Leakage	0.00	0.85	10.26	5.13	1.71	0.00	0.00	0.00	0.85
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.71	0.00	0.00	0.00	5.98	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open circuit	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	29.06	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	1.71	0.00	0.00	0.00	0.85	0.00	0.00	0.00
Unknown	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	43.59	8.55	10.26	5.13	2.56	21.37	0.00	0.00	0.85

Failure descriptior versus failure mode, continued
Item: Valves described by application - Blowdown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Breakage	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	1.71
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13
Instrument failure - general	0.00	0.00	0.85	0.00	0.00	0.00	0.00	0.00	12.82
Leakage	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.66
Looseness	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	2.56
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
Miscellaneous - general	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.85
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.77
Sticking	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00	4.27
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Total	0.85	0.00	0.85	0.00	5.13	0.85	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.1.1	Control and Safety Equipment Valves Blowdown Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
58	6	1.5890	1.5556	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**16***	**0.01**	**6.36**	**25.63**	**9.64**	**10.07**	**3.7**	**2.0**	**8.3**	**29.0**
	16†	**0.02**	**6.47**	**25.62**	**9.56**	**10.29**				
Fail to close on demand	1*	0.00	0.78	3.48	1.38	0.63	3.0	3.0	3.0	3.0
	1†	0.00	0.80	3.60	1.43	0.64				
Fail to open on demand	15*	0.00	5.33	25.58	10.53	9.44	3.8	2.0	8.7	29.0
	15†	0.00	5.40	25.61	10.50	9.64				
Degraded	**13***	**4.32**	**7.79**	**12.09**	**2.39**	**8.18**	**8.0**	**1.0**	**13.9**	**36.0**
	13†	**4.59**	**7.98**	**12.13**	**2.32**	**8.36**				
Delayed operation	8*	0.15	4.50	13.65	4.69	5.03	7.0	6.0	16.0	36.0
	8†	0.17	4.55	13.75	4.69	5.14				
External leakage - Process medium	3*	0.02	1.91	6.19	2.25	1.89	14.0	1.0	14.0	36.0
	3†	0.02	1.97	6.64	2.44	1.93				
External leakage - Utility medium	2*	0.04	1.08	3.26	1.12	1.26	3.0	1.0	5.5	10.0
	2†	0.05	1.10	3.30	1.12	1.29				
Incipient	**14***	**5.19**	**9.32**	**14.42**	**2.84**	**8.81**	**5.9**	**1.0**	**6.2**	**30.0**
	14†	**4.86**	**9.71**	**15.91**	**3.41**	**9.00**				
Abnormal instrument reading	3*	0.05	3.26	10.32	3.71	1.89	4.7	4.0	4.7	6.0
	3†	0.05	3.33	10.52	3.77	1.93				
External leakage - Process medium	2*	0.25	1.29	3.01	0.89	1.26	4.0	1.0	4.0	7.0
	2†	0.26	1.33	3.09	0.91	1.29				
Internal leakage	1*	0.00	0.65	2.52	0.93	0.63	30.0	30.0	30.0	30.0
	1†	0.00	0.67	2.64	0.98	0.64				
Minor in-service problems	6*	0.32	3.35	9.17	2.96	3.78	3.7	2.0	4.0	6.0
	6†	0.30	3.43	9.50	3.08	3.86				
Other	1*	0.01	2.85	11.12	4.12	0.63	2.0	4.0	4.0	4.0
	1†	0.01	2.94	11.46	4.25	0.64				
Valve leakage in closed position	1*	0.00	0.65	2.52	0.93	0.63	7.0	7.0	7.0	7.0
	1†	0.00	0.67	2.64	0.98	0.64				
All modes	**43***	**14.12**	**25.15**	**38.76**	**7.57**	**27.06**	**5.8**	**1.0**	**9.3**	**36.0**
	43†	**15.65**	**25.89**	**38.22**	**6.92**	**27.64**				

Comments

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Taxonomy no
4.4.1.1.1

Item
Control and Safety Equipment
Valves
Blowdown
Ball
(1.1-5.0) inch

Population	Installations
55	6

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
1.5181	1.4863

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**16***	**0.03**	**7.02**	**25.78**	**9.52**	**10.54**	**3.7**	**2.0**	**8.3**	**29.0**
	16†	**0.04**	**7.15**	**25.48**	**9.41**	**10.76**				
Fail to close on demand	1*	0.00	0.83	3.56	1.38	0.66	3.0	3.0	3.0	3.0
	1†	0.00	0.85	3.68	1.43	0.67				
Fail to open on demand	15*	0.00	5.88	26.55	10.55	9.88	3.8	2.0	8.7	29.0
	15†	0.00	5.95	26.56	10.49	10.09				
Degraded	**12***	**0.72**	**6.38**	**16.75**	**5.28**	**7.90**	**8.3**	**1.0**	**14.3**	**36.0**
	12†	**0.75**	**6.52**	**17.00**	**5.34**	**8.07**				
Delayed operation	7*	0.21	3.52	10.35	3.44	4.61	7.3	6.0	16.9	36.0
	7†	0.30	3.62	10.15	3.31	4.71				
External leakage - Process medium	3*	0.03	2.08	6.61	2.38	1.98	14.0	1.0	14.0	36.0
	3†	0.02	2.16	7.07	2.57	2.02				
External leakage - Utility medium	2*	0.07	1.14	3.36	1.12	1.32	3.0	1.0	5.5	10.0
	2†	0.08	1.17	3.38	1.12	1.35				
Incipient	**13***	**2.47**	**9.57**	**20.45**	**5.71**	**8.56**	**5.9**	**1.0**	**6.2**	**30.0**
	13†	**2.35**	**9.93**	**21.81**	**6.20**	**8.75**				
Abnormal instrument reading	2*	0.01	1.67	5.66	2.08	1.32	4.0	4.0	4.0	4.0
	2†	0.01	1.72	5.90	2.17	1.35				
External leakage - Process medium	2*	0.27	1.37	3.17	0.93	1.32	4.0	1.0	4.0	7.0
	2†	0.29	1.42	3.25	0.95	1.35				
Internal leakage	1*	0.00	0.70	2.63	0.97	0.66	30.0	30.0	30.0	30.0
	1†	0.00	0.72	2.78	1.02	0.67				
Minor in-service problems	6*	0.39	3.62	9.62	3.06	3.95	3.7	2.0	4.0	6.0
	6†	0.38	3.71	9.97	3.19	4.04				
Other	1*	0.07	5.53	17.63	6.36	0.66	2.0	4.0	4.0	4.0
	1†	0.08	5.69	18.17	6.56	0.67				
Valve leakage in closed position	1*	0.00	0.70	2.63	0.97	0.66	7.0	7.0	7.0	7.0
	1†	0.00	0.72	2.78	1.02	0.67				
All modes	**41***	**12.60**	**24.40**	**39.35**	**8.24**	**27.01**	**5.8**	**1.0**	**9.4**	**36.0**
	41†	**14.07**	**25.19**	**38.92**	**7.64**	**27.58**				

Comments

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Taxonomy no	Item
4.4.1.1.2	Control and Safety Equipment Valves Blowdown Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0227	0.0220	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**2.20**	**44.05**	**208.99**	**44.05**	**44.05**	**5.0**	**10.0**	**10.0**	**10.0**
	1†	**2.27**	**45.45**	**215.68**	**45.45**	**45.45**				
Delayed operation	1*	2.20	44.05	208.99	44.05	44.05	5.0	10.0	10.0	10.0
	1†	2.27	45.45	215.68	45.45	45.45				
All modes	**1***	**2.20**	**44.05**	**208.99**	**44.05**	**44.05**	**5.0**	**10.0**	**10.0**	**10.0**
	1†	**2.27**	**45.45**	**215.68**	**45.45**	**45.45**				

Comments

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Taxonomy no	Item
4.4.1.1.3	Control and Safety Equipment Valves Blowdown Ball Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0482	0.0473	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.18**	**19.14**	**63.13**	**23.07**	**20.76**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.21**	**19.46**	**63.42**	**23.09**	**21.16**				
Abnormal instrument reading	1*	0.18	19.14	63.13	23.07	20.76	6.0	6.0	6.0	6.0
	1†	0.21	19.46	63.42	23.09	21.16				
All modes	**1***	**0.18**	**19.14**	**63.13**	**23.07**	**20.76**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.21**	**19.46**	**63.42**	**23.09**	**21.16**				

Comments

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Taxonomy no	Item
4.4.1.2	Control and Safety Equipment Valves Blowdown Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
36	19	2.9612	0.1822	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**0.00**	**5.43**	**22.97**	**8.83**	**4.39**	**9.8**	**1.0**	**14.2**	**60.0**
	13†	**0.14**	**134.04**	**556.78**	**211.86**	**71.35**				
Fail to close on demand	2*	0.00	0.72	2.63	0.97	0.68	1.5	2.0	2.0	2.0
	2†	0.00	18.23	93.39	40.43	10.98				
Fail to open on demand	10*	0.00	4.51	22.10	9.28	3.38	11.6	1.0	17.2	60.0
	10†	0.00	109.71	520.95	213.55	54.89				
Spurious operation	1*	0.00	0.29	1.52	0.68	0.34	8.0	8.0	8.0	8.0
	1†	0.00	5.60	32.07	17.29	5.49				
Degraded	**7***	**0.00**	**2.60**	**12.99**	**5.54**	**2.36**	**7.3**	**3.0**	**9.0**	**30.0**
	7†	**0.00**	**64.94**	**317.24**	**132.71**	**38.42**				
External leakage - Process medium	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0
	7†	0.00	64.94	317.24	132.71	38.42				
Incipient	**54***	**4.41**	**19.89**	**44.53**	**12.83**	**18.24**	**2.1**	**1.0**	**3.3**	**80.0**
	54†	**62.42**	**438.33**	**1098.32**	**338.44**	**296.39**				
Abnormal instrument reading	48*	2.78	18.37	45.40	13.89	16.21	2.2	1.0	3.5	80.0
	48†	42.30	398.52	1062.14	338.00	263.46				
Delayed operation	2*	0.00	0.63	3.39	1.56	0.68	1.0	1.0	1.0	1.0
	2†	2.32	11.51	26.49	7.76	10.98				
External leakage - Utility medium	4*	0.00	1.22	5.31	2.07	1.35	1.5	1.0	1.5	3.0
	4†	0.00	29.96	164.20	76.87	21.95				
All modes	**74***	**6.47**	**27.99**	**61.88**	**17.66**	**24.99**	**4.0**	**1.0**	**5.8**	**80.0**
	74†	**94.42**	**648.55**	**1617.21**	**497.07**	**406.16**				

Comments

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Taxonomy no	Item
4.4.1.2.1	Control and Safety Equipment Valves Blowdown Gate (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
36	19	2.9612	0.1822	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**0.00**	**5.43**	**22.97**	**8.83**	**4.39**	**9.8**	**1.0**	**14.2**	**60.0**
	13†	**0.14**	**134.04**	**556.78**	**211.86**	**71.35**				
Fail to close on demand	2*	0.00	0.72	2.63	0.97	0.68	1.5	2.0	2.0	2.0
	2†	0.00	18.23	93.39	40.43	10.98				
Fail to open on demand	10*	0.00	4.51	22.10	9.28	3.38	11.6	1.0	17.2	60.0
	10†	0.00	109.71	520.95	213.55	54.89				
Spurious operation	1*	0.00	0.29	1.52	0.68	0.34	8.0	8.0	8.0	8.0
	1†	0.00	5.60	32.07	17.29	5.49				
Degraded	**7***	**0.00**	**2.60**	**12.99**	**5.54**	**2.36**	**7.3**	**3.0**	**9.0**	**30.0**
	7†	**0.00**	**64.94**	**317.24**	**132.71**	**38.42**				
External leakage - Process medium	7*	0.00	2.60	12.99	5.54	2.36	7.3	3.0	9.0	30.0
	7†	0.00	64.94	317.24	132.71	38.42				
Incipient	**54***	**4.41**	**19.89**	**44.53**	**12.83**	**18.24**	**2.1**	**1.0**	**3.3**	**80.0**
	54†	**62.42**	**438.33**	**1098.32**	**338.44**	**296.39**				
Abnormal instrument reading	48*	2.78	18.37	45.40	13.89	16.21	2.2	1.0	3.5	80.0
	48†	42.30	398.52	1062.14	338.00	263.46				
Delayed operation	2*	0.00	0.63	3.39	1.56	0.68	1.0	1.0	1.0	1.0
	2†	2.32	11.51	26.49	7.76	10.98				
External leakage - Utility medium	4*	0.00	1.22	5.31	2.07	1.35	1.5	1.0	1.5	3.0
	4†	0.00	29.96	164.20	76.87	21.95				
All modes	**74***	**6.47**	**27.99**	**61.88**	**17.66**	**24.99**	**4.0**	**1.0**	**5.8**	**80.0**
	74†	**94.42**	**648.55**	**1617.21**	**497.07**	**406.16**				

Comments

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Taxonomy no	Item
4.4.2	Control and Safety Equipment Valves By-pass

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.1373	0.1353	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**0.17**	**16.16**	**52.69**	**19.19**	**14.57**	**10.5**	**2.0**	**20.0**	**38.0**
	2†	**0.19**	**16.23**	**52.48**	**19.05**	**14.79**				
External leakage - Utility medium	1*	0.55	7.70	22.11	7.28	7.28	2.0	2.0	2.0	2.0
	1†	0.54	7.78	22.41	7.39	7.39				
Internal leakage	1*	0.55	7.70	22.11	7.28	7.28	19.0	38.0	38.0	38.0
	1†	0.54	7.78	22.41	7.39	7.39				
Incipient	**1***	**0.04**	**6.88**	**24.29**	**8.97**	**7.28**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**0.04**	**7.01**	**24.92**	**9.20**	**7.39**				
Abnormal instrument reading	1*	0.04	6.88	24.29	8.97	7.28	8.0	8.0	8.0	8.0
	1†	0.04	7.01	24.92	9.20	7.39				
All modes	**3***	**4.50**	**22.51**	**51.88**	**15.22**	**21.85**	**9.7**	**2.0**	**16.0**	**38.0**
	3†	**4.83**	**22.76**	**51.62**	**15.00**	**22.18**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - By-pass

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Control unit	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, general	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	33.33	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33

Maintainable item versus failure mode, continued
Item: Valves described by application - By-pass

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Pilot valve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by application - By-pass

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Instrument failure - general	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33
Total	33.33	0.00	0.00	33.33	0.00	0.00	0.00	0.00	33.33

Failure descriptior versus failure mode, continued
Item: Valves described by application - By-pass

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.2.1	Control and Safety Equipment Valves By-pass Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.1373	0.1353	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**0.17**	**16.16**	**52.69**	**19.19**	**14.57**	**10.5**	**2.0**	**20.0**	**38.0**
	2†	**0.19**	**16.23**	**52.48**	**19.05**	**14.79**				
External leakage - Utility medium	1*	0.55	7.70	22.11	7.28	7.28	2.0	2.0	2.0	2.0
	1†	0.54	7.78	22.41	7.39	7.39				
Internal leakage	1*	0.55	7.70	22.11	7.28	7.28	19.0	38.0	38.0	38.0
	1†	0.54	7.78	22.41	7.39	7.39				
Incipient	**1***	**0.04**	**6.88**	**24.29**	**8.97**	**7.28**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**0.04**	**7.01**	**24.92**	**9.20**	**7.39**				
Abnormal instrument reading	1*	0.04	6.88	24.29	8.97	7.28	8.0	8.0	8.0	8.0
	1†	0.04	7.01	24.92	9.20	7.39				
All modes	**3***	**4.50**	**22.51**	**51.88**	**15.22**	**21.85**	**9.7**	**2.0**	**16.0**	**38.0**
	3†	**4.83**	**22.76**	**51.62**	**15.00**	**22.18**				

Comments

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Taxonomy no	Item
4.4.2.1.1	Control and Safety Equipment Valves By-pass Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	2	0.1110	0.1097	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**1.45**	**17.61**	**49.38**	**16.12**	**18.01**	**10.5**	**2.0**	**20.0**	**38.0**
	2†	**1.61**	**17.75**	**48.96**	**15.86**	**18.24**				
External leakage - Utility medium	1*	0.04	8.79	32.76	12.09	9.01	2.0	2.0	2.0	2.0
	1†	0.04	8.86	32.76	12.10	9.12				
Internal leakage	1*	0.04	8.79	32.76	12.09	9.01	19.0	38.0	38.0	38.0
	1†	0.04	8.86	32.76	12.10	9.12				
Incipient	**1***	**0.53**	**9.18**	**27.09**	**9.01**	**9.01**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**0.55**	**9.33**	**27.46**	**9.12**	**9.12**				
Abnormal instrument reading	1*	0.53	9.18	27.09	9.01	9.01	8.0	8.0	8.0	8.0
	1†	0.55	9.33	27.46	9.12	9.12				
All modes	**3***	**7.29**	**26.89**	**56.57**	**15.60**	**27.02**	**9.7**	**2.0**	**16.0**	**38.0**
	3†	**7.36**	**27.20**	**57.26**	**15.80**	**27.36**				

Comments

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Taxonomy no	Item
4.4.2.1.2	Control and Safety Equipment Valves By-pass Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.04	10.31	39.60	14.58	0.00	-	-	-	-
	0†	0.04	10.51	40.35	14.86	0.00				

Comments

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Taxonomy no		Item
4.4.3		Control and Safety Equipment Valves Combined

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	3	0.1608	0.1589	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	2.83 3.10	10.85 11.89	4.00 4.38	0.00 0.00	-	-	-	-

Comments

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Taxonomy no		Item
4.4.3.1		Control and Safety Equipment Valves Combined Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	3	0.1608	0.1589	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	1.48 1.56	5.69 5.99	2.09 2.21	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.4.3.1.1	Control and Safety Equipment Valves Combined Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.1169	0.1169	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	1.10	4.22	1.56	0.00	-	-	-	-
	0†	0.00	1.14	4.39	1.62	0.00				

Comments

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Taxonomy no	Item
4.4.3.1.2	Control and Safety Equipment Valves Combined Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0438	0.0420	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	1.31	5.03	1.85	0.00	-	-	-	-
	0†	0.01	1.38	5.30	1.95	0.00				

Comments

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Taxonomy no	Item
4.4.4	Control and Safety Equipment Valves ESD

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
59	4	1.9199	1.8970	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**84***	**0.04**	**18.82**	**75.56**	**28.35**	**43.75**	**3.5**	**1.0**	**5.1**	**45.0**
	84†	**0.04**	**19.11**	**76.58**	**28.71**	**44.28**				
Fail to close on demand	63*	0.13	15.92	53.52	19.65	32.81	3.8	1.0	5.7	45.0
	63†	0.13	16.14	54.23	19.91	33.21				
Fail to open on demand	15*	0.88	5.79	14.28	4.37	7.81	2.4	1.0	3.1	6.0
	15†	0.89	5.86	14.46	4.42	7.91				
Spurious operation	1*	0.01	0.48	1.48	0.52	0.52	2.0	2.0	2.0	2.0
	1†	0.01	0.49	1.50	0.53	0.53				
Structural deficiency	5*	0.53	2.30	5.10	1.46	2.60	4.3	2.0	4.5	9.0
	5†	0.54	2.33	5.16	1.47	2.64				
Degraded	**23***	**8.40**	**55.59**	**137.43**	**42.05**	**11.98**	**3.3**	**1.0**	**8.7**	**41.0**
	23†	**8.92**	**58.05**	**142.95**	**43.64**	**12.12**				
Abnormal instrument reading	4*	0.46	1.88	4.11	1.16	2.08	3.8	2.0	3.8	5.0
	4†	0.46	1.91	4.16	1.18	2.11				
Delayed operation	6*	1.11	5.43	12.44	3.64	3.13	2.6	1.0	6.0	15.0
	6†	1.15	5.43	12.33	3.58	3.16				
External leakage - Process medium	3*	1.31	21.13	61.80	20.49	1.56	-	1.0	2.0	3.0
	3†	1.55	22.44	64.66	21.33	1.58				
External leakage - Utility medium	2*	0.14	0.96	2.40	0.74	1.04	2.5	1.0	2.5	4.0
	2†	0.14	0.97	2.42	0.75	1.05				
Internal leakage	4*	0.00	7.61	34.71	13.84	2.08	-	8.0	27.7	41.0
	4†	0.00	7.65	34.88	13.90	2.11				
Other	2*	0.75	11.64	33.89	11.22	1.04	-	2.0	12.5	23.0
	2†	0.85	12.22	35.21	11.61	1.05				
Structural deficiency	2*	0.07	7.81	25.83	9.45	1.04	6.0	6.0	6.0	6.0
	2†	0.09	8.36	27.19	9.89	1.05				
Incipient	**28***	**6.32**	**16.39**	**30.31**	**7.48**	**14.58**	**2.4**	**1.0**	**2.6**	**5.0**
	28†	**6.59**	**16.52**	**30.08**	**7.31**	**14.76**				
Abnormal instrument reading	14*	0.16	6.40	19.63	6.86	7.29	2.5	1.0	2.7	5.0
	14†	0.18	6.48	19.80	6.88	7.38				
External leakage - Process medium	1*	0.00	3.52	14.86	5.71	0.52	-	3.0	3.0	3.0
	1†	0.00	3.54	14.94	5.74	0.53				
Internal leakage	1*	0.00	3.52	14.86	5.71	0.52	-	4.0	4.0	4.0
	1†	0.00	3.54	14.94	5.74	0.53				
Minor in-service problems	12*	0.63	5.70	15.05	4.76	6.25	2.1	1.0	2.1	4.0
	12†	0.65	5.77	15.16	4.78	6.33				
Unknown	**14***	**0.87**	**5.48**	**13.40**	**4.07**	**7.29**	**2.4**	**1.0**	**3.5**	**8.0**
	14†	**0.88**	**5.55**	**13.57**	**4.12**	**7.38**				
Unknown	14*	0.87	5.48	13.40	4.07	7.29	2.4	1.0	3.5	8.0
	14†	0.88	5.55	13.57	4.12	7.38				

Comments

(cont.)

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Taxonomy no		Item								
4.4.4		Control and Safety Equipment Valves ESD								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
		Calendar time *		**Operational time †**						
59	4	1.9199		1.8970						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**				**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	***n*/τ**		**Min**	**Mean**	**Max**
All modes		**149*** **149†**	**67.28** **61.01**	**77.44** **78.29**	**88.18** **97.35**	**6.36** **11.07**	**77.61** **78.54**	**3.2**	**1.0**	**5.1**	**45.0**
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - ESD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.67	0.00	0.00	0.67	0.00	0.00	0.00	0.00
Control unit	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	8.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
Pilot valve	0.00	0.00	0.00	0.67	12.75	2.68	0.00	0.00	0.00
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Seat rings	0.00	0.00	0.67	0.00	0.67	0.00	0.00	0.00	0.67
Stem	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	2.68	2.68	0.00	0.00	0.00
Unknown	1.34	2.68	1.34	0.00	23.49	4.70	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	1.34	0.00	0.00	0.00	0.00
Total	12.08	4.03	2.68	1.34	42.28	10.07	0.00	0.00	3.36

Maintainable item versus failure mode, continued
Item: Valves described by application - ESD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	1.34
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.67
Cabling & junction boxes	0.00	0.00	0.67	0.00	1.34	0.00	0.67	0.00	4.03
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.72
Other	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.67
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Pilot valve	0.00	0.00	0.00	0.00	3.36	0.00	1.34	2.01	22.82
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Subunit	0.00	0.00	0.00	0.00	2.01	0.00	0.67	2.01	10.07
Unknown	0.00	0.00	0.00	0.00	0.67	0.67	0.67	5.37	40.94
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	2.01
Total	0.00	0.00	1.34	0.00	8.05	0.67	4.70	9.40	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - ESD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.67	0.00	0.00	0.00	8.05	2.68	0.00	0.00	0.67
Breakage	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.67	0.00	0.67	0.00	1.34	0.00	0.00	0.00	0.00
Electrical failure - general	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	4.03	1.34	0.00	0.00	19.46	3.36	0.00	0.00	0.00
Leakage	0.00	0.00	2.01	0.67	0.00	0.00	0.00	0.00	0.00
Looseness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Mechanical Failure - general	0.67	2.01	0.00	0.00	10.07	0.67	0.00	0.00	1.34
Misc. external influences	0.67	0.00	0.00	0.67	1.34	0.67	0.00	0.00	0.00
Open circuit	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.67	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00
Short circuiting	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.67	0.00	0.00	2.01	2.01	0.00	0.00	0.00
Total	12.08	4.03	2.68	1.34	42.28	10.07	0.00	0.00	3.36

Failure descriptior versus failure mode, continued
Item: Valves described by application - ESD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.08
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	2.01
Corrosion	0.00	0.00	0.67	0.00	2.01	0.00	0.67	0.00	6.04
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.67	1.34	3.36	33.56
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.68
Looseness	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	1.34
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	1.34
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.67	0.00	1.34	1.34	18.12
Misc. external influences	0.00	0.00	0.00	0.00	2.68	0.00	0.67	0.00	6.71
Open circuit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
Sticking	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.67
Unknown	0.00	0.00	0.00	0.00	2.01	0.00	0.00	4.03	10.74
Total	0.00	0.00	1.34	0.00	8.05	0.67	4.70	9.40	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.4.1	Control and Safety Equipment Valves ESD Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
30	3	0.9731	0.9610	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**53***	**0.14**	**28.56**	**103.69**	**38.31**	**54.47**	**3.3**	**1.0**	**4.7**	**36.0**
	53†	**0.15**	**29.08**	**104.96**	**38.78**	**55.15**				
Fail to close on demand	42*	0.23	24.06	79.49	29.07	43.16	3.5	1.0	5.1	36.0
	42†	0.24	24.49	80.56	29.42	43.71				
Fail to open on demand	9*	0.68	7.06	19.19	6.17	9.25	2.6	1.0	3.2	6.0
	9†	0.70	7.16	19.44	6.25	9.37				
Spurious operation	1*	0.02	0.94	2.91	1.03	1.03	2.0	2.0	2.0	2.0
	1†	0.02	0.95	2.94	1.04	1.04				
Structural deficiency	1*	0.02	0.94	2.91	1.03	1.03	-	-	-	-
	1†	0.02	0.95	2.94	1.04	1.04				
Degraded	**16***	**7.90**	**60.64**	**154.75**	**48.11**	**16.44**	**3.1**	**1.0**	**9.1**	**41.0**
	16†	**8.56**	**64.01**	**162.49**	**50.39**	**16.65**				
Abnormal instrument reading	2*	0.26	1.88	4.71	1.45	2.06	3.5	2.0	3.5	5.0
	2†	0.27	1.90	4.77	1.47	2.08				
Delayed operation	5*	0.59	5.59	14.92	4.75	5.14	2.6	1.0	3.8	9.0
	5†	0.62	5.66	15.00	4.76	5.20				
External leakage - Process medium	2*	0.71	23.63	71.85	24.82	2.06	-	1.0	1.0	1.0
	2†	1.00	25.41	76.55	25.99	2.08				
External leakage - Utility medium	1*	0.02	0.94	2.91	1.03	1.03	4.0	4.0	4.0	4.0
	1†	0.02	0.95	2.94	1.04	1.04				
Internal leakage	4*	0.01	10.48	43.03	16.31	4.11	-	8.0	27.7	41.0
	4†	0.01	10.57	43.32	16.41	4.16				
Other	1*	0.21	11.06	34.45	12.23	1.03	-	2.0	2.0	2.0
	1†	0.28	11.89	36.55	12.82	1.04				
Structural deficiency	1*	0.21	11.06	34.45	12.23	1.03	-	6.0	6.0	6.0
	1†	0.28	11.89	36.55	12.82	1.04				
Incipient	**13***	**2.95**	**11.89**	**25.77**	**7.26**	**13.36**	**2.1**	**1.0**	**2.1**	**5.0**
	13†	**3.01**	**12.06**	**26.08**	**7.34**	**13.53**				
Abnormal instrument reading	4*	0.50	3.54	8.89	2.74	4.11	2.7	1.0	2.7	5.0
	4†	0.51	3.59	9.01	2.78	4.16				
Minor in-service problems	9*	2.09	8.80	19.32	5.49	9.25	1.8	1.0	1.8	4.0
	9†	2.15	8.93	19.50	5.52	9.37				
Unknown	**8***	**0.66**	**6.40**	**17.18**	**5.49**	**8.22**	**2.0**	**1.0**	**2.7**	**8.0**
	8†	**0.67**	**6.49**	**17.40**	**5.56**	**8.33**				
Unknown	8*	0.66	6.40	17.18	5.49	8.22	2.0	1.0	2.7	8.0
	8†	0.67	6.49	17.40	5.56	8.33				
All modes	**90***	**52.70**	**87.94**	**130.48**	**23.86**	**92.49**	**3.0**	**1.0**	**5.0**	**41.0**
	90†	**50.12**	**89.38**	**137.84**	**26.96**	**93.66**				

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Taxonomy no	Item
4.4.4.1.1	Control and Safety Equipment Valves ESD Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.4208	0.4157	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**25.74**	**40.40**	**60.60**	**40.40**	**40.40**	**3.0**	**1.0**	**3.7**	**9.0**
	17†	**26.06**	**40.90**	**61.34**	**40.90**	**40.90**				
Fail to close on demand	8*	9.46	19.01	34.31	19.01	19.01	3.3	2.0	3.9	9.0
	8†	9.57	19.25	34.73	19.25	19.25				
Fail to open on demand	8*	9.46	19.01	34.31	19.01	19.01	2.8	1.0	3.5	6.0
	8†	9.57	19.25	34.73	19.25	19.25				
Structural deficiency	1*	0.12	2.38	11.28	2.38	2.38	-	-	-	-
	1†	0.12	2.41	11.42	2.41	2.41				
Incipient	**3***	**1.95**	**7.13**	**18.43**	**7.13**	**7.13**	**1.0**	**1.0**	**1.0**	**1.0**
	3†	**1.97**	**7.22**	**18.66**	**7.22**	**7.22**				
Abnormal instrument reading	1*	0.12	2.38	11.28	2.38	2.38	1.0	1.0	1.0	1.0
	1†	0.12	2.41	11.42	2.41	2.41				
Minor in-service problems	2*	0.84	4.75	14.96	4.75	4.75	1.0	1.0	1.0	1.0
	2†	0.85	4.81	15.14	4.81	4.81				
Unknown	**1***	**0.12**	**2.38**	**11.28**	**2.38**	**2.38**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.12**	**2.41**	**11.42**	**2.41**	**2.41**				
Unknown	1*	0.12	2.38	11.28	2.38	2.38	3.0	3.0	3.0	3.0
	1†	0.12	2.41	11.42	2.41	2.41				
All modes	**21***	**33.44**	**49.91**	**71.87**	**49.91**	**49.91**	**2.8**	**1.0**	**3.4**	**9.0**
	21†	**33.85**	**50.52**	**72.75**	**50.52**	**50.52**				

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Taxonomy no	Item
4.4.4.1.2	Control and Safety Equipment Valves ESD Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.2805	0.2771	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**19***	**44.35**	**67.73**	**99.38**	**67.73**	**67.73**	**4.1**	**1.0**	**7.0**	**36.0**
	19†	**44.89**	**68.56**	**100.60**	**68.56**	**68.56**				
Fail to close on demand	18*	41.47	64.17	95.15	64.17	64.17	4.3	1.0	7.4	36.0
	18†	41.98	64.95	96.31	64.95	64.95				
Fail to open on demand	1*	0.18	3.56	16.92	3.56	3.56	1.0	1.0	1.0	1.0
	1†	0.18	3.61	17.12	3.61	3.61				
Degraded	**5***	**7.02**	**17.82**	**37.49**	**17.82**	**17.82**	**3.3**	**1.0**	**4.2**	**9.0**
	5†	**7.11**	**18.04**	**37.94**	**18.04**	**18.04**				
Abnormal instrument reading	2*	1.27	7.13	22.44	7.13	7.13	3.5	2.0	3.5	5.0
	2†	1.28	7.22	22.72	7.22	7.22				
Delayed operation	2*	1.27	7.13	22.44	7.13	7.13	2.8	1.0	5.0	9.0
	2†	1.28	7.22	22.72	7.22	7.22				
External leakage - Utility medium	1*	0.18	3.56	16.92	3.56	3.56	4.0	4.0	4.0	4.0
	1†	0.18	3.61	17.12	3.61	3.61				
Incipient	**6***	**9.32**	**21.39**	**42.21**	**21.39**	**21.39**	**2.7**	**2.0**	**2.7**	**4.0**
	6†	**9.44**	**21.65**	**42.73**	**21.65**	**21.65**				
Abnormal instrument reading	2*	1.27	7.13	22.44	7.13	7.13	2.0	2.0	2.0	2.0
	2†	1.28	7.22	22.72	7.22	7.22				
Minor in-service problems	4*	4.87	14.26	32.64	14.26	14.26	3.0	2.0	3.0	4.0
	4†	4.93	14.43	33.04	14.43	14.43				
Unknown	**6***	**9.32**	**21.39**	**42.21**	**21.39**	**21.39**	**1.6**	**1.0**	**2.6**	**8.0**
	6†	**9.44**	**21.65**	**42.73**	**21.65**	**21.65**				
Unknown	6*	9.32	21.39	42.21	21.39	21.39	1.6	1.0	2.6	8.0
	6†	9.44	21.65	42.73	21.65	21.65				
All modes	**36***	**95.29**	**128.34**	**169.48**	**128.34**	**128.34**	**3.4**	**1.0**	**5.4**	**36.0**
	36†	**96.46**	**129.91**	**171.55**	**129.91**	**129.91**				

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Taxonomy no	Item
4.4.4.1.3	Control and Safety Equipment Valves ESD Ball (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1403	0.1386	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**77.22**	**121.21**	**181.79**	**121.21**	**121.21**	**2.7**	**1.0**	**3.2**	**11.0**
	17†	**78.17**	**122.69**	**184.02**	**122.69**	**122.69**				
Fail to close on demand	16*	71.54	114.08	173.25	114.08	114.08	2.7	1.0	3.3	11.0
	16†	72.42	115.47	175.37	115.47	115.47				
Spurious operation	1*	0.36	7.13	33.83	7.13	7.13	2.0	2.0	2.0	2.0
	1†	0.36	7.22	34.25	7.22	7.22				
Degraded	**3***	**5.85**	**21.39**	**55.29**	**21.39**	**21.39**	**2.5**	**2.0**	**2.5**	**3.0**
	3†	**5.92**	**21.65**	**55.97**	**21.65**	**21.65**				
Delayed operation	2*	2.53	14.26	44.88	14.26	14.26	2.5	2.0	2.5	3.0
	2†	2.56	14.43	45.43	14.43	14.43				
Internal leakage	1*	0.36	7.13	33.83	7.13	7.13	-	-	-	-
	1†	0.36	7.22	34.25	7.22	7.22				
Incipient	**3***	**5.85**	**21.39**	**55.29**	**21.39**	**21.39**	**2.3**	**1.0**	**2.3**	**5.0**
	3†	**5.92**	**21.65**	**55.97**	**21.65**	**21.65**				
Abnormal instrument reading	1*	0.36	7.13	33.83	7.13	7.13	5.0	5.0	5.0	5.0
	1†	0.36	7.22	34.25	7.22	7.22				
Minor in-service problems	2*	2.53	14.26	44.88	14.26	14.26	1.0	1.0	1.0	1.0
	2†	2.56	14.43	45.43	14.43	14.43				
Unknown	**1***	**0.36**	**7.13**	**33.83**	**7.13**	**7.13**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.36**	**7.22**	**34.25**	**7.22**	**7.22**				
Unknown	1*	0.36	7.13	33.83	7.13	7.13	3.0	3.0	3.0	3.0
	1†	0.36	7.22	34.25	7.22	7.22				
All modes	**24***	**117.98**	**171.12**	**240.64**	**171.12**	**171.12**	**2.6**	**1.0**	**3.0**	**11.0**
	24†	**119.43**	**173.21**	**243.58**	**173.21**	**173.21**				

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Taxonomy no	Item
4.4.4.1.4	Control and Safety Equipment Valves ESD Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0526	0.0526	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**6.75**	**38.02**	**119.66**	**38.02**	**38.02**	-	**8.0**	**8.0**	**8.0**
	2†	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**				
Delayed operation	1*	0.95	19.01	90.20	19.01	19.01	-	-	-	-
	1†	0.95	19.03	90.28	19.03	19.03				
Internal leakage	1*	0.95	19.01	90.20	19.01	19.01	-	8.0	8.0	8.0
	1†	0.95	19.03	90.28	19.03	19.03				
All modes	**2***	**6.75**	**38.02**	**119.66**	**38.02**	**38.02**	-	**8.0**	**8.0**	**8.0**
	2†	**6.75**	**38.05**	**119.77**	**38.05**	**38.05**				

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Taxonomy no	Item
4.4.4.1.5	Control and Safety Equipment Valves ESD Ball (30.1-40) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	2	0.0789	0.0770	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**6***	**14.11**	**88.64**	**216.45**	**65.74**	**76.01**	-	**1.0**	**16.8**	**41.0**
	6†	**12.36**	**93.95**	**239.27**	**74.33**	**77.88**				
External leakage - Process medium	2*	0.18	34.82	125.88	46.51	25.34	-	1.0	1.0	1.0
	2†	0.18	37.38	136.96	50.60	25.96				
Internal leakage	2*	3.41	23.39	58.30	17.92	25.34	-	34.0	37.5	41.0
	2†	0.24	22.62	73.85	26.91	25.96				
Other	1*	0.16	15.83	52.00	18.98	12.67	-	2.0	2.0	2.0
	1†	0.13	16.96	57.42	21.11	12.98				
Structural deficiency	1*	0.16	15.83	52.00	18.98	12.67	-	6.0	6.0	6.0
	1†	0.13	16.96	57.42	21.11	12.98				
Incipient	**1***	**0.15**	**11.61**	**37.19**	**13.44**	**12.67**	-	-	-	-
	1†	**0.18**	**11.88**	**37.51**	**13.45**	**12.98**				
Minor in-service problems	1*	0.15	11.61	37.19	13.44	12.67	-	-	-	-
	1†	0.18	11.88	37.51	13.45	12.98				
All modes	**7***	**36.00**	**95.61**	**178.48**	**44.46**	**88.68**	-	**1.0**	**16.8**	**41.0**
	7†	**31.11**	**100.91**	**203.25**	**54.15**	**90.86**				

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Taxonomy no	Item
4.4.4.2	Control and Safety Equipment Valves ESD Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
29	2	0.9468	0.9361	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**31***	**2.81**	**23.75**	**61.67**	**19.32**	**32.74**	**3.8**	**1.0**	**5.7**	**45.0**
	31†	**2.78**	**23.96**	**62.51**	**19.63**	**33.12**				
Fail to close on demand	21*	4.66	18.05	38.61	10.78	22.18	4.2	1.0	6.8	45.0
	21†	4.59	18.19	39.19	11.00	22.43				
Fail to open on demand	6*	0.48	5.39	14.92	4.84	6.34	2.1	1.0	2.8	6.0
	6†	0.48	5.45	15.09	4.90	6.41				
Structural deficiency	4*	0.38	3.75	10.09	3.23	4.22	4.3	2.0	4.5	9.0
	4†	0.39	3.79	10.21	3.27	4.27				
Degraded	**7***	**0.29**	**22.39**	**71.72**	**25.93**	**7.39**	**3.8**	**1.0**	**8.0**	**23.0**
	7†	**0.29**	**22.43**	**71.74**	**25.91**	**7.48**				
Abnormal instrument reading	2*	0.23	1.98	5.15	1.61	2.11	4.0	4.0	4.0	4.0
	2†	0.23	2.00	5.21	1.63	2.14				
Delayed operation	1*	0.02	6.64	26.01	9.66	1.06	-	15.0	15.0	15.0
	1†	0.02	6.64	26.03	9.67	1.07				
External leakage - Process medium	1*	0.02	6.64	26.01	9.66	1.06	-	3.0	3.0	3.0
	1†	0.02	6.64	26.03	9.67	1.07				
External leakage - Utility medium	1*	0.03	1.00	3.04	1.06	1.06	1.0	1.0	1.0	1.0
	1†	0.03	1.01	3.08	1.07	1.07				
Other	1*	0.02	6.64	26.01	9.66	1.06	-	23.0	23.0	23.0
	1†	0.02	6.64	26.03	9.67	1.07				
Structural deficiency	1*	0.03	1.00	3.04	1.06	1.06	6.0	6.0	6.0	6.0
	1†	0.03	1.01	3.08	1.07	1.07				
Incipient	**15***	**4.45**	**24.65**	**58.26**	**17.33**	**15.84**	**2.5**	**1.0**	**2.9**	**5.0**
	15†	**4.59**	**24.70**	**57.99**	**17.19**	**16.02**				
Abnormal instrument reading	10*	5.92	10.77	16.78	3.34	10.56	2.4	1.0	2.7	5.0
	10†	5.98	10.88	16.97	3.38	10.68				
External leakage - Process medium	1*	0.02	6.64	26.01	9.66	1.06	-	3.0	3.0	3.0
	1†	0.02	6.64	26.03	9.67	1.07				
Internal leakage	1*	0.02	6.64	26.01	9.66	1.06	-	4.0	4.0	4.0
	1†	0.02	6.64	26.03	9.67	1.07				
Minor in-service problems	3*	0.32	2.89	7.64	2.42	3.17	3.0	3.0	3.0	3.0
	3†	0.32	2.92	7.73	2.45	3.20				
Unknown	**6***	**0.48**	**5.39**	**14.92**	**4.84**	**6.34**	**2.9**	**1.0**	**4.5**	**8.0**
	6†	**0.48**	**5.45**	**15.09**	**4.90**	**6.41**				
Unknown	6*	0.48	5.39	14.92	4.84	6.34	2.9	1.0	4.5	8.0
	6†	0.48	5.45	15.09	4.90	6.41				
All modes	**59***	**40.32**	**66.53**	**98.06**	**17.70**	**62.32**	**3.4**	**1.0**	**5.2**	**45.0**
	59†	**41.32**	**66.97**	**97.66**	**17.26**	**63.03**				

Comments

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Taxonomy no	Item
4.4.4.2.1	Control and Safety Equipment Valves ESD Gate (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	1	0.3506	0.3464	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**2.34**	**8.56**	**22.12**	**8.56**	**8.56**	**2.7**	**1.0**	**5.0**	**12.0**
	3†	**2.37**	**8.66**	**22.39**	**8.66**	**8.66**				
Fail to close on demand	2*	1.01	5.70	17.95	5.70	5.70	3.5	1.0	6.5	12.0
	2†	1.02	5.77	18.17	5.77	5.77				
Structural deficiency	1*	0.14	2.85	13.53	2.85	2.85	1.0	2.0	2.0	2.0
	1†	0.14	2.89	13.70	2.89	2.89				
Degraded	**1***	**0.14**	**2.85**	**13.53**	**2.85**	**2.85**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.14**	**2.89**	**13.70**	**2.89**	**2.89**				
Structural deficiency	1*	0.14	2.85	13.53	2.85	2.85	6.0	6.0	6.0	6.0
	1†	0.14	2.89	13.70	2.89	2.89				
Incipient	**3***	**2.34**	**8.56**	**22.12**	**8.56**	**8.56**	**3.0**	**3.0**	**3.0**	**3.0**
	3†	**2.37**	**8.66**	**22.39**	**8.66**	**8.66**				
Minor in-service problems	3*	2.34	8.56	22.12	8.56	8.56	3.0	3.0	3.0	3.0
	3†	2.37	8.66	22.39	8.66	8.66				
All modes	**7***	**9.37**	**19.96**	**37.50**	**19.96**	**19.96**	**3.3**	**1.0**	**4.5**	**12.0**
	7†	**9.48**	**20.21**	**37.96**	**20.21**	**20.21**				

Comments

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Taxonomy no	Item
4.4.4.2.2	Control and Safety Equipment Valves ESD Gate (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.4208	0.4157	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**21***	**33.44**	**49.91**	**71.87**	**49.91**	**49.91**	**4.0**	**1.0**	**6.1**	**45.0**
	21†	**33.85**	**50.52**	**72.75**	**50.52**	**50.52**				
Fail to close on demand	15*	21.97	35.65	54.89	35.65	35.65	4.3	1.0	7.1	45.0
	15†	22.24	36.09	55.56	36.09	36.09				
Fail to open on demand	3*	1.95	7.13	18.43	7.13	7.13	1.2	1.0	1.7	3.0
	3†	1.97	7.22	18.66	7.22	7.22				
Structural deficiency	3*	1.95	7.13	18.43	7.13	7.13	5.3	2.0	5.3	9.0
	3†	1.97	7.22	18.66	7.22	7.22				
Incipient	**7***	**7.81**	**16.64**	**31.25**	**16.64**	**16.64**	**2.3**	**1.0**	**2.3**	**5.0**
	7†	**7.90**	**16.84**	**31.63**	**16.84**	**16.84**				
Abnormal instrument reading	7*	7.81	16.64	31.25	16.64	16.64	2.3	1.0	2.3	5.0
	7†	7.90	16.84	31.63	16.84	16.84				
Unknown	**3***	**1.95**	**7.13**	**18.43**	**7.13**	**7.13**	**3.0**	**2.0**	**5.3**	**8.0**
	3†	**1.97**	**7.22**	**18.66**	**7.22**	**7.22**				
Unknown	3*	1.95	7.13	18.43	7.13	7.13	3.0	2.0	5.3	8.0
	3†	1.97	7.22	18.66	7.22	7.22				
All modes	**31***	**53.34**	**73.67**	**99.43**	**73.67**	**73.67**	**3.5**	**1.0**	**5.2**	**45.0**
	31†	**53.99**	**74.58**	**100.65**	**74.58**	**74.58**				

Comments

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Taxonomy no	Item
4.4.4.2.3	Control and Safety Equipment Valves ESD Gate (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1052	0.1039	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**31.23**	**66.54**	**125.01**	**66.54**	**66.54**	**3.9**	**2.0**	**5.0**	**10.0**
	7†	**31.61**	**67.36**	**126.54**	**67.36**	**67.36**				
Fail to close on demand	4*	12.98	38.03	87.03	38.03	38.03	4.5	4.0	5.8	10.0
	4†	13.14	38.49	88.10	38.49	38.49				
Fail to open on demand	3*	7.80	28.52	73.72	28.52	28.52	3.0	2.0	4.0	6.0
	3†	7.89	28.87	74.62	28.87	28.87				
Degraded	**3***	**7.80**	**28.52**	**73.72**	**28.52**	**28.52**	**3.0**	**1.0**	**3.0**	**4.0**
	3†	**7.89**	**28.87**	**74.62**	**28.87**	**28.87**				
Abnormal instrument reading	2*	3.37	19.01	59.84	19.01	19.01	4.0	4.0	4.0	4.0
	2†	3.42	19.25	60.58	19.25	19.25				
External leakage - Utility medium	1*	0.48	9.51	45.11	9.51	9.51	1.0	1.0	1.0	1.0
	1†	0.48	9.62	45.66	9.62	9.62				
Incipient	**2***	**3.37**	**19.01**	**59.84**	**19.01**	**19.01**	**3.0**	**2.0**	**3.0**	**4.0**
	2†	**3.42**	**19.25**	**60.58**	**19.25**	**19.25**				
Abnormal instrument reading	2*	3.37	19.01	59.84	19.01	19.01	3.0	2.0	3.0	4.0
	2†	3.42	19.25	60.58	19.25	19.25				
Unknown	**3***	**7.80**	**28.52**	**73.72**	**28.52**	**28.52**	**2.8**	**1.0**	**3.7**	**5.0**
	3†	**7.89**	**28.87**	**74.62**	**28.87**	**28.87**				
Unknown	3*	7.80	28.52	73.72	28.52	28.52	2.8	1.0	3.7	5.0
	3†	7.89	28.87	74.62	28.87	28.87				
All modes	**15***	**87.89**	**142.60**	**219.55**	**142.60**	**142.60**	**3.4**	**1.0**	**4.1**	**10.0**
	15†	**88.96**	**144.34**	**222.24**	**144.34**	**144.34**				

Comments

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Taxonomy no	Item
4.4.4.2.4	Control and Safety Equipment Valves ESD Gate (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.0702	0.0701	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**3***	**11.68**	**42.75**	**110.51**	**42.75**	**42.75**	-	**3.0**	**13.7**	**23.0**
	3†	**11.70**	**42.81**	**110.66**	**42.81**	**42.81**				
Delayed operation	1*	0.71	14.25	67.62	14.25	14.25	-	15.0	15.0	15.0
	1†	0.71	14.27	67.71	14.27	14.27				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	-	3.0	3.0	3.0
	1†	0.71	14.27	67.71	14.27	14.27				
Other	1*	0.71	14.25	67.62	14.25	14.25	-	23.0	23.0	23.0
	1†	0.71	14.27	67.71	14.27	14.27				
Incipient	**3***	**11.68**	**42.75**	**110.51**	**42.75**	**42.75**	-	**3.0**	**4.0**	**5.0**
	3†	**11.70**	**42.81**	**110.66**	**42.81**	**42.81**				
Abnormal instrument reading	1*	0.71	14.25	67.62	14.25	14.25	-	5.0	5.0	5.0
	1†	0.71	14.27	67.71	14.27	14.27				
External leakage - Process medium	1*	0.71	14.25	67.62	14.25	14.25	-	3.0	3.0	3.0
	1†	0.71	14.27	67.71	14.27	14.27				
Internal leakage	1*	0.71	14.25	67.62	14.25	14.25	-	4.0	4.0	4.0
	1†	0.71	14.27	67.71	14.27	14.27				
All modes	**6***	**37.26**	**85.50**	**168.72**	**85.50**	**85.50**	-	**3.0**	**8.8**	**23.0**
	6†	**37.31**	**85.62**	**168.95**	**85.62**	**85.62**				

Comments

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Taxonomy no	Item
4.4.5	Control and Safety Equipment Valves ESD/PSD

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
161	7	5.5206	5.5161	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**52***	**2.25**	**16.29**	**41.07**	**12.70**	**9.42**	**6.6**	**1.0**	**12.6**	**66.0**
	52†	**2.31**	**16.37**	**41.08**	**12.67**	**9.43**				
Delayed operation	2*	0.00	0.66	2.77	1.06	0.36	19.8	28.0	39.5	51.0
	2†	0.00	0.66	2.76	1.05	0.36				
External leakage - Utility medium	1*	0.00	0.28	0.98	0.36	0.18	8.5	17.0	17.0	17.0
	1†	0.00	0.28	0.97	0.36	0.18				
Fail to close on demand	18*	1.46	5.37	11.28	3.11	3.26	10.9	2.0	21.6	66.0
	18†	1.46	5.43	11.45	3.16	3.26				
Fail to open on demand	8*	0.20	3.67	10.87	3.62	1.45	3.4	2.0	5.6	12.0
	8†	0.21	3.70	10.95	3.64	1.45				
Other	3*	0.00	0.99	4.39	1.73	0.54	8.3	1.0	16.7	37.0
	3†	0.00	0.99	4.37	1.72	0.54				
Spurious operation	19*	0.01	4.24	16.66	6.20	3.44	2.8	1.0	4.5	24.0
	19†	0.01	4.23	16.58	6.16	3.44				
Structural deficiency	1*	0.00	0.17	0.51	0.18	0.18	2.0	2.0	2.0	2.0
	1†	0.00	0.17	0.52	0.18	0.18				
Degraded	**35***	**3.17**	**15.92**	**36.73**	**10.78**	**6.34**	**8.3**	**2.0**	**14.9**	**61.0**
	35†	**3.22**	**16.01**	**36.84**	**10.80**	**6.35**				
Abnormal instrument reading	1*	0.02	1.66	5.39	1.96	0.18	-	6.0	6.0	6.0
	1†	0.02	1.74	5.57	2.01	0.18				
Delayed operation	6*	0.11	2.39	7.16	2.41	1.09	9.3	4.0	10.2	14.0
	6†	0.11	2.40	7.20	2.42	1.09				
External leakage - Process medium	3*	0.08	0.51	1.25	0.38	0.54	6.0	10.0	21.3	35.0
	3†	0.08	0.51	1.25	0.38	0.54				
External leakage - Utility medium	14*	0.15	3.82	11.50	3.91	2.54	6.5	2.0	11.3	40.0
	14†	0.15	3.83	11.53	3.91	2.54				
Fail to open on demand	1*	0.00	0.17	0.51	0.18	0.18	6.0	6.0	6.0	6.0
	1†	0.00	0.17	0.52	0.18	0.18				
Internal leakage	3*	0.07	3.51	10.89	3.86	0.54	10.0	9.0	28.5	48.0
	3†	0.07	3.52	10.91	3.86	0.54				
Other	6*	0.06	3.11	9.70	3.45	1.09	13.5	4.0	22.4	61.0
	6†	0.06	3.10	9.69	3.45	1.09				
Plugged/Choked	1*	0.00	0.88	3.42	1.27	0.18	-	-	-	-
	1†	0.00	0.88	3.43	1.27	0.18				
Incipient	**74***	**5.22**	**27.22**	**63.41**	**18.72**	**13.40**	**4.3**	**1.0**	**8.2**	**29.0**
	74†	**5.34**	**27.38**	**63.51**	**18.70**	**13.42**				
Abnormal instrument reading	10*	0.41	5.50	15.65	5.14	1.81	5.0	2.0	8.8	29.0
	10†	0.42	5.54	15.75	5.17	1.81				
External leakage - Process medium	1*	0.00	0.18	0.54	0.19	0.18	-	-	-	-
	1†	0.00	0.18	0.54	0.19	0.18				

Comments

(cont.)

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Taxonomy no		Item									
4.4.5		Control and Safety Equipment Valves ESD/PSD									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
161	7	**Calendar time *** 5.5206			**Operational time †** 5.5161						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
External leakage - Utility medium		25*	0.04	5.06	16.94	6.22	4.53	3.6	2.0	6.9	20.0
		25†	0.04	5.13	17.14	6.29	4.53				
Internal leakage		1*	0.00	0.18	0.54	0.19	0.18	6.0	12.0	12.0	12.0
		1†	0.00	0.18	0.54	0.19	0.18				
Low output		1*	0.00	0.28	0.98	0.36	0.18	6.0	12.0	12.0	12.0
		1†	0.00	0.28	0.97	0.36	0.18				
Minor in-service problems		11*	0.35	7.02	21.00	7.01	1.99	2.0	2.0	4.3	10.0
		11†	0.37	7.06	21.06	7.02	1.99				
Other		22*	0.00	5.89	29.66	12.72	3.99	4.9	1.0	9.6	28.0
		22†	0.00	5.86	29.52	12.67	3.99				
Structural deficiency		3*	0.02	2.19	7.23	2.64	0.54	9.0	13.0	15.5	18.0
		3†	0.02	2.20	7.23	2.64	0.54				
All modes		**161***	**15.30**	**61.20**	**132.25**	**37.20**	**29.16**	**5.9**	**1.0**	**11.1**	**66.0**
		161†	**15.61**	**61.59**	**132.52**	**37.16**	**29.19**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - ESD/PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.00	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00
Control unit	0.62	0.00	0.00	0.62	1.24	0.00	0.00	0.00	0.00
Electric motor (electric actuator)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicator	0.62	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Instrument, general	0.62	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00
Instrument, position	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monitoring	0.62	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.62	0.00	3.11	0.62	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	1.24	1.24	0.62	0.00	0.00	0.00	0.00
Packing	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Pilot valve	0.62	0.00	0.00	2.48	1.86	0.62	0.00	0.00	0.62
Piston(s)	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Seals (gaskets)	0.00	0.00	0.62	11.80	0.00	0.00	0.00	0.00	0.62
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Stem	0.00	0.62	0.62	0.00	0.62	0.00	0.00	0.00	0.00
Subunit	0.00	0.62	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Unknown	1.24	1.86	0.00	1.86	3.11	2.48	0.00	0.00	0.62
Valve body w/internals	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valves	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00
Total	6.83	4.97	2.48	24.84	11.18	5.59	0.00	0.00	2.48

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by application - ESD/PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.62	3.73	0.00	0.00	6.21	0.00	0.00	11.80
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Control unit	0.00	0.00	0.00	0.00	0.00	1.86	0.00	0.00	4.35
Electric motor (electric actuator)	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.62
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Instrument, general	0.00	0.00	0.62	0.00	0.62	1.24	0.00	0.00	4.97
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.86
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.62
Monitoring	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	2.48
Other	0.00	0.00	6.21	0.00	0.00	0.00	0.00	0.00	6.83
Other actuator components	0.00	0.00	2.48	0.00	0.62	0.00	0.00	0.00	7.45
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.11
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Pilot valve	0.00	0.00	0.00	0.00	1.86	0.62	0.00	0.00	8.70
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.24
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.04
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Stem	0.00	0.00	0.00	0.00	0.62	0.62	0.62	0.00	3.73
Subunit	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00	3.73
Unknown	0.00	0.00	1.24	0.62	3.11	0.62	1.86	0.00	18.63
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Valves	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	1.86
Total	0.00	0.62	19.25	0.62	6.83	11.80	2.48	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - ESD/PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00
Breakage	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Cavitation	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control failure	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	0.00	0.62	0.00	1.24	0.00	0.00	0.00	0.00	0.00
Earth/isolation fault	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Faulty signal/indication/alarm	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	1.86	1.24	0.00	1.24	1.24	2.48	0.00	0.00	0.00
Leakage	0.00	0.62	1.86	18.01	0.00	0.00	0.00	0.00	1.24
Looseness	0.00	0.00	0.00	0.62	0.62	0.00	0.00	0.00	0.00
Material failure - general	0.62	0.00	0.62	2.48	0.62	0.00	0.00	0.00	0.62
Mechanical Failure - general	0.62	0.62	0.00	0.62	1.86	1.24	0.00	0.00	0.62
Misc. external influences	0.62	0.62	0.00	0.00	0.00	0.62	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	1.24	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Short circuiting	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
Sticking	0.00	1.24	0.00	0.00	1.86	0.62	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.62	1.24	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	6.83	4.97	2.48	24.84	11.18	5.59	0.00	0.00	2.48

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by application - ESD/PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	1.86
Breakage	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	1.24
Cavitation	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	1.24
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Corrosion	0.00	0.00	4.35	0.00	0.00	0.62	0.62	0.00	7.45
Earth/isolation fault	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
Electrical failure - general	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.62
External influence - general	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00	1.86
Faulty signal/indication/alarm	0.00	0.62	1.86	0.00	0.00	3.73	0.00	0.00	6.83
Instrument failure - general	0.00	0.00	1.86	0.00	0.62	4.35	0.00	0.00	14.91
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.74
Looseness	0.00	0.00	0.62	0.00	2.48	0.62	0.00	0.00	4.97
Material failure - general	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	5.59
Mechanical Failure - general	0.00	0.00	1.24	0.00	1.86	0.00	0.62	0.00	9.32
Misc. external influences	0.00	0.00	1.86	0.00	0.62	0.00	0.00	0.00	4.35
No cause found	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.62
Other	0.00	0.00	0.00	0.00	0.62	0.00	0.62	0.00	1.24
Out of adjustment	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	3.11
Short circuiting	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	1.24
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.73
Unknown	0.00	0.00	1.86	0.62	0.00	1.24	0.00	0.00	5.59
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.62
Total	0.00	0.62	19.25	0.62	6.83	11.80	2.48	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.5.1	Control and Safety Equipment Valves ESD/PSD Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
117	5	4.2331	4.2359	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**38***	**0.63**	**13.85**	**41.57**	**13.97**	**8.98**	**6.8**	**1.0**	**12.9**	**55.0**
	38†	**0.64**	**13.78**	**41.34**	**13.87**	**8.97**				
Delayed operation	2*	0.00	0.87	3.46	1.29	0.47	19.8	28.0	39.5	51.0
	2†	0.00	0.86	3.43	1.28	0.47				
External leakage - Utility medium	1*	0.00	0.37	1.32	0.49	0.24	8.5	17.0	17.0	17.0
	1†	0.00	0.36	1.31	0.48	0.24				
Fail to close on demand	11*	0.34	3.36	9.06	2.90	2.60	12.3	2.0	23.4	55.0
	11†	0.34	3.35	9.03	2.89	2.60				
Fail to open on demand	4*	0.13	1.31	3.52	1.13	0.94	3.8	4.0	6.8	12.0
	4†	0.13	1.30	3.51	1.12	0.94				
Other	3*	0.00	1.33	5.46	2.07	0.71	8.3	1.0	16.7	37.0
	3†	0.00	1.32	5.42	2.06	0.71				
Spurious operation	16*	0.02	5.50	20.55	7.58	3.78	2.3	1.0	4.3	24.0
	16†	0.02	5.46	20.40	7.53	3.78				
Structural deficiency	1*	0.00	0.24	0.81	0.30	0.24	2.0	2.0	2.0	2.0
	1†	0.00	0.24	0.81	0.30	0.24				
Degraded	**31***	**4.34**	**19.29**	**43.01**	**12.35**	**7.32**	**8.4**	**2.0**	**15.7**	**61.0**
	31†	**4.33**	**19.27**	**42.98**	**12.34**	**7.32**				
Delayed operation	4*	0.06	2.64	8.18	2.89	0.94	10.0	4.0	9.8	14.0
	4†	0.06	2.64	8.18	2.88	0.94				
External leakage - Process medium	3*	0.12	0.66	1.57	0.47	0.71	6.0	10.0	21.3	35.0
	3†	0.12	0.66	1.57	0.47	0.71				
External leakage - Utility medium	13*	0.41	4.94	13.81	4.50	3.07	6.5	2.0	11.8	40.0
	13†	0.41	4.94	13.80	4.50	3.07				
Fail to open on demand	1*	0.00	0.24	0.81	0.30	0.24	6.0	6.0	6.0	6.0
	1†	0.00	0.24	0.81	0.30	0.24				
Internal leakage	3*	0.43	4.97	13.86	4.51	0.71	10.0	9.0	28.5	48.0
	3†	0.43	4.97	13.85	4.51	0.71				
Other	6*	0.29	4.25	12.25	4.04	1.42	13.5	4.0	22.4	61.0
	6†	0.29	4.23	12.20	4.03	1.42				
Plugged/Choked	1*	0.01	1.18	4.06	1.50	0.24	-	-	-	-
	1†	0.01	1.18	4.06	1.50	0.24				
Incipient	**62***	**4.07**	**26.42**	**65.01**	**19.84**	**14.65**	**4.5**	**1.0**	**9.0**	**29.0**
	62†	**4.08**	**26.34**	**64.74**	**19.74**	**14.64**				
Abnormal instrument reading	5*	0.24	3.30	9.45	3.11	1.18	9.0	6.0	15.5	29.0
	5†	0.24	3.30	9.43	3.10	1.18				
External leakage - Process medium	1*	0.00	0.22	0.67	0.24	0.24	-	-	-	-
	1†	0.00	0.22	0.67	0.24	0.24				
External leakage - Utility medium	22*	0.00	3.49	14.70	5.64	5.20	3.6	2.0	7.3	20.0
	22†	0.00	3.48	14.70	5.65	5.19				

Comments

(cont.)

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Taxonomy no	Item
4.4.5.1	Control and Safety Equipment Valves ESD/PSD Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
117	5	4.2331	4.2359	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Internal leakage	1*	0.00	0.22	0.67	0.24	0.24	6.0	12.0	12.0	12.0
	1†	0.00	0.22	0.67	0.24	0.24				
Low output	1*	0.00	0.37	1.32	0.49	0.24	6.0	12.0	12.0	12.0
	1†	0.00	0.36	1.31	0.48	0.24				
Minor in-service problems	8*	0.29	7.52	22.68	7.72	1.89	2.0	2.0	4.8	10.0
	8†	0.29	7.53	22.69	7.71	1.89				
Other	21*	0.00	8.11	35.98	14.17	4.96	4.9	1.0	9.6	28.0
	21†	0.00	8.05	35.74	14.09	4.96				
Structural deficiency	3*	0.11	3.00	9.06	3.09	0.71	9.0	13.0	15.5	18.0
	3†	0.11	3.00	9.05	3.09	0.71				
All modes	**131***	**13.15**	**61.78**	**139.95**	**40.63**	**30.95**	**6.1**	**1.0**	**11.7**	**61.0**
	131†	**13.18**	**61.60**	**139.39**	**40.43**	**30.93**				

Comments

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Taxonomy no	Item
4.4.5.1.1	Control and Safety Equipment Valves ESD/PSD Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
37	3	1.3554	1.3594	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.52**	**4.27**	**11.00**	**3.44**	**4.43**	**4.0**	**2.0**	**7.2**	**14.0**
	6†	**0.51**	**4.24**	**10.98**	**3.44**	**4.41**				
Fail to close on demand	4*	0.65	2.88	6.39	1.83	2.95	4.0	2.0	6.8	14.0
	4†	0.64	2.86	6.38	1.83	2.94				
Fail to open on demand	2*	0.23	1.50	3.70	1.13	1.48	4.0	4.0	8.0	12.0
	2†	0.22	1.49	3.71	1.14	1.47				
Degraded	**13***	**0.04**	**8.56**	**32.26**	**11.90**	**9.59**	**6.2**	**2.0**	**15.8**	**48.0**
	13†	**0.03**	**8.49**	**32.22**	**11.88**	**9.56**				
Delayed operation	1*	0.00	0.75	2.67	0.99	0.74	7.0	14.0	14.0	14.0
	1†	0.00	0.74	2.67	0.99	0.74				
External leakage - Process medium	2*	0.23	1.50	3.70	1.13	1.48	2.0	19.0	27.0	35.0
	2†	0.22	1.49	3.71	1.14	1.47				
External leakage - Utility medium	8*	0.01	5.43	22.00	8.29	5.90	5.4	2.0	10.5	40.0
	8†	0.01	5.39	21.92	8.28	5.88				
Fail to open on demand	1*	0.01	0.70	2.26	0.82	0.74	6.0	6.0	6.0	6.0
	1†	0.01	0.69	2.25	0.82	0.74				
Internal leakage	1*	0.00	0.75	2.67	0.99	0.74	16.0	48.0	48.0	48.0
	1†	0.00	0.74	2.67	0.99	0.74				
Incipient	**5***	**0.02**	**3.55**	**13.01**	**4.81**	**3.69**	**3.2**	**3.0**	**6.2**	**12.0**
	5†	**0.02**	**3.52**	**12.99**	**4.80**	**3.68**				
External leakage - Utility medium	4*	0.02	2.89	9.86	3.63	2.95	3.5	4.0	7.0	12.0
	4†	0.02	2.87	9.84	3.63	2.94				
Other	1*	0.00	0.75	2.67	0.99	0.74	2.0	3.0	3.0	3.0
	1†	0.00	0.74	2.67	0.99	0.74				
All modes	**24***	**0.07**	**15.10**	**55.35**	**20.45**	**17.71**	**5.0**	**2.0**	**11.7**	**48.0**
	24†	**0.07**	**15.00**	**55.28**	**20.42**	**17.65**				

Comments

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Taxonomy no	Item
4.4.5.1.2	Control and Safety Equipment Valves ESD/PSD Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
26	3	0.9684	0.9695	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**0.88**	**3.98**	**8.93**	**2.57**	**4.13**	**14.0**	**4.0**	**20.5**	**46.0**
	4†	**0.87**	**3.98**	**8.93**	**2.58**	**4.13**				
Fail to close on demand	3*	0.52	2.98	7.08	2.12	3.10	17.3	12.0	26.0	46.0
	3†	0.52	2.97	7.08	2.12	3.09				
Spurious operation	1*	0.01	1.01	3.64	1.35	1.03	4.0	4.0	4.0	4.0
	1†	0.01	1.01	3.64	1.35	1.03				
Degraded	**3***	**0.60**	**3.74**	**9.13**	**2.77**	**3.10**	**8.5**	**9.0**	**13.0**	**17.0**
	3†	**0.63**	**3.69**	**8.84**	**2.65**	**3.09**				
Delayed operation	1*	0.01	1.01	3.64	1.35	1.03	13.0	13.0	13.0	13.0
	1†	0.01	1.01	3.64	1.35	1.03				
Internal leakage	1*	0.01	0.98	3.32	1.22	1.03	4.0	9.0	9.0	9.0
	1†	0.01	0.98	3.32	1.22	1.03				
Other	1*	0.03	3.72	12.82	4.73	1.03	8.5	17.0	17.0	17.0
	1†	0.02	3.63	12.61	4.65	1.03				
Incipient	**5***	**2.22**	**5.38**	**9.66**	**2.31**	**5.16**	**3.6**	**4.0**	**6.4**	**12.0**
	5†	**2.22**	**5.37**	**9.64**	**2.31**	**5.16**				
External leakage - Utility medium	2*	0.32	1.98	4.82	1.46	2.07	2.5	4.0	5.0	6.0
	2†	0.32	1.98	4.82	1.46	2.06				
Internal leakage	1*	0.01	0.98	3.32	1.22	1.03	6.0	12.0	12.0	12.0
	1†	0.01	0.98	3.32	1.22	1.03				
Minor in-service problems	1*	0.01	1.01	3.64	1.35	1.03	4.0	4.0	4.0	4.0
	1†	0.01	1.01	3.64	1.35	1.03				
Other	1*	0.03	3.72	12.82	4.73	1.03	3.0	6.0	6.0	6.0
	1†	0.02	3.63	12.61	4.65	1.03				
All modes	**12***	**7.55**	**12.81**	**19.20**	**3.58**	**12.39**	**8.3**	**4.0**	**12.8**	**46.0**
	12†	**2.30**	**14.66**	**35.93**	**10.93**	**12.38**				

Comments

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Taxonomy no	Item
4.4.5.1.3	Control and Safety Equipment Valves ESD/PSD Ball (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
38	3	1.4991	1.4982	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**13***	**0.32**	**15.19**	**47.02**	**16.60**	**8.67**	**8.1**	**1.0**	**16.2**	**51.0**
	13†	**0.32**	**15.21**	**47.07**	**16.62**	**8.68**				
Delayed operation	2*	0.01	3.00	11.79	4.39	1.33	19.8	28.0	39.5	51.0
	2†	0.01	3.00	11.80	4.39	1.33				
Fail to close on demand	1*	0.00	1.33	5.31	1.99	0.67	17.0	34.0	34.0	34.0
	1†	0.00	1.33	5.32	1.99	0.67				
Other	2*	0.01	3.00	11.79	4.39	1.33	9.5	1.0	19.0	37.0
	2†	0.01	3.00	11.80	4.39	1.33				
Spurious operation	7*	0.50	5.68	15.71	5.10	4.67	4.0	1.0	8.1	24.0
	7†	0.50	5.68	15.73	5.11	4.67				
Structural deficiency	1*	0.01	0.88	3.03	1.11	0.67	2.0	2.0	2.0	2.0
	1†	0.01	0.88	3.03	1.12	0.67				
Degraded	**3***	**0.29**	**2.47**	**6.43**	**2.02**	**2.00**	**7.2**	**2.0**	**10.3**	**19.0**
	3†	**0.29**	**2.47**	**6.44**	**2.02**	**2.00**				
External leakage - Process medium	1*	0.01	0.88	3.03	1.11	0.67	10.0	10.0	10.0	10.0
	1†	0.01	0.88	3.03	1.12	0.67				
External leakage - Utility medium	1*	0.01	0.59	1.86	0.67	0.67	2.0	2.0	2.0	2.0
	1†	0.01	0.59	1.86	0.67	0.67				
Other	1*	0.00	1.33	5.31	1.99	0.67	9.5	19.0	19.0	19.0
	1†	0.00	1.33	5.32	1.99	0.67				
Incipient	**28***	**2.79**	**19.64**	**49.23**	**15.17**	**18.68**	**4.4**	**1.0**	**8.8**	**28.0**
	28†	**2.79**	**19.66**	**49.28**	**15.19**	**18.69**				
Abnormal instrument reading	2*	0.28	1.45	3.38	1.00	1.33	6.3	6.0	12.5	19.0
	2†	0.28	1.45	3.38	1.00	1.33				
External leakage - Process medium	1*	0.01	0.59	1.86	0.67	0.67	-	-	-	-
	1†	0.01	0.59	1.86	0.67	0.67				
External leakage - Utility medium	16*	0.43	7.81	23.16	7.71	10.67	3.8	2.0	7.6	20.0
	16†	0.43	7.81	23.17	7.71	10.68				
Minor in-service problems	2*	0.03	1.11	3.41	1.20	1.33	1.0	2.0	2.0	2.0
	2†	0.03	1.11	3.42	1.20	1.33				
Other	7*	0.05	10.02	36.55	13.50	4.67	6.1	1.0	12.1	28.0
	7†	0.05	10.03	36.58	13.52	4.67				
All modes	**44***	**4.35**	**38.26**	**100.29**	**31.59**	**29.35**	**5.7**	**1.0**	**11.2**	**51.0**
	44†	**4.35**	**38.30**	**100.39**	**31.63**	**29.37**				

Comments

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Taxonomy no	Item
4.4.5.1.4	Control and Safety Equipment Valves ESD/PSD Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	3	0.2542	0.2540	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**8***	**3.69**	**27.71**	**70.40**	**21.84**	**31.47**	**2.1**	**1.0**	**4.1**	**17.0**
	8†	**3.69**	**27.73**	**70.48**	**21.87**	**31.50**				
External leakage - Utility medium	1*	0.04	3.67	12.04	4.39	3.93	8.5	17.0	17.0	17.0
	1†	0.04	3.68	12.05	4.40	3.94				
Fail to open on demand	2*	1.30	7.70	18.50	5.56	7.87	3.5	4.0	5.5	7.0
	2†	1.31	7.71	18.52	5.57	7.88				
Spurious operation	5*	0.22	16.67	53.32	19.26	19.67	0.5	1.0	1.0	1.0
	5†	0.22	16.68	53.38	19.28	19.69				
Degraded	**9***	**5.30**	**39.99**	**101.71**	**31.58**	**35.41**	**20.0**	**4.0**	**12.0**	**40.0**
	9†	**5.30**	**40.01**	**101.76**	**31.59**	**35.44**				
Delayed operation	2*	0.83	7.97	21.34	6.81	7.87	-	4.0	6.0	8.0
	2†	0.83	7.98	21.35	6.81	7.88				
External leakage - Utility medium	3*	1.29	11.53	30.32	9.57	11.80	20.0	4.0	22.0	40.0
	3†	1.30	11.54	30.34	9.58	11.81				
Internal leakage	1*	0.09	13.99	48.51	17.89	3.93	-	-	-	-
	1†	0.09	13.99	48.52	17.90	3.94				
Other	2*	0.83	7.97	21.34	6.81	7.87	-	4.0	4.0	4.0
	2†	0.83	7.98	21.35	6.81	7.88				
Plugged/Choked	1*	0.02	3.98	14.87	5.49	3.93	-	-	-	-
	1†	0.02	3.98	14.88	5.49	3.94				
Incipient	**13***	**8.50**	**45.91**	**107.87**	**31.99**	**51.14**	**4.6**	**1.0**	**8.6**	**17.0**
	13†	**8.51**	**45.95**	**107.97**	**32.02**	**51.19**				
Abnormal instrument reading	2*	0.83	7.97	21.34	6.81	7.87	-	8.0	8.0	8.0
	2†	0.83	7.98	21.35	6.81	7.88				
Low output	1*	0.04	3.67	12.04	4.39	3.93	6.0	12.0	12.0	12.0
	1†	0.04	3.68	12.05	4.40	3.94				
Minor in-service problems	3*	0.14	11.74	37.81	13.70	11.80	-	6.0	6.0	6.0
	3†	0.14	11.75	37.83	13.71	11.81				
Other	7*	0.11	22.19	80.41	29.71	27.54	4.4	1.0	8.6	17.0
	7†	0.11	22.21	80.50	29.74	27.56				
All modes	**30***	**59.72**	**114.09**	**182.66**	**37.86**	**118.02**	**4.5**	**1.0**	**7.8**	**40.0**
	30†	**59.73**	**114.18**	**182.86**	**37.93**	**118.13**				

Comments

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Taxonomy no	Item
4.4.5.1.5	Control and Safety Equipment Valves ESD/PSD Ball (30.1-40) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1253	0.1242	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**17.44**	**52.56**	**103.02**	**26.84**	**55.85**	**7.5**	**1.0**	**18.3**	**55.0**
	7†	**17.26**	**52.96**	**104.52**	**27.39**	**56.35**				
Fail to close on demand	3*	6.86	24.34	50.58	13.82	23.94	18.8	40.0	47.5	55.0
	3†	6.90	24.53	51.01	13.94	24.15				
Other	1*	0.15	7.28	22.56	7.98	7.98	6.0	12.0	12.0	12.0
	1†	0.15	7.35	22.77	8.05	8.05				
Spurious operation	3*	5.01	21.83	48.36	13.82	23.94	0.5	1.0	1.0	1.0
	3†	5.06	22.04	48.80	13.94	24.15				
Degraded	**3***	**6.86**	**24.34**	**50.58**	**13.82**	**23.94**	**18.0**	**11.0**	**36.0**	**61.0**
	3†	**6.90**	**24.53**	**51.01**	**13.94**	**24.15**				
External leakage - Utility medium	1*	0.06	11.82	42.68	15.77	7.98	-	-	-	-
	1†	0.06	11.83	42.55	15.72	8.05				
Other	2*	0.21	13.82	43.68	15.67	15.96	18.0	11.0	36.0	61.0
	2†	0.21	13.95	44.15	15.86	16.10				
Incipient	**11***	**51.40**	**90.08**	**137.56**	**26.46**	**87.77**	**7.5**	**4.0**	**14.0**	**29.0**
	11†	**51.77**	**90.79**	**138.69**	**26.70**	**88.55**				
Abnormal instrument reading	1*	0.15	7.28	22.56	7.98	7.98	14.5	29.0	29.0	29.0
	1†	0.15	7.35	22.77	8.05	8.05				
Minor in-service problems	2*	0.11	26.08	98.13	36.20	15.96	-	10.0	10.0	10.0
	2†	0.11	26.10	98.06	36.18	16.10				
Other	5*	4.24	33.98	87.42	27.28	39.90	4.7	4.0	9.3	20.0
	5†	4.11	34.25	88.74	27.78	40.25				
Structural deficiency	3*	3.43	29.52	76.90	24.13	23.94	9.0	13.0	15.5	18.0
	3†	3.59	29.58	76.47	23.91	24.15				
All modes	**21***	**112.58**	**167.87**	**232.18**	**36.56**	**167.56**	**9.1**	**1.0**	**18.7**	**61.0**
	21†	**113.45**	**169.24**	**234.11**	**36.89**	**169.04**				

Comments

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Taxonomy no	Item
4.4.5.1.6	Control and Safety Equipment Valves ESD/PSD Ball Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.05	12.91	49.56	18.25	0.00	-	-	-	-
	0†	0.05	12.91	49.56	18.25	0.00				

Comments

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Taxonomy no		Item
4.4.5.2		Control and Safety Equipment Valves ESD/PSD Butterfly

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1226	0.1225	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.82	14.68	5.41	0.00	-	-	-	-
	0†	0.01	3.83	14.70	5.41	0.00				

Comments

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Taxonomy no	Item
4.4.5.2.1	Control and Safety Equipment Valves ESD/PSD Butterfly (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0919	0.0919	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	2.25 2.25	8.62 8.63	3.18 3.18	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.4.5.2.2	Control and Safety Equipment Valves ESD/PSD Butterfly (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0306	0.0306	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	3.10	11.90	4.38	0.00	-	-	-	-
	0†	0.01	3.10	11.91	4.39	0.00				

Comments

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Taxonomy no	Item
4.4.5.3	Control and Safety Equipment Valves ESD/PSD Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
40	4	1.1649	1.1577	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**14***	**2.17**	**14.81**	**36.90**	**11.34**	**12.02**	**6.1**	**2.0**	**11.7**	**66.0**
	14†	**2.15**	**15.05**	**37.68**	**11.61**	**12.09**				
Fail to close on demand	7*	1.59	8.18	19.01	5.60	6.01	8.3	2.0	18.5	66.0
	7†	1.55	8.35	19.63	5.82	6.05				
Fail to open on demand	4*	0.00	4.60	19.97	7.76	3.43	3.0	2.0	4.0	6.0
	4†	0.00	4.66	20.27	7.88	3.46				
Spurious operation	3*	0.21	2.16	5.85	1.88	2.58	5.7	3.0	5.7	8.0
	3†	0.22	2.17	5.87	1.88	2.59				
Degraded	**4***	**0.03**	**5.10**	**18.33**	**6.77**	**3.43**	**7.0**	**6.0**	**8.0**	**12.0**
	4†	**1.46**	**3.79**	**7.00**	**1.73**	**3.46**				
Abnormal instrument reading	1*	0.02	3.38	12.57	4.64	0.86	-	6.0	6.0	6.0
	1†	0.02	3.54	13.05	4.82	0.86				
Delayed operation	2*	0.14	1.81	5.13	1.68	1.72	8.0	12.0	12.0	12.0
	2†	0.14	1.83	5.19	1.70	1.73				
External leakage - Utility medium	1*	0.01	0.76	2.39	0.86	0.86	6.0	6.0	6.0	6.0
	1†	0.01	0.76	2.41	0.86	0.86				
Incipient	**12***	**2.72**	**22.48**	**58.16**	**18.19**	**10.30**	**2.3**	**2.0**	**2.8**	**4.0**
	12†	**2.80**	**23.00**	**59.42**	**18.58**	**10.37**				
Abnormal instrument reading	5*	0.00	5.60	25.21	10.00	4.29	2.0	2.0	2.0	2.0
	5†	0.00	5.68	25.58	10.15	4.32				
External leakage - Utility medium	3*	0.06	7.43	25.12	9.23	2.58	4.0	4.0	4.0	4.0
	3†	0.06	7.76	26.12	9.59	2.59				
Minor in-service problems	3*	0.00	3.55	14.54	5.51	2.58	2.0	2.0	2.0	2.0
	3†	0.00	3.60	14.77	5.60	2.59				
Other	1*	0.41	8.73	26.17	8.77	0.86	-	-	-	-
	1†	0.40	8.77	26.32	8.84	0.86				
All modes	**30***	**6.65**	**42.45**	**104.06**	**31.68**	**25.75**	**5.0**	**2.0**	**8.1**	**66.0**
	30†	**6.75**	**43.40**	**106.58**	**32.48**	**25.91**				

Comments

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Taxonomy no	Item
4.4.5.3.1	Control and Safety Equipment Valves ESD/PSD Gate (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
21	2	0.6789	0.6752	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**10***	**1.29**	**16.44**	**46.46**	**15.21**	**14.73**	**3.2**	**2.0**	**4.0**	**7.0**
	10†	**1.27**	**16.61**	**47.13**	**15.46**	**14.81**				
Fail to close on demand	4*	0.04	6.91	24.77	9.15	5.89	2.5	2.0	3.7	7.0
	4†	0.04	6.99	25.10	9.28	5.92				
Fail to open on demand	4*	0.04	6.91	24.77	9.15	5.89	3.0	2.0	4.0	6.0
	4†	0.04	6.99	25.10	9.28	5.92				
Spurious operation	2*	0.44	2.80	6.85	2.08	2.95	4.5	3.0	4.5	6.0
	2†	0.44	2.82	6.89	2.09	2.96				
Degraded	**3***	**1.18**	**4.38**	**9.23**	**2.55**	**4.42**	**7.0**	**6.0**	**9.0**	**12.0**
	3†	**1.19**	**4.40**	**9.28**	**2.57**	**4.44**				
Delayed operation	2*	0.54	2.98	7.01	2.08	2.95	8.0	12.0	12.0	12.0
	2†	0.55	2.99	7.05	2.09	2.96				
External leakage - Utility medium	1*	0.01	1.38	4.81	1.77	1.47	6.0	6.0	6.0	6.0
	1†	0.01	1.39	4.82	1.78	1.48				
Incipient	**8***	**0.06**	**14.04**	**52.16**	**19.26**	**11.78**	**2.0**	**2.0**	**2.0**	**2.0**
	8†	**0.06**	**14.21**	**52.83**	**19.50**	**11.85**				
Abnormal instrument reading	5*	0.04	8.69	31.62	11.68	7.36	2.0	2.0	2.0	2.0
	5†	0.04	8.80	32.04	11.84	7.40				
Minor in-service problems	3*	0.03	5.13	17.92	6.62	4.42	2.0	2.0	2.0	2.0
	3†	0.03	5.19	18.17	6.71	4.44				
All modes	**21***	**1.98**	**35.00**	**103.46**	**34.42**	**30.93**	**3.3**	**2.0**	**4.0**	**12.0**
	21†	**1.94**	**35.36**	**104.92**	**34.94**	**31.10**				

Comments

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Taxonomy no	Item
4.4.5.3.2	Control and Safety Equipment Valves ESD/PSD Gate (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	2	0.0744	0.0737	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.25**	**12.25**	**37.98**	**13.44**	**13.44**	**24.0**	**24.0**	**24.0**	**24.0**
	1†	**0.25**	**12.37**	**38.35**	**13.56**	**13.56**				
Fail to close on demand	1*	0.25	12.25	37.98	13.44	13.44	24.0	24.0	24.0	24.0
	1†	0.25	12.37	38.35	13.56	13.56				
All modes	**1***	**0.25**	**12.25**	**37.98**	**13.44**	**13.44**	**24.0**	**24.0**	**24.0**	**24.0**
	1†	**0.25**	**12.37**	**38.35**	**13.56**	**13.56**				

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Taxonomy no	Item
4.4.5.3.3	Control and Safety Equipment Valves ESD/PSD Gate (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	3	0.1357	0.1331	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**2.35**	**14.25**	**34.49**	**10.42**	**14.74**	**10.0**	**10.0**	**38.0**	**66.0**
	2†	**2.39**	**14.54**	**35.22**	**10.65**	**15.02**				
Fail to close on demand	2*	2.35	14.25	34.49	10.42	14.74	10.0	10.0	38.0	66.0
	2†	2.39	14.54	35.22	10.65	15.02				
Degraded	**1***	**0.01**	**7.17**	**29.13**	**10.99**	**7.37**	**-**	**6.0**	**6.0**	**6.0**
	1†	**0.01**	**7.40**	**30.44**	**11.55**	**7.51**				
Abnormal instrument reading	1*	0.01	7.17	29.13	10.99	7.37	-	6.0	6.0	6.0
	1†	0.01	7.40	30.44	11.55	7.51				
Incipient	**3***	**6.95**	**23.27**	**47.43**	**12.76**	**22.10**	**-**	**4.0**	**4.0**	**4.0**
	3†	**7.15**	**23.82**	**48.43**	**13.01**	**22.53**				
External leakage - Utility medium	2*	0.76	14.41	42.91	14.31	14.74	-	4.0	4.0	4.0
	2†	0.46	14.83	45.03	15.53	15.02				
Other	1*	0.03	11.39	44.89	16.72	7.37	-	-	-	-
	1†	0.03	11.44	44.99	16.74	7.51				
All modes	**6***	**19.80**	**44.81**	**78.02**	**18.05**	**44.21**	**10.0**	**4.0**	**18.0**	**66.0**
	6†	**20.33**	**45.85**	**79.69**	**18.40**	**45.07**				

Comments

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Taxonomy no	Item
4.4.5.3.4	Control and Safety Equipment Valves ESD/PSD Gate Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
9	1	0.2758	0.2756	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.18**	**3.63**	**17.20**	**3.63**	**3.63**	**8.0**	**8.0**	**8.0**	**8.0**
	1†	**0.18**	**3.63**	**17.22**	**3.63**	**3.63**				
Spurious operation	1*	0.18	3.63	17.20	3.63	3.63	8.0	8.0	8.0	8.0
	1†	0.18	3.63	17.22	3.63	3.63				
Incipient	**1***	**0.18**	**3.63**	**17.20**	**3.63**	**3.63**	**4.0**	**4.0**	**4.0**	**4.0**
	1†	**0.18**	**3.63**	**17.22**	**3.63**	**3.63**				
External leakage - Utility medium	1*	0.18	3.63	17.20	3.63	3.63	4.0	4.0	4.0	4.0
	1†	0.18	3.63	17.22	3.63	3.63				
All modes	**2***	**1.29**	**7.25**	**22.82**	**7.25**	**7.25**	**6.0**	**4.0**	**6.0**	**8.0**
	2†	**1.29**	**7.26**	**22.84**	**7.26**	**7.26**				

Comments

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Taxonomy no		Item									
4.4.6		Control and Safety Equipment Valves Monitoring									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
		Calendar time *		**Operational time †**							
1	1	0.0175		0.0175							
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Degraded		**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
		1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
External leakage - Utility medium		1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
		1†	2.85	57.08	270.83	57.08	57.08				
All modes		**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
		1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Monitoring

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by application - Monitoring

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Monitoring

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
External influence - general	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.00	100.0	0.00	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by application - Monitoring

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
External influence - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.6.1	Control and Safety Equipment Valves Monitoring Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				

Comments

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Taxonomy no	Item
4.4.6.1.1	Control and Safety Equipment Valves Monitoring Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				
External leakage - Utility medium	1*	2.85	57.08	270.83	57.08	57.08	-	-	-	-
	1†	2.85	57.08	270.83	57.08	57.08				
All modes	**1***	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**	-	-	-	-
	1†	**2.85**	**57.08**	**270.83**	**57.08**	**57.08**				

Comments

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Taxonomy no		Item									
4.4.7		Control and Safety Equipment Valves Press. red									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
14	1	**Calendar time *** 0.6349		**Operational time †** 0.4749							
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Degraded		**2***	**0.56**	**3.15**	**9.91**	**3.15**	**3.15**	**3.5**	**3.5**	**3.5**	**3.5**
		2†	**0.75**	**4.21**	**13.26**	**4.21**	**4.21**				
High output		1*	0.08	1.57	7.47	1.57	1.57	3.5	3.5	3.5	3.5
		1†	0.11	2.11	9.99	2.11	2.11				
Other		1*	0.08	1.57	7.47	1.57	1.57	-	-	-	-
		1†	0.11	2.11	9.99	2.11	2.11				
Incipient		**1***	**0.08**	**1.57**	**7.47**	**1.57**	**1.57**	**3.0**	**3.0**	**3.0**	**3.0**
		1†	**0.11**	**2.11**	**9.99**	**2.11**	**2.11**				
Minor in-service problems		1*	0.08	1.57	7.47	1.57	1.57	3.0	3.0	3.0	3.0
		1†	0.11	2.11	9.99	2.11	2.11				
All modes		**3***	**1.29**	**4.72**	**12.21**	**4.72**	**4.72**	**3.3**	**3.0**	**3.3**	**3.5**
		3†	**1.73**	**6.32**	**16.33**	**6.32**	**6.32**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Press. red

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00

Maintainable item versus failure mode, continued
Item: Valves described by application - Press. red

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Closure member (Ball/gate/disc/etc.)	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00	33.33
Other valve components	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	33.33
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Total	0.00	0.00	33.33	0.00	33.33	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Press. red

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by application - Press. red

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Erosion	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00	33.33
Instrument failure - general	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	66.67
Total	0.00	0.00	33.33	0.00	33.33	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.7.1	Control and Safety Equipment Valves Press. red Check

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.45	9.39	3.46	0.00	-	-	-	-
	0†	0.01	3.32	12.74	4.69	0.00				

Comments

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Taxonomy no	Item
4.4.7.1.1	Control and Safety Equipment Valves Press. red Check Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	1.65	6.34	2.33	0.00	-	-	-	-
	0†	0.01	2.25	8.63	3.18	0.00				

Comments

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Taxonomy no	Item
4.4.7.2	Control and Safety Equipment Valves Press. red Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.5364	0.4032	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**0.66**	**3.73**	**11.74**	**3.73**	**3.73**	**3.5**	**3.5**	**3.5**	**3.5**
	2†	**0.88**	**4.96**	**15.61**	**4.96**	**4.96**				
High output	1*	0.09	1.86	8.85	1.86	1.86	3.5	3.5	3.5	3.5
	1†	0.12	2.48	11.77	2.48	2.48				
Other	1*	0.09	1.86	8.85	1.86	1.86	-	-	-	-
	1†	0.12	2.48	11.77	2.48	2.48				
Incipient	**1***	**0.09**	**1.86**	**8.85**	**1.86**	**1.86**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.12**	**2.48**	**11.77**	**2.48**	**2.48**				
Minor in-service problems	1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0
	1†	0.12	2.48	11.77	2.48	2.48				
All modes	**3***	**1.53**	**5.59**	**14.46**	**5.59**	**5.59**	**3.3**	**3.0**	**3.3**	**3.5**
	3†	**2.03**	**7.44**	**19.23**	**7.44**	**7.44**				

Comments

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Taxonomy no	Item
4.4.7.2.1	Control and Safety Equipment Valves Press. red Globe (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.5364	0.4032	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**2***	**0.66**	**3.73**	**11.74**	**3.73**	**3.73**	**3.5**	**3.5**	**3.5**	**3.5**
	2†	**0.88**	**4.96**	**15.61**	**4.96**	**4.96**				
High output	1*	0.09	1.86	8.85	1.86	1.86	3.5	3.5	3.5	3.5
	1†	0.12	2.48	11.77	2.48	2.48				
Other	1*	0.09	1.86	8.85	1.86	1.86	-	-	-	-
	1†	0.12	2.48	11.77	2.48	2.48				
Incipient	**1***	**0.09**	**1.86**	**8.85**	**1.86**	**1.86**	**3.0**	**3.0**	**3.0**	**3.0**
	1†	**0.12**	**2.48**	**11.77**	**2.48**	**2.48**				
Minor in-service problems	1*	0.09	1.86	8.85	1.86	1.86	3.0	3.0	3.0	3.0
	1†	0.12	2.48	11.77	2.48	2.48				
All modes	**3***	**1.53**	**5.59**	**14.46**	**5.59**	**5.59**	**3.3**	**3.0**	**3.3**	**3.5**
	3†	**2.03**	**7.44**	**19.23**	**7.44**	**7.44**				

Comments

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Taxonomy no		Item									
4.4.8		Control and Safety Equipment Valves Process control									
Population	**Installations**	**Aggregated time in service (10^6 hours)**						**No of demands**			
319	11	**Calendar time *** 9.5848			**Operational time †** 8.5060						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	**n/τ**		**Min**	**Mean**	**Max**
Critical		**128***	**0.01**	**6.91**	**28.15**	**10.64**	**13.35**	**14.2**	**1.0**	**16.5**	**113.0**
		128†	**0.04**	**7.76**	**28.17**	**10.41**	**15.05**				
Delayed operation		1*	0.00	0.17	0.71	0.27	0.10	56.5	113.0	113.0	113.0
		1†	0.00	0.21	0.92	0.36	0.12				
External leakage - Process medium		8*	0.07	0.75	2.09	0.68	0.83	11.6	1.0	13.5	54.0
		8†	0.09	0.83	2.18	0.69	0.94				
External leakage - Utility medium		1*	0.00	0.17	0.71	0.27	0.10	11.0	22.0	22.0	22.0
		1†	0.00	0.21	0.92	0.36	0.12				
Fail to close on demand		34*	0.01	1.95	7.68	2.86	3.55	14.1	2.0	14.5	78.0
		34†	0.02	2.23	7.41	2.72	4.00				
Fail to open on demand		10*	0.16	1.19	3.01	0.93	1.04	16.0	1.5	20.8	78.0
		10†	0.23	1.35	3.22	0.96	1.18				
Fail to regulate		63*	0.00	2.88	14.62	6.30	6.57	12.0	2.0	13.7	93.0
		63†	0.00	3.16	15.35	6.37	7.41				
High output		1*	0.00	0.09	0.29	0.10	0.10	6.0	6.0	6.0	6.0
		1†	0.00	0.10	0.32	0.12	0.12				
Internal leakage		3*	0.06	0.27	0.62	0.18	0.31	26.3	6.0	34.0	48.0
		3†	0.06	0.30	0.70	0.20	0.35				
Spurious operation		1*	0.00	0.18	0.79	0.31	0.10	8.0	8.0	8.0	8.0
		1†	0.00	0.19	0.80	0.31	0.12				
Structural deficiency		1*	0.00	0.09	0.29	0.10	0.10	12.0	16.0	16.0	16.0
		1†	0.00	0.10	0.32	0.12	0.12				
Unknown		2*	0.02	0.18	0.47	0.15	0.21	62.0	36.0	65.0	94.0
		2†	0.02	0.20	0.53	0.17	0.24				
Valve leakage in closed position		3*	0.07	0.29	0.64	0.18	0.31	11.3	6.0	17.0	35.0
		3†	0.08	0.33	0.73	0.21	0.35				
Degraded		**62***	**1.48**	**6.46**	**14.31**	**4.09**	**6.47**	**10.3**	**0.5**	**12.3**	**92.0**
		62†	**6.05**	**7.58**	**9.26**	**0.98**	**7.29**				
Delayed operation		2*	0.00	0.28	0.89	0.32	0.21	3.3	2.5	5.3	8.0
		2†	0.01	0.32	0.98	0.34	0.24				
External leakage - Process medium		14*	0.50	1.50	2.95	0.77	1.46	9.2	1.0	11.4	45.0
		14†	0.12	1.64	4.72	1.55	1.65				
External leakage - Utility medium		11*	0.29	1.27	2.81	0.80	1.15	11.1	2.0	18.1	92.0
		11†	0.19	1.54	3.98	1.25	1.29				
Fail to open on demand		1*	0.00	0.11	0.36	0.13	0.10	0.5	0.5	0.5	0.5
		1†	0.00	0.14	0.48	0.18	0.12				
High output		3*	0.03	0.34	0.97	0.32	0.31	4.3	2.0	4.7	9.0
		3†	0.04	0.39	1.05	0.34	0.35				
Internal leakage		8*	0.12	0.70	1.66	0.50	0.83	16.5	4.0	16.5	42.0
		8†	0.17	0.78	1.76	0.51	0.94				
Comments											

(cont.)

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Taxonomy no	Item
4.4.8	Control and Safety Equipment Valves Process control

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
319	11	9.5848	8.5060	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	12*	0.00	1.13	5.03	1.99	1.25	6.0	1.5	6.0	13.0
	12†	0.00	1.41	6.76	2.78	1.41				
Other	1*	0.00	0.09	0.29	0.10	0.10	20.0	32.0	32.0	32.0
	1†	0.00	0.10	0.32	0.12	0.12				
Plugged/Choked	2*	0.00	0.23	0.72	0.26	0.21	-	-	-	-
	2†	0.00	0.29	0.97	0.36	0.24				
Spurious operation	1*	0.00	0.09	0.29	0.10	0.10	11.0	11.0	11.0	11.0
	1†	0.00	0.10	0.32	0.12	0.12				
Unknown	1*	0.00	0.09	0.29	0.10	0.10	10.0	10.0	10.0	10.0
	1†	0.00	0.10	0.32	0.12	0.12				
Valve leakage in closed position	6*	0.22	0.75	1.53	0.41	0.63	17.0	4.0	17.0	46.0
	6†	0.38	0.80	1.34	0.30	0.71				
Incipient	**36***	**0.55**	**6.18**	**17.12**	**5.56**	**3.76**	**6.5**	**1.0**	**8.9**	**67.0**
	36†	**0.67**	**7.02**	**19.17**	**6.18**	**4.23**				
Abnormal instrument reading	19*	0.39	1.72	3.81	1.09	1.98	8.4	2.0	11.3	67.0
	19†	0.40	1.96	4.49	1.31	2.23				
External leakage - Utility medium	1*	0.00	0.17	0.71	0.27	0.10	8.5	17.0	17.0	17.0
	1†	0.00	0.21	0.92	0.36	0.12				
Low output	1*	0.00	0.11	0.36	0.13	0.10	1.0	1.0	1.0	1.0
	1†	0.00	0.14	0.48	0.18	0.12				
Minor in-service problems	11*	0.73	6.98	18.68	5.96	1.15	3.7	2.0	4.4	8.0
	11†	0.66	7.28	20.06	6.49	1.29				
Other	3*	0.08	0.44	1.03	0.30	0.31	5.2	3.0	9.3	13.0
	3†	0.07	0.57	1.50	0.47	0.35				
Valve leakage in closed position	1*	0.00	0.11	0.36	0.13	0.10	2.0	2.0	2.0	2.0
	1†	0.00	0.14	0.48	0.18	0.12				
Unknown	**2***	**0.02**	**0.18**	**0.47**	**0.15**	**0.21**	**77.0**	**114.0**	**116.5**	**119.0**
	2†	**0.02**	**0.20**	**0.53**	**0.17**	**0.24**				
Unknown	2*	0.02	0.18	0.47	0.15	0.21	77.0	114.0	116.5	119.0
	2†	0.02	0.20	0.53	0.17	0.24				
All modes	**228***	**7.63**	**19.61**	**36.10**	**8.87**	**23.79**	**12.6**	**0.5**	**15.1**	**119.0**
	228†	**13.23**	**23.00**	**34.95**	**6.67**	**26.80**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Process control

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	0.44	0.00	0.00	0.00	0.00	0.44	0.44	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Case	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00
Control unit	2.63	0.00	0.00	0.00	0.00	0.44	3.07	0.00	0.00
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.44	0.44	0.00	0.00
Flange	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Indicator	0.00	0.00	0.00	0.00	0.22	0.00	0.88	0.00	0.00
Instrument, general	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Internal power supply	0.44	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Monitoring	1.75	0.00	0.00	0.00	0.44	0.00	0.44	0.00	0.00
Other	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	0.44	0.44	0.00	0.44	0.00	0.00
Other valve components	0.00	0.00	0.44	0.00	0.44	0.00	0.88	0.00	0.00
Packing	0.00	0.00	1.97	0.00	0.51	0.00	0.00	0.00	0.44
Piston(s)	0.00	0.00	0.00	0.44	0.88	0.44	1.46	0.00	0.00
Positioner	0.44	0.00	0.00	0.44	0.66	0.44	3.95	0.44	0.00
Seals	0.00	0.00	1.97	0.00	1.83	0.00	0.44	0.22	0.88
Seals (gaskets)	0.00	0.00	0.88	0.44	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.88	0.00	2.05	0.00	0.00	0.22	0.88
Spring	0.00	0.00	0.00	0.00	0.44	0.44	0.15	0.00	0.00
Stem	0.00	0.44	0.44	0.88	0.00	0.00	1.02	0.00	0.00
Subunit	0.44	0.88	0.44	2.19	5.26	0.88	10.53	0.44	2.19
Unknown	0.00	0.00	0.00	0.00	0.00	0.88	0.88	0.00	0.00
Valve body w/internals	0.00	0.00	1.75	0.44	1.32	0.00	1.75	0.44	0.44
Total	8.33	1.32	9.65	5.70	14.91	4.82	27.63	1.75	4.82

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Maintainable item versus failure mode, continued
Item: Valves described by application - Process control

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.75
Cabling & junction boxes	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
Case	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.88
Control unit	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.44	7.46
Diaphragm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Flange	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Indicator	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
Instrument, general	0.00	0.44	0.44	0.00	0.44	0.00	0.00	0.00	3.51
Internal power supply	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Monitoring	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	3.07
Other	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.88
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Other valve components	0.00	0.00	0.44	0.00	0.44	0.00	0.00	0.00	2.63
Packing	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.24
Piston(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	3.44
Positioner	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	7.24
Seals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.34
Seals (gaskets)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	1.54
Seat rings	0.88	0.00	0.00	0.00	0.44	0.00	0.00	0.00	5.34
Spring	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Stem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.78
Subunit	1.32	0.00	0.00	0.00	0.44	0.44	0.00	1.32	26.75
Unknown	0.88	1.32	0.00	0.44	0.88	0.44	0.00	0.00	5.70
Valve body w/internals	0.00	3.51	0.00	0.00	0.00	0.00	0.44	0.00	10.09
Total	4.39	5.70	1.75	0.88	4.82	0.88	0.44	2.19	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Process control

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.88	0.00	0.00	0.00	1.75	0.00	2.19	0.88	0.00
Breakage	0.00	0.00	0.88	0.88	0.00	0.00	0.00	0.00	0.00
Clearance/ alignment failure	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.44
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Control failure	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corrosion	1.32	0.44	0.00	0.00	0.00	0.44	1.75	0.00	0.00
Deformation	0.00	0.00	1.32	0.44	0.44	0.88	0.88	0.44	0.00
Electrical failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Erosion	0.00	0.00	0.44	0.00	0.44	0.00	0.88	0.00	0.44
Faulty signal/indication/alarm	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.88	0.44	0.00	0.00
Leakage	0.00	0.00	0.00	0.88	0.44	0.44	0.44	0.00	0.00
Looseness	0.00	0.44	0.88	0.44	0.00	0.00	0.44	0.00	0.44
Material failure - general	0.00	0.00	0.00	0.44	0.00	0.44	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.44	0.00	0.00	0.44	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No signal/indication/alarm	0.88	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00
Out of adjustment	3.51	0.00	0.00	0.88	3.95	0.44	13.60	0.00	0.44
Software failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sticking	0.00	0.44	0.00	0.00	0.00	0.44	0.00	0.00	0.00
Unknown	0.00	0.00	1.32	0.00	0.44	0.00	0.88	0.44	0.00
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.00	0.00
Wear	0.00	0.00	4.82	1.32	7.46	0.44	3.51	0.00	2.63
Total	8.33	1.32	9.65	5.70	14.91	4.82	27.63	1.75	4.82

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Failure descriptior versus failure mode, continued
Item: Valves described by application - Process control

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	5.26	0.00	0.88	0.44	0.44	0.00	0.00	12.72
Breakage	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	2.19
Clearance/ alignment failure	0.88	0.00	0.00	0.00	0.00	0.44	0.00	0.00	2.19
Combined causes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Corrosion	0.44	0.00	0.00	0.00	1.32	0.00	0.00	0.44	6.14
Deformation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.39
Electrical failure - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
Erosion	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.07
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	1.75
Instrument failure - general	0.44	0.00	0.00	0.00	0.88	0.00	0.00	0.00	2.63
Leakage	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	2.63
Looseness	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51
Material failure - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	1.32
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Miscellaneous - general	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.44
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Out of adjustment	0.00	0.44	0.00	0.00	0.44	0.00	0.00	0.44	24.12
Software failure	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.88
Sticking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88
Unknown	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.32	4.82
Vibration	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	2.19
Wear	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.61
Total	4.39	5.70	1.75	0.88	4.82	0.88	0.44	2.19	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.8.1	Control and Safety Equipment Valves Process control Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
53	9	1.5170	1.1917	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**5***	**0.92**	**3.09**	**6.30**	**1.70**	**3.30**	**22.9**	**2.0**	**45.4**	**113.0**
	5†	**1.01**	**3.85**	**8.20**	**2.28**	**4.20**				
Delayed operation	1*	0.01	0.57	1.83	0.66	0.66	56.5	113.0	113.0	113.0
	1†	0.01	0.72	2.32	0.84	0.84				
External leakage - Utility medium	1*	0.01	0.57	1.83	0.66	0.66	11.0	22.0	22.0	22.0
	1†	0.01	0.72	2.32	0.84	0.84				
Fail to close on demand	1*	0.01	0.57	1.83	0.66	0.66	6.0	12.0	12.0	12.0
	1†	0.01	0.72	2.32	0.84	0.84				
Fail to open on demand	2*	0.12	1.46	4.12	1.35	1.32	20.5	2.0	40.0	78.0
	2†	0.08	1.84	5.52	1.85	1.68				
Degraded	**6***	**1.16**	**3.62**	**7.20**	**1.90**	**3.96**	**14.6**	**2.5**	**28.7**	**92.0**
	6†	**1.30**	**4.52**	**9.32**	**2.53**	**5.03**				
Delayed operation	1*	0.01	1.04	3.66	1.35	0.66	2.5	2.5	2.5	2.5
	1†	0.01	1.31	5.05	1.86	0.84				
External leakage - Utility medium	5*	0.89	2.84	5.69	1.51	3.30	17.6	13.0	35.3	92.0
	5†	1.04	3.55	7.28	1.97	4.20				
Incipient	**11***	**0.08**	**11.70**	**40.72**	**15.02**	**7.25**	**9.2**	**2.0**	**17.9**	**67.0**
	11†	**0.10**	**12.48**	**42.03**	**15.44**	**9.23**				
Abnormal instrument reading	5*	0.42	3.40	8.78	2.74	3.30	11.8	2.0	22.8	67.0
	5†	0.38	4.21	11.61	3.76	4.20				
External leakage - Utility medium	1*	0.01	0.57	1.83	0.66	0.66	8.5	17.0	17.0	17.0
	1†	0.01	0.72	2.32	0.84	0.84				
Minor in-service problems	3*	0.03	11.85	47.13	17.60	1.98	2.5	5.0	5.0	5.0
	3†	0.01	11.83	49.65	19.01	2.52				
Other	2*	0.13	1.14	2.97	0.93	1.32	6.3	12.0	12.5	13.0
	2†	0.16	1.44	3.77	1.19	1.68				
All modes	**22***	**1.79**	**14.42**	**37.14**	**11.59**	**14.50**	**14.2**	**2.0**	**28.0**	**113.0**
	22†	**4.11**	**17.41**	**38.27**	**10.88**	**18.46**				

Comments

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Taxonomy no	Item
4.4.8.1.1	Control and Safety Equipment Valves Process control Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
11	4	0.2759	0.2214	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.04**	**3.13**	**10.02**	**3.62**	**3.62**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.05**	**3.88**	**12.48**	**4.52**	**4.52**				
Fail to open on demand	1*	0.04	3.13	10.02	3.62	3.62	2.0	2.0	2.0	2.0
	1†	0.05	3.88	12.48	4.52	4.52				
Degraded	**1***	**0.04**	**3.13**	**10.02**	**3.62**	**3.62**	**2.5**	**2.5**	**2.5**	**2.5**
	1†	**0.05**	**3.88**	**12.48**	**4.52**	**4.52**				
Delayed operation	1*	0.04	3.13	10.02	3.62	3.62	2.5	2.5	2.5	2.5
	1†	0.05	3.88	12.48	4.52	4.52				
Incipient	**2***	**0.72**	**6.25**	**16.32**	**5.13**	**7.25**	**2.0**	**2.0**	**2.0**	**2.0**
	2†	**0.61**	**7.58**	**21.35**	**6.98**	**9.03**				
Abnormal instrument reading	2*	0.72	6.25	16.32	5.13	7.25	2.0	2.0	2.0	2.0
	2†	0.61	7.58	21.35	6.98	9.03				
All modes	**4***	**0.99**	**11.27**	**31.25**	**10.15**	**14.50**	**2.1**	**2.0**	**2.1**	**2.5**
	4†	**0.47**	**13.49**	**40.79**	**13.96**	**18.07**				

Comments

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Taxonomy no	Item
4.4.8.1.2	Control and Safety Equipment Valves Process control Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
14	4	0.4042	0.3121	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.04**	**2.23**	**6.95**	**2.47**	**2.47**	**39.0**	**78.0**	**78.0**	**78.0**
	1†	**0.05**	**2.87**	**8.98**	**3.20**	**3.20**				
Fail to open on demand	1*	0.04	2.23	6.95	2.47	2.47	39.0	78.0	78.0	78.0
	1†	0.05	2.87	8.98	3.20	3.20				
Degraded	**2***	**0.60**	**4.45**	**11.29**	**3.50**	**4.95**	**6.5**	**13.0**	**13.0**	**13.0**
	2†	**0.76**	**5.74**	**14.59**	**4.53**	**6.41**				
External leakage - Utility medium	2*	0.60	4.45	11.29	3.50	4.95	6.5	13.0	13.0	13.0
	2†	0.76	5.74	14.59	4.53	6.41				
Incipient	**2***	**0.60**	**4.45**	**11.29**	**3.50**	**4.95**	**24.5**	**31.0**	**49.0**	**67.0**
	2†	**0.76**	**5.74**	**14.59**	**4.53**	**6.41**				
Abnormal instrument reading	2*	0.60	4.45	11.29	3.50	4.95	24.5	31.0	49.0	67.0
	2†	0.76	5.74	14.59	4.53	6.41				
All modes	**5***	**1.82**	**10.41**	**24.79**	**7.41**	**12.37**	**20.2**	**13.0**	**40.4**	**78.0**
	5†	**2.25**	**13.34**	**32.10**	**9.66**	**16.02**				

Comments

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Taxonomy no	Item
4.4.8.1.3	Control and Safety Equipment Valves Process control Ball (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
20	1	0.6134	0.4705	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**1.34**	**4.89**	**12.64**	**4.89**	**4.89**	**24.5**	**12.0**	**49.0**	**113.0**
	3†	**1.74**	**6.38**	**16.48**	**6.38**	**6.38**				
Delayed operation	1*	0.08	1.63	7.74	1.63	1.63	56.5	113.0	113.0	113.0
	1†	0.11	2.13	10.09	2.13	2.13				
External leakage - Utility medium	1*	0.08	1.63	7.74	1.63	1.63	11.0	22.0	22.0	22.0
	1†	0.11	2.13	10.09	2.13	2.13				
Fail to close on demand	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
Degraded	**3***	**1.34**	**4.89**	**12.64**	**4.89**	**4.89**	**28.8**	**23.0**	**57.5**	**92.0**
	3†	**1.74**	**6.38**	**16.48**	**6.38**	**6.38**				
External leakage - Utility medium	3*	1.34	4.89	12.64	4.89	4.89	28.8	23.0	57.5	92.0
	3†	1.74	6.38	16.48	6.38	6.38				
Incipient	**4***	**2.23**	**6.52**	**14.92**	**6.52**	**6.52**	**5.8**	**5.0**	**11.5**	**17.0**
	4†	**2.90**	**8.50**	**19.46**	**8.50**	**8.50**				
Abnormal instrument reading	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
External leakage - Utility medium	1*	0.08	1.63	7.74	1.63	1.63	8.5	17.0	17.0	17.0
	1†	0.11	2.13	10.09	2.13	2.13				
Minor in-service problems	1*	0.08	1.63	7.74	1.63	1.63	2.5	5.0	5.0	5.0
	1†	0.11	2.13	10.09	2.13	2.13				
Other	1*	0.08	1.63	7.74	1.63	1.63	6.0	12.0	12.0	12.0
	1†	0.11	2.13	10.09	2.13	2.13				
All modes	**10***	**8.84**	**16.30**	**27.65**	**16.30**	**16.30**	**17.1**	**5.0**	**34.2**	**113.0**
	10†	**11.53**	**21.25**	**36.05**	**21.25**	**21.25**				

Comments

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Taxonomy no	Item
4.4.8.1.4	Control and Safety Equipment Valves Process control Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	3	0.2235	0.1877	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**3***	**0.34**	**33.54**	**109.85**	**40.06**	**13.42**	**6.5**	**13.0**	**13.0**	**13.0**
	3†	**0.35**	**33.60**	**109.94**	**40.09**	**15.98**				
Minor in-service problems	2*	0.22	33.50	116.35	42.92	8.95	-	-	-	-
	2†	0.18	33.06	118.03	43.61	10.66				
Other	1*	0.06	3.96	12.49	4.47	4.47	6.5	13.0	13.0	13.0
	1†	0.08	4.75	14.91	5.33	5.33				
All modes	**3***	**0.34**	**33.54**	**109.85**	**40.06**	**13.42**	**6.5**	**13.0**	**13.0**	**13.0**
	3†	**0.35**	**33.60**	**109.94**	**40.09**	**15.98**				

Comments

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Taxonomy no	Item
4.4.8.2	Control and Safety Equipment Valves Process control Butterfly

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
21	2	0.5748	0.5226	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**7***	**4.61**	**11.60**	**21.17**	**5.15**	**12.18**	**4.6**	**2.0**	**4.6**	**8.0**
	7†	**5.95**	**13.02**	**22.31**	**5.06**	**13.39**				
External leakage - Process medium	1*	0.03	1.58	4.91	1.74	1.74	2.0	2.0	2.0	2.0
	1†	0.03	1.74	5.40	1.91	1.91				
Fail to close on demand	2*	0.06	3.01	9.35	3.31	3.48	5.0	4.0	5.0	6.0
	2†	0.14	3.34	10.06	3.41	3.83				
Fail to regulate	4*	2.36	6.94	13.47	3.48	6.96	5.0	2.0	5.0	8.0
	4†	2.74	7.80	14.97	3.83	7.65				
Degraded	**8***	**4.10**	**12.93**	**25.77**	**6.81**	**13.92**	**7.3**	**1.0**	**7.3**	**28.0**
	8†	**7.12**	**14.76**	**24.64**	**5.41**	**15.31**				
External leakage - Process medium	5*	1.29	7.50	17.94	5.38	8.70	9.0	1.0	9.0	28.0
	5†	3.04	8.69	16.71	4.28	9.57				
External leakage - Utility medium	1*	0.01	2.81	10.48	3.87	1.74	4.0	4.0	4.0	4.0
	1†	0.01	3.95	15.31	5.67	1.91				
Internal leakage	1*	0.03	1.58	4.91	1.74	1.74	5.0	5.0	5.0	5.0
	1†	0.03	1.74	5.40	1.91	1.91				
Low output	1*	0.03	1.58	4.91	1.74	1.74	4.0	4.0	4.0	4.0
	1†	0.03	1.74	5.40	1.91	1.91				
Unknown	**1***	**0.03**	**1.58**	**4.91**	**1.74**	**1.74**	**67.0**	**114.0**	**114.0**	**114.0**
	1†	**0.03**	**1.74**	**5.40**	**1.91**	**1.91**				
Unknown	1*	0.03	1.58	4.91	1.74	1.74	67.0	114.0	114.0	114.0
	1†	0.03	1.74	5.40	1.91	1.91				
All modes	**16***	**15.15**	**26.35**	**40.08**	**7.66**	**27.83**	**9.8**	**1.0**	**12.8**	**114.0**
	16†	**13.83**	**28.89**	**48.39**	**10.68**	**30.61**				

Comments

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Taxonomy no	Item
4.4.8.2.1	Control and Safety Equipment Valves Process control Butterfly (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
4	1	0.1051	0.1024	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**3.38**	**19.03**	**59.88**	**19.03**	**19.03**	**5.0**	**4.0**	**5.0**	**6.0**
	2†	**3.47**	**19.53**	**61.46**	**19.53**	**19.53**				
Fail to close on demand	2*	3.38	19.03	59.88	19.03	19.03	5.0	4.0	5.0	6.0
	2†	3.47	19.53	61.46	19.53	19.53				
All modes	**2***	**3.38**	**19.03**	**59.88**	**19.03**	**19.03**	**5.0**	**4.0**	**5.0**	**6.0**
	2†	**3.47**	**19.53**	**61.46**	**19.53**	**19.53**				

Comments

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Taxonomy no
4.4.8.2.2

Item
Control and Safety Equipment
Valves
Process control
Butterfly
(5.1-10) inch

Population	Installations
9	2

Aggregated time in service (10^6 hours)

Calendar time *	Operational time †
0.3055	0.2611

No of demands

Failure mode	No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical	**1***	**0.18**	**3.31**	**9.83**	**3.27**	**3.27**	**2.0**	**2.0**	**2.0**	**2.0**
	1†	**0.31**	**4.10**	**11.67**	**3.83**	**3.83**				
Fail to regulate	1*	0.18	3.31	9.83	3.27	3.27	2.0	2.0	2.0	2.0
	1†	0.31	4.10	11.67	3.83	3.83				
Degraded	**4***	**2.69**	**13.00**	**29.70**	**8.67**	**13.09**	**9.5**	**2.0**	**9.5**	**28.0**
	4†	**5.00**	**15.03**	**29.43**	**7.66**	**15.32**				
External leakage - Process medium	2*	0.45	6.45	18.58	6.13	6.55	15.0	2.0	15.0	28.0
	2†	1.15	7.28	17.82	5.42	7.66				
External leakage - Utility medium	1*	0.18	3.31	9.83	3.27	3.27	4.0	4.0	4.0	4.0
	1†	0.31	4.10	11.67	3.83	3.83				
Low output	1*	0.01	3.22	12.16	4.48	3.27	4.0	4.0	4.0	4.0
	1†	0.02	3.59	12.48	4.60	3.83				
All modes	**5***	**6.42**	**16.34**	**29.94**	**7.32**	**16.37**	**8.0**	**2.0**	**8.0**	**28.0**
	5†	**7.52**	**19.13**	**35.04**	**8.56**	**19.15**				

Comments

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Taxonomy no	Item
4.4.8.2.3	Control and Safety Equipment Valves Process control Butterfly (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.1642	0.1591	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**4***	**8.31**	**24.36**	**55.74**	**24.36**	**24.36**	**5.0**	**2.0**	**5.0**	**8.0**
	4†	**8.58**	**25.14**	**57.54**	**25.14**	**25.14**				
External leakage - Process medium	1*	0.30	6.09	28.89	6.09	6.09	2.0	2.0	2.0	2.0
	1†	0.31	6.28	29.82	6.28	6.28				
Fail to regulate	3*	4.99	18.27	47.22	18.27	18.27	6.0	4.0	6.0	8.0
	3†	5.15	18.85	48.74	18.85	18.85				
Degraded	**4***	**8.31**	**24.36**	**55.74**	**24.36**	**24.36**	**5.0**	**1.0**	**5.0**	**13.0**
	4†	**8.58**	**25.14**	**57.54**	**25.14**	**25.14**				
External leakage - Process medium	3*	4.99	18.27	47.22	18.27	18.27	5.0	1.0	5.0	13.0
	3†	5.15	18.85	48.74	18.85	18.85				
Internal leakage	1*	0.30	6.09	28.89	6.09	6.09	5.0	5.0	5.0	5.0
	1†	0.31	6.28	29.82	6.28	6.28				
Unknown	**1***	**0.30**	**6.09**	**28.89**	**6.09**	**6.09**	**67.0**	**114.0**	**114.0**	**114.0**
	1†	**0.31**	**6.28**	**29.82**	**6.28**	**6.28**				
Unknown	1*	0.30	6.09	28.89	6.09	6.09	67.0	114.0	114.0	114.0
	1†	0.31	6.28	29.82	6.28	6.28				
All modes	**9***	**28.59**	**54.80**	**95.63**	**54.80**	**54.80**	**11.9**	**1.0**	**17.1**	**114.0**
	9†	**29.51**	**56.56**	**98.70**	**56.56**	**56.56**				

Comments

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Taxonomy no	Item
4.4.8.3	Control and Safety Equipment Valves Process control Check

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.03	15.48	5.70	0.00	-	-	-	-
	0†	0.02	5.36	20.57	7.57	0.00				

Comments

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Taxonomy no	Item
4.4.8.3.1	Control and Safety Equipment Valves Process control Check (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0985	0.0716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.01	2.25	8.63	3.18	0.00	-	-	-	-
	0†	0.01	3.03	11.64	4.29	0.00				

Comments

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Taxonomy no	Item
4.4.8.4	Control and Safety Equipment Valves Process control Diaphragm

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**36.0**	**36.0**	**36.0**	**36.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**7.0**	**5.0**	**7.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**3***	**31.20**	**114.16**	**295.09**	**114.16**	**114.16**	**16.7**	**5.0**	**16.7**	**36.0**
	3†	**32.02**	**117.15**	**302.84**	**117.15**	**117.15**				

Comments

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Taxonomy no	Item
4.4.8.4.1	Control and Safety Equipment Valves Process control Diaphragm (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**36.0**	**36.0**	**36.0**	**36.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
Unknown	1*	1.90	38.05	180.56	38.05	38.05	36.0	36.0	36.0	36.0
	1†	1.95	39.05	185.29	39.05	39.05				
Degraded	**2***	**13.51**	**76.10**	**239.54**	**76.10**	**76.10**	**7.0**	**5.0**	**7.0**	**9.0**
	2†	**13.86**	**78.10**	**245.82**	**78.10**	**78.10**				
External leakage - Utility medium	1*	1.90	38.05	180.56	38.05	38.05	5.0	5.0	5.0	5.0
	1†	1.95	39.05	185.29	39.05	39.05				
High output	1*	1.90	38.05	180.56	38.05	38.05	9.0	9.0	9.0	9.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**3***	**31.20**	**114.16**	**295.09**	**114.16**	**114.16**	**16.7**	**5.0**	**16.7**	**36.0**
	3†	**32.02**	**117.15**	**302.84**	**117.15**	**117.15**				

Comments

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Taxonomy no	Item
4.4.8.5	Control and Safety Equipment Valves Process control Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0351	0.0350	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.03	8.25 8.81	31.69 33.81	11.67 12.45	0.00 0.00	-	-	-	-

Comments

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Taxonomy no		Item
4.4.8.5.1		Control and Safety Equipment Valves Process control Gate (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0351	0.0350	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	5.23	20.07	7.39	0.00	-	-	-	-
	0†	0.02	5.45	20.91	7.70	0.00				

Comments

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Taxonomy no	Item
4.4.8.6	Control and Safety Equipment Valves Process control Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
240	3	7.3330	6.6594	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**115***	**0.15**	**10.83**	**34.54**	**12.46**	**15.68**	**14.2**	**1.0**	**15.8**	**94.0**
	115†	**0.28**	**11.55**	**35.44**	**12.39**	**17.27**				
External leakage - Process medium	7*	0.29	0.95	1.91	0.51	0.95	13.0	1.0	15.1	54.0
	7†	0.48	1.04	1.77	0.40	1.05				
Fail to close on demand	31*	0.01	2.60	10.43	3.91	4.23	15.0	2.0	15.2	78.0
	31†	0.01	2.80	10.81	3.99	4.66				
Fail to open on demand	8*	0.31	1.26	2.73	0.77	1.09	14.9	1.5	15.9	48.0
	8†	0.45	1.35	2.63	0.68	1.20				
Fail to regulate	59*	0.00	4.78	20.02	7.65	8.05	12.5	2.0	14.3	93.0
	59†	0.01	5.12	20.80	7.85	8.86				
High output	1*	0.00	0.12	0.38	0.14	0.14	6.0	6.0	6.0	6.0
	1†	0.00	0.13	0.42	0.15	0.15				
Internal leakage	3*	0.00	0.32	1.05	0.38	0.41	26.3	6.0	34.0	48.0
	3†	0.01	0.35	1.11	0.40	0.45				
Spurious operation	1*	0.00	0.26	1.05	0.39	0.14	8.0	8.0	8.0	8.0
	1†	0.00	0.27	1.09	0.41	0.15				
Structural deficiency	1*	0.00	0.12	0.38	0.14	0.14	12.0	16.0	16.0	16.0
	1†	0.00	0.13	0.42	0.15	0.15				
Unknown	1*	0.00	0.12	0.38	0.14	0.14	88.0	94.0	94.0	94.0
	1†	0.00	0.13	0.42	0.15	0.15				
Valve leakage in closed position	3*	0.06	0.39	0.95	0.29	0.41	11.3	6.0	17.0	35.0
	3†	0.04	0.44	1.18	0.38	0.45				
Degraded	**46***	**2.73**	**7.93**	**15.34**	**3.95**	**6.27**	**10.5**	**0.5**	**11.5**	**46.0**
	46†	**2.48**	**9.30**	**19.68**	**5.45**	**6.91**				
Delayed operation	1*	0.00	0.26	1.05	0.39	0.14	4.0	8.0	8.0	8.0
	1†	0.00	0.27	1.09	0.41	0.15				
External leakage - Process medium	9*	0.10	1.93	5.74	1.91	1.23	9.3	1.0	12.7	45.0
	9†	0.12	2.03	5.98	1.98	1.35				
External leakage - Utility medium	4*	0.14	0.48	1.00	0.27	0.55	7.8	2.0	7.8	14.0
	4†	0.15	0.53	1.10	0.30	0.60				
Fail to open on demand	1*	0.00	0.16	0.51	0.18	0.14	0.5	0.5	0.5	0.5
	1†	0.00	0.22	0.80	0.30	0.15				
High output	2*	0.04	0.39	1.06	0.34	0.27	2.0	2.0	2.5	3.0
	2†	0.04	0.46	1.26	0.41	0.30				
Internal leakage	7*	0.40	0.90	1.56	0.36	0.95	18.1	4.0	18.1	42.0
	7†	0.12	0.91	2.31	0.72	1.05				
Low output	11*	0.00	2.00	8.73	3.41	1.50	6.1	1.5	6.1	13.0
	11†	0.00	2.73	11.67	4.51	1.65				
Other	1*	0.00	0.12	0.38	0.14	0.14	20.0	32.0	32.0	32.0
	1†	0.00	0.13	0.42	0.15	0.15				

Comments

(cont.)

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Taxonomy no	Item
4.4.8.6	Control and Safety Equipment Valves Process control Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
240	3	7.3330	6.6594	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Plugged/Choked	2*	0.00	0.36	1.40	0.52	0.27	-	-	-	-
	2†	0.00	0.47	1.92	0.73	0.30				
Spurious operation	1*	0.00	0.12	0.38	0.14	0.14	11.0	11.0	11.0	11.0
	1†	0.00	0.13	0.42	0.15	0.15				
Unknown	1*	0.00	0.12	0.38	0.14	0.14	10.0	10.0	10.0	10.0
	1†	0.00	0.13	0.42	0.15	0.15				
Valve leakage in closed position	6*	0.12	1.28	3.49	1.12	0.82	17.0	4.0	17.0	46.0
	6†	0.15	1.43	3.86	1.23	0.90				
Incipient	**25***	**2.35**	**3.45**	**4.73**	**0.73**	**3.41**	**5.5**	**1.0**	**5.7**	**19.0**
	25†	**2.72**	**3.86**	**5.18**	**0.75**	**3.75**				
Abnormal instrument reading	14*	0.07	1.38	4.12	1.38	1.91	7.2	3.0	7.2	19.0
	14†	0.16	1.56	4.16	1.33	2.10				
Low output	1*	0.00	0.16	0.51	0.18	0.14	1.0	1.0	1.0	1.0
	1†	0.00	0.22	0.80	0.30	0.15				
Minor in-service problems	8*	0.16	1.55	4.14	1.32	1.09	3.9	2.0	4.4	8.0
	8†	0.14	1.90	5.46	1.80	1.20				
Other	1*	0.00	0.26	1.05	0.39	0.14	3.0	3.0	3.0	3.0
	1†	0.00	0.27	1.09	0.41	0.15				
Valve leakage in closed position	1*	0.00	0.16	0.51	0.18	0.14	2.0	2.0	2.0	2.0
	1†	0.00	0.22	0.80	0.30	0.15				
Unknown	**1***	**0.00**	**0.12**	**0.38**	**0.14**	**0.14**	**87.0**	**119.0**	**119.0**	**119.0**
	1†	**0.00**	**0.13**	**0.42**	**0.15**	**0.15**				
Unknown	1*	0.00	0.12	0.38	0.14	0.14	87.0	119.0	119.0	119.0
	1†	0.00	0.13	0.42	0.15	0.15				
All modes	**187***	**12.32**	**22.91**	**36.15**	**7.33**	**25.50**	**12.6**	**0.5**	**14.0**	**119.0**
	187†	**18.78**	**26.12**	**34.45**	**4.78**	**28.08**				

Comments

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Taxonomy no	Item
4.4.8.6.1	Control and Safety Equipment Valves Process control Globe (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
152	2	4.6798	4.1811	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**72***	**0.32**	**12.17**	**37.20**	**12.95**	**15.39**	**9.1**	**1.0**	**9.3**	**28.0**
	72†	**0.90**	**13.10**	**37.82**	**12.48**	**17.22**				
External leakage - Process medium	4*	0.09	0.75	1.95	0.61	0.85	5.5	1.0	5.5	8.0
	4†	0.25	0.87	1.79	0.49	0.96				
Fail to close on demand	25*	0.02	4.05	14.40	5.32	5.34	10.8	4.0	11.0	28.0
	25†	0.03	4.26	14.58	5.37	5.98				
Fail to open on demand	4*	0.28	0.84	1.64	0.43	0.85	14.4	1.5	15.4	24.0
	4†	0.32	0.95	1.85	0.48	0.96				
Fail to regulate	36*	0.23	6.16	18.58	6.33	7.69	7.9	2.0	8.1	24.0
	36†	0.59	6.69	18.55	6.02	8.61				
Internal leakage	1*	0.00	0.20	0.62	0.22	0.21	6.0	6.0	6.0	6.0
	1†	0.00	0.22	0.68	0.24	0.24				
Valve leakage in closed position	2*	0.09	0.45	1.03	0.30	0.43	8.0	6.0	8.0	10.0
	2†	0.07	0.53	1.36	0.42	0.48				
Degraded	**31***	**2.02**	**7.70**	**16.38**	**4.56**	**6.62**	**7.8**	**0.5**	**7.8**	**36.0**
	31†	**1.43**	**9.91**	**24.75**	**7.61**	**7.41**				
External leakage - Process medium	4*	0.28	0.84	1.64	0.43	0.85	11.0	2.0	11.0	36.0
	4†	0.32	0.95	1.85	0.48	0.96				
External leakage - Utility medium	4*	0.09	0.75	1.95	0.61	0.85	7.8	2.0	7.8	14.0
	4†	0.25	0.87	1.79	0.49	0.96				
Fail to open on demand	1*	0.00	0.28	0.93	0.34	0.21	0.5	0.5	0.5	0.5
	1†	0.00	0.38	1.43	0.53	0.24				
High output	1*	0.00	0.28	0.93	0.34	0.21	3.0	3.0	3.0	3.0
	1†	0.00	0.38	1.43	0.53	0.24				
Internal leakage	5*	0.07	0.91	2.57	0.84	1.07	9.6	4.0	9.6	19.0
	5†	0.17	1.03	2.48	0.75	1.20				
Low output	10*	0.01	3.28	12.49	4.60	2.14	6.2	1.5	6.2	13.0
	10†	0.02	4.54	17.42	6.42	2.39				
Plugged/Choked	2*	0.00	0.61	2.23	0.82	0.43	-	-	-	-
	2†	0.00	0.85	3.22	1.19	0.48				
Spurious operation	1*	0.00	0.20	0.62	0.22	0.21	11.0	11.0	11.0	11.0
	1†	0.00	0.22	0.68	0.24	0.24				
Unknown	1*	0.00	0.20	0.62	0.22	0.21	10.0	10.0	10.0	10.0
	1†	0.00	0.22	0.68	0.24	0.24				
Valve leakage in closed position	2*	0.00	0.61	2.23	0.82	0.43	9.0	6.0	9.0	12.0
	2†	0.00	0.85	3.22	1.19	0.48				
Incipient	**17***	**2.34**	**3.66**	**5.22**	**0.88**	**3.63**	**5.6**	**1.0**	**5.6**	**19.0**
	17†	**2.25**	**4.28**	**6.83**	**1.41**	**4.07**				
Abnormal instrument reading	11*	0.43	2.07	4.74	1.38	2.35	7.0	3.0	7.0	19.0
	11†	1.03	2.42	4.28	1.01	2.63				

Comments

(cont.)

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Taxonomy no	Item
4.4.8.6.1	Control and Safety Equipment Valves Process control Globe (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
152	2	4.6798	4.1811	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Low output	1*	0.00	0.28	0.93	0.34	0.21	1.0	1.0	1.0	1.0
	1†	0.00	0.38	1.43	0.53	0.24				
Minor in-service problems	4*	0.08	1.07	3.05	1.00	0.85	3.8	2.0	3.8	8.0
	4†	0.03	1.43	4.41	1.55	0.96				
Valve leakage in closed position	1*	0.00	0.28	0.93	0.34	0.21	2.0	2.0	2.0	2.0
	1†	0.00	0.38	1.43	0.53	0.24				
All modes	**120***	**13.63**	**24.03**	**36.80**	**7.12**	**25.64**	**8.3**	**0.5**	**8.4**	**36.0**
	120†	**22.56**	**28.19**	**34.34**	**3.59**	**28.70**				

Comments

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Taxonomy no	Item
4.4.8.6.2	Control and Safety Equipment Valves Process control Globe (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
40	2	1.1662	1.0489	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**17***	**3.35**	**12.35**	**26.00**	**7.17**	**14.58**	**18.1**	**2.0**	**19.3**	**54.0**
	17†	**7.35**	**14.80**	**24.34**	**5.24**	**16.21**				
External leakage - Process medium	1*	0.02	0.78	2.42	0.86	0.86	54.0	54.0	54.0	54.0
	1†	0.02	0.87	2.70	0.95	0.95				
Fail to close on demand	5*	1.67	4.27	7.83	1.92	4.29	23.4	2.0	23.6	49.0
	5†	1.94	4.84	8.79	2.13	4.77				
Fail to open on demand	1*	0.02	0.78	2.42	0.86	0.86	6.0	6.0	6.0	6.0
	1†	0.02	0.87	2.70	0.95	0.95				
Fail to regulate	8*	0.65	5.52	14.34	4.49	6.86	13.4	4.0	13.6	29.0
	8†	1.48	6.44	14.26	4.08	7.63				
High output	1*	0.02	0.78	2.42	0.86	0.86	6.0	6.0	6.0	6.0
	1†	0.02	0.87	2.70	0.95	0.95				
Valve leakage in closed position	1*	0.02	0.78	2.42	0.86	0.86	18.0	35.0	35.0	35.0
	1†	0.02	0.87	2.70	0.95	0.95				
Degraded	**3***	**0.81**	**2.71**	**5.52**	**1.49**	**2.57**	**29.7**	**6.0**	**29.7**	**46.0**
	3†	**0.56**	**3.25**	**7.76**	**2.32**	**2.86**				
Internal leakage	1*	0.02	0.78	2.42	0.86	0.86	37.0	37.0	37.0	37.0
	1†	0.02	0.87	2.70	0.95	0.95				
Low output	1*	0.01	1.72	6.64	2.46	0.86	6.0	6.0	6.0	6.0
	1†	0.01	2.41	9.47	3.52	0.95				
Valve leakage in closed position	1*	0.02	0.78	2.42	0.86	0.86	46.0	46.0	46.0	46.0
	1†	0.02	0.87	2.70	0.95	0.95				
Incipient	**4***	**1.22**	**3.49**	**6.70**	**1.72**	**3.43**	**6.3**	**2.0**	**6.3**	**9.0**
	4†	**1.43**	**3.97**	**7.53**	**1.91**	**3.81**				
Abnormal instrument reading	3*	0.05	2.15	6.60	2.31	2.57	7.7	6.0	7.7	9.0
	3†	0.11	2.43	7.28	2.44	2.86				
Minor in-service problems	1*	0.01	1.72	6.64	2.46	0.86	2.0	2.0	2.0	2.0
	1†	0.01	2.41	9.47	3.52	0.95				
All modes	**24***	**13.44**	**19.81**	**27.19**	**4.20**	**20.58**	**17.6**	**2.0**	**18.4**	**54.0**
	24†	**14.40**	**22.25**	**31.47**	**5.22**	**22.88**				

Comments

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Taxonomy no	Item
4.4.8.6.3	Control and Safety Equipment Valves Process control Globe (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	1	0.1957	0.1718	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**20***	**67.72**	**102.19**	**148.48**	**102.19**	**102.19**	**29.8**	**3.0**	**36.3**	**94.0**
	20†	**77.16**	**116.44**	**169.18**	**116.44**	**116.44**				
Fail to close on demand	1*	0.26	5.11	24.24	5.11	5.11	78.0	78.0	78.0	78.0
	1†	0.29	5.82	27.62	5.82	5.82				
Fail to regulate	15*	47.24	76.64	118.00	76.64	76.64	23.0	3.0	29.5	93.0
	15†	53.82	87.33	134.45	87.33	87.33				
Internal leakage	2*	1.81	10.22	32.16	10.22	10.22	36.5	48.0	48.0	48.0
	2†	2.07	11.64	36.65	11.64	11.64				
Structural deficiency	1*	0.26	5.11	24.24	5.11	5.11	12.0	16.0	16.0	16.0
	1†	0.29	5.82	27.62	5.82	5.82				
Unknown	1*	0.26	5.11	24.24	5.11	5.11	88.0	94.0	94.0	94.0
	1†	0.29	5.82	27.62	5.82	5.82				
Degraded	**1***	**0.26**	**5.11**	**24.24**	**5.11**	**5.11**	**20.0**	**32.0**	**32.0**	**32.0**
	1†	**0.29**	**5.82**	**27.62**	**5.82**	**5.82**				
Other	1*	0.26	5.11	24.24	5.11	5.11	20.0	32.0	32.0	32.0
	1†	0.29	5.82	27.62	5.82	5.82				
Unknown	**1***	**0.26**	**5.11**	**24.24**	**5.11**	**5.11**	**87.0**	**119.0**	**119.0**	**119.0**
	1†	**0.29**	**5.82**	**27.62**	**5.82**	**5.82**				
Unknown	1*	0.26	5.11	24.24	5.11	5.11	87.0	119.0	119.0	119.0
	1†	0.29	5.82	27.62	5.82	5.82				
All modes	**22***	**76.09**	**112.41**	**160.50**	**112.41**	**112.41**	**32.0**	**3.0**	**39.9**	**119.0**
	22†	**86.70**	**128.08**	**182.88**	**128.08**	**128.08**				

Comments

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Taxonomy no	Item
4.4.8.6.4	Control and Safety Equipment Valves Process control Globe Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
38	3	1.2912	1.2576	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**0.12**	**3.42**	**10.33**	**3.53**	**4.65**	**13.2**	**2.0**	**16.3**	**48.0**
	6†	**0.20**	**3.59**	**10.61**	**3.53**	**4.77**				
External leakage - Process medium	2*	0.13	1.35	3.66	1.18	1.55	7.5	6.0	15.0	24.0
	2†	0.15	1.40	3.71	1.18	1.59				
Fail to open on demand	3*	0.16	1.92	5.40	1.76	2.32	18.7	2.0	20.0	48.0
	3†	0.19	2.00	5.47	1.77	2.39				
Spurious operation	1*	0.01	0.68	2.16	0.77	0.77	8.0	8.0	8.0	8.0
	1†	0.01	0.71	2.22	0.80	0.80				
Degraded	**11***	**0.76**	**6.18**	**15.92**	**4.97**	**8.52**	**11.3**	**1.0**	**14.5**	**45.0**
	11†	**1.27**	**6.67**	**15.57**	**4.60**	**8.75**				
Delayed operation	1*	0.01	0.68	2.16	0.77	0.77	4.0	8.0	8.0	8.0
	1†	0.01	0.71	2.22	0.80	0.80				
External leakage - Process medium	5*	0.15	2.95	8.81	2.94	3.87	7.9	1.0	14.0	45.0
	5†	0.21	3.09	8.91	2.94	3.98				
High output	1*	0.01	0.68	2.16	0.77	0.77	1.0	2.0	2.0	2.0
	1†	0.01	0.71	2.22	0.80	0.80				
Internal leakage	1*	0.01	0.68	2.16	0.77	0.77	42.0	42.0	42.0	42.0
	1†	0.01	0.71	2.22	0.80	0.80				
Valve leakage in closed position	3*	0.16	1.92	5.40	1.76	2.32	12.7	4.0	12.7	24.0
	3†	0.19	2.00	5.47	1.77	2.39				
Incipient	**4***	**1.12**	**3.17**	**6.07**	**1.55**	**3.10**	**4.3**	**2.0**	**5.3**	**8.0**
	4†	**0.41**	**3.62**	**9.48**	**2.99**	**3.18**				
Minor in-service problems	3*	0.30	2.72	7.19	2.28	2.32	4.7	2.0	6.0	8.0
	3†	0.09	3.44	10.52	3.67	2.39				
Other	1*	0.01	0.68	2.16	0.77	0.77	3.0	3.0	3.0	3.0
	1†	0.01	0.71	2.22	0.80	0.80				
All modes	**21***	**1.72**	**12.03**	**30.13**	**9.28**	**16.26**	**10.5**	**1.0**	**13.3**	**48.0**
	21†	**2.31**	**12.89**	**30.54**	**9.09**	**16.70**				

Comments

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Taxonomy no		Item								
4.4.9		Control and Safety Equipment Valves PSD								
Population	**Installations**	**Aggregated time in service (10^6 hours)**					**No of demands**			
7	3	**Calendar time *** 0.1610		**Operational time †** 0.1577						
Failure mode		**No of failures**	**Failure rate (per 10^6 hours).**					**Active rep.hrs**	**Repair (manhours)**		
			Lower	**Mean**	**Upper**	**SD**	n/τ		**Min**	**Mean**	**Max**
Critical		**1***	**0.07**	**5.50**	**17.60**	**6.36**	**6.21**	**30.0**	**60.0**	**60.0**	**60.0**
		1†	**0.07**	**5.62**	**18.10**	**6.56**	**6.34**				
Fail to close on demand		1*	0.07	5.50	17.60	6.36	6.21	30.0	60.0	60.0	60.0
		1†	0.07	5.62	18.10	6.56	6.34				
Incipient		**5***	**3.40**	**27.71**	**71.49**	**22.34**	**31.06**	**2.8**	**1.0**	**3.4**	**8.0**
		5†	**3.35**	**28.28**	**73.42**	**23.00**	**31.71**				
Abnormal instrument reading		5*	3.40	27.71	71.49	22.34	31.06	2.8	1.0	3.4	8.0
		5†	3.35	28.28	73.42	23.00	31.71				
All modes		**6***	**14.02**	**34.74**	**62.96**	**15.22**	**37.27**	**7.3**	**1.0**	**12.8**	**60.0**
		6†	**14.33**	**35.48**	**64.29**	**15.53**	**38.05**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Instrument, general	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument, position	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Positioner	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
Total	83.33	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by application - PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Instrument, general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Instrument, position	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Positioner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Subunit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by application - PSD

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Faulty signal/indication/alarm	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
Total	83.33	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by application - PSD

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.9.1	Control and Safety Equipment Valves PSD Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.1084	0.1055	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.17**	**8.43**	**26.12**	**9.23**	**9.23**	**30.0**	**60.0**	**60.0**	**60.0**
	1†	**0.18**	**8.65**	**26.81**	**9.48**	**9.48**				
Fail to close on demand	1*	0.17	8.43	26.12	9.23	9.23	30.0	60.0	60.0	60.0
	1†	0.18	8.65	26.81	9.48	9.48				
Incipient	**4***	**1.18**	**30.42**	**91.68**	**31.14**	**36.91**	**3.3**	**2.0**	**4.0**	**8.0**
	4†	**1.13**	**31.18**	**94.16**	**32.14**	**37.91**				
Abnormal instrument reading	4*	1.18	30.42	91.68	31.14	36.91	3.3	2.0	4.0	8.0
	4†	1.13	31.18	94.16	32.14	37.91				
All modes	**5***	**1.09**	**37.00**	**112.56**	**38.93**	**46.14**	**8.6**	**2.0**	**15.2**	**60.0**
	5†	**1.05**	**37.92**	**115.69**	**40.18**	**47.38**				

Comments

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Taxonomy no	Item
4.4.9.1.1	Control and Safety Equipment Valves PSD Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	1	0.0454	0.0440	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.03	8.49 8.74	32.59 33.57	12.00 12.36	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.4.9.1.2	Control and Safety Equipment Valves PSD Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0227	0.0220	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**4***	**60.12**	**176.18**	**403.23**	**176.18**	**176.18**	**3.3**	**2.0**	**4.0**	**8.0**
	4†	**62.05**	**181.82**	**416.14**	**181.82**	**181.82**				
Abnormal instrument reading	4*	60.12	176.18	403.23	176.18	176.18	3.3	2.0	4.0	8.0
	4†	62.05	181.82	416.14	181.82	181.82				
All modes	**4***	**60.12**	**176.18**	**403.23**	**176.18**	**176.18**	**3.3**	**2.0**	**4.0**	**8.0**
	4†	**62.05**	**181.82**	**416.14**	**181.82**	**181.82**				

Comments

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Taxonomy no	Item
4.4.9.1.3	Control and Safety Equipment Valves PSD Ball (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0227	0.0220	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**2.20**	**44.05**	**208.99**	**44.05**	**44.05**	**30.0**	**60.0**	**60.0**	**60.0**
	1†	**2.27**	**45.45**	**215.68**	**45.45**	**45.45**				
Fail to close on demand	1*	2.20	44.05	208.99	44.05	44.05	30.0	60.0	60.0	60.0
	1†	2.27	45.45	215.68	45.45	45.45				
All modes	**1***	**2.20**	**44.05**	**208.99**	**44.05**	**44.05**	**30.0**	**60.0**	**60.0**	**60.0**
	1†	**2.27**	**45.45**	**215.68**	**45.45**	**45.45**				

Comments

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Taxonomy no	Item
4.4.9.1.4	Control and Safety Equipment Valves PSD Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.06	16.10	61.82	22.77	0.00	-	-	-	-
	0†	0.06	16.28	62.53	23.03	0.00				

Comments

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Taxonomy no	Item
4.4.9.2	Control and Safety Equipment Valves PSD Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
2	2	0.0526	0.0522	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.23**	**17.42**	**55.80**	**20.17**	**19.01**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.22**	**17.58**	**56.42**	**20.41**	**19.17**				
Abnormal instrument reading	1*	0.23	17.42	55.80	20.17	19.01	1.0	1.0	1.0	1:0
	1†	0.22	17.58	56.42	20.41	19.17				
All modes	**1***	**0.23**	**17.42**	**55.80**	**20.17**	**19.01**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.22**	**17.58**	**56.42**	**20.41**	**19.17**				

Comments

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Taxonomy no	Item
4.4.9.2.1	Control and Safety Equipment Valves PSD Gate (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0351	0.0346	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**1.43**	**28.52**	**135.32**	**28.52**	**28.52**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**1.44**	**28.87**	**136.98**	**28.87**	**28.87**				
Abnormal instrument reading	1*	1.43	28.52	135.32	28.52	28.52	1.0	1.0	1.0	1.0
	1†	1.44	28.87	136.98	28.87	28.87				
All modes	**1***	**1.43**	**28.52**	**135.32**	**28.52**	**28.52**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**1.44**	**28.87**	**136.98**	**28.87**	**28.87**				

Comments

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Taxonomy no	Item
4.4.9.2.2	Control and Safety Equipment Valves PSD Gate (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0175	0.0175	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.04	10.81	41.52	15.29	0.00	-	-	-	-
	0†	0.04	10.88	41.77	15.39	0.00				

Comments

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Taxonomy no	Item
4.4.10	Control and Safety Equipment Valves Relief

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
278	7	8.0979	7.1698	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**33***	**2.83**	**3.92**	**5.15**	**0.71**	**4.08**	**8.3**	**2.0**	**8.6**	**30.0**
	33†	**0.40**	**3.99**	**10.75**	**3.44**	**4.60**				
External leakage - Process medium	3*	0.06	0.65	1.75	0.56	0.37	8.5	2.0	13.3	30.0
	3†	0.04	1.00	3.00	1.02	0.42				
Fail to close on demand	4*	0.00	0.42	1.76	0.68	0.49	6.0	4.0	5.5	6.0
	4†	0.00	0.53	2.55	1.05	0.56				
Fail to open on demand	17*	0.06	1.40	4.22	1.43	2.10	9.0	5.0	9.0	30.0
	17†	0.16	1.68	4.61	1.49	2.37				
Spurious operation	1*	0.00	0.25	1.12	0.44	0.12	-	8.0	8.0	8.0
	1†	0.00	0.38	1.76	0.70	0.14				
Valve leakage in closed position	8*	0.02	0.77	2.37	0.83	0.99	7.6	6.0	7.6	15.0
	8†	0.07	0.92	2.62	0.86	1.12				
Degraded	**128***	**0.06**	**13.25**	**48.93**	**18.07**	**15.81**	**6.7**	**2.0**	**7.1**	**35.0**
	128†	**0.15**	**16.36**	**54.46**	**19.95**	**17.85**				
Delayed operation	4*	0.00	1.12	4.67	1.78	0.49	4.7	5.0	8.3	14.0
	4†	0.01	1.98	7.79	2.90	0.56				
External leakage - Process medium	1*	0.00	0.27	1.23	0.49	0.12	1.0	2.0	2.0	2.0
	1†	0.00	0.48	2.18	0.87	0.14				
Other	29*	0.00	4.38	24.34	12.55	3.58	4.5	2.0	4.8	14.0
	29†	0.00	4.58	26.20	14.11	4.04				
Spurious operation	72*	0.02	4.28	16.30	6.01	8.89	7.0	4.0	7.3	35.0
	72†	0.10	5.55	17.28	6.13	10.04				
Valve leakage in closed position	22*	0.00	3.62	18.93	8.50	2.72	9.2	2.0	9.3	24.0
	22†	0.00	4.18	21.67	9.56	3.07				
Incipient	**111***	**0.03**	**6.92**	**26.59**	**9.79**	**13.71**	**6.4**	**1.0**	**6.8**	**24.0**
	111†	**0.15**	**9.47**	**29.89**	**10.72**	**15.48**				
Delayed operation	2*	0.00	0.57	2.75	1.13	0.25	4.0	7.0	7.5	8.0
	2†	0.00	1.04	4.69	1.86	0.28				
Other	1*	0.00	0.25	1.12	0.44	0.12	-	24.0	24.0	24.0
	1†	0.00	0.38	1.76	0.70	0.14				
Spurious operation	7*	0.03	2.04	6.50	2.35	0.86	4.8	1.0	8.7	16.0
	7†	0.08	3.44	10.58	3.72	0.98				
Valve leakage in closed position	101*	0.00	3.83	21.56	11.39	12.47	6.5	2.0	6.5	14.0
	101†	0.00	4.53	24.90	12.04	14.09				
All modes	**272***	**3.03**	**23.29**	**59.45**	**18.49**	**33.59**	**6.8**	**1.0**	**7.2**	**35.0**
	272†	**6.90**	**30.17**	**66.90**	**19.13**	**37.94**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Relief

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Other valve components	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Seals	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Seat rings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.37	0.37	0.00	0.37	1.10	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	1.10	5.15	0.00	0.00	0.00
Valve body w/internals	0.00	1.84	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	2.21	1.47	0.00	1.47	6.25	0.00	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by application - Relief

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Other valve components	0.37	0.00	0.37	0.00	0.00	0.74	0.00	0.00	1.84
Seals	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
Seat rings	3.31	0.00	0.37	0.00	0.00	0.37	0.00	0.00	4.04
Subunit	5.15	0.00	10.29	0.00	0.00	1.10	0.00	0.00	18.75
Unknown	38.60	0.00	0.00	0.00	0.00	23.90	0.00	0.00	68.75
Valve body w/internals	0.37	0.00	0.00	0.00	0.00	3.31	0.00	0.00	5.88
Total	48.16	0.00	11.03	0.00	0.00	29.41	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Relief

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Breakage	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	1.10	0.00	0.37	0.00	0.00	0.00	0.00
Material failure - general	0.00	0.00	0.00	0.00	1.10	5.15	0.00	0.00	0.00
Mechanical Failure - general	0.00	1.84	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No cause found	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.37	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00
Total	0.00	2.21	1.47	0.00	1.47	6.25	0.00	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by application - Relief

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Breakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
Leakage	8.82	0.00	0.00	0.00	0.00	1.10	0.00	0.00	11.40
Material failure - general	38.60	0.00	0.00	0.00	0.00	23.90	0.00	0.00	68.75
Mechanical Failure - general	0.74	0.00	0.37	0.00	0.00	1.84	0.00	0.00	5.15
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	1.10
No cause found	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.37
Out of adjustment	0.00	0.00	10.29	0.00	0.00	0.74	0.00	0.00	11.76
Unknown	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.37
Wear	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.74
Total	48.16	0.00	11.03	0.00	0.00	29.41	0.00	0.00	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no	Item
4.4.10.1	Control and Safety Equipment Valves Relief Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
39	1	0.9724	0.9452	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**2.69**	**6.17**	**12.18**	**6.17**	**6.17**	**14.8**	**2.0**	**14.8**	**30.0**
	6†	**2.77**	**6.35**	**12.53**	**6.35**	**6.35**				
External leakage - Process medium	1*	0.05	1.03	4.88	1.03	1.03	2.0	2.0	2.0	2.0
	1†	0.05	1.06	5.02	1.06	1.06				
Fail to open on demand	3*	0.84	3.09	7.98	3.09	3.09	20.7	5.0	20.7	30.0
	3†	0.87	3.17	8.20	3.17	3.17				
Valve leakage in closed position	2*	0.37	2.06	6.47	2.06	2.06	12.5	10.0	12.5	15.0
	2†	0.38	2.12	6.66	2.12	2.12				
Degraded	**51***	**40.98**	**52.45**	**66.23**	**52.45**	**52.45**	**7.1**	**2.0**	**7.3**	**35.0**
	51†	**42.16**	**53.96**	**68.14**	**53.96**	**53.96**				
Other	29*	21.33	29.82	40.66	29.82	29.82	4.5	2.0	4.8	14.0
	29†	21.95	30.68	41.83	30.68	30.68				
Spurious operation	2*	0.37	2.06	6.47	2.06	2.06	21.0	7.0	21.0	35.0
	2†	0.38	2.12	6.66	2.12	2.12				
Valve leakage in closed position	20*	13.63	20.57	29.88	20.57	20.57	9.4	2.0	9.4	24.0
	20†	14.02	21.16	30.75	21.16	21.16				
All modes	**57***	**46.46**	**58.62**	**73.09**	**58.62**	**58.62**	**7.9**	**2.0**	**8.1**	**35.0**
	57†	**47.79**	**60.31**	**75.19**	**60.31**	**60.31**				

Comments

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Taxonomy no	Item
4.4.10.1.1	Control and Safety Equipment Valves Relief Gate (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
36	1	0.8936	0.8684	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**2.93**	**6.71**	**13.25**	**6.71**	**6.71**	**14.8**	**2.0**	**14.8**	**30.0**
	6†	**3.01**	**6.91**	**13.63**	**6.91**	**6.91**				
External leakage - Process medium	1*	0.06	1.12	5.31	1.12	1.12	2.0	2.0	2.0	2.0
	1†	0.06	1.15	5.46	1.15	1.15				
Fail to open on demand	3*	0.92	3.36	8.68	3.36	3.36	20.7	5.0	20.7	30.0
	3†	0.94	3.45	8.93	3.45	3.45				
Valve leakage in closed position	2*	0.40	2.24	7.04	2.24	2.24	12.5	10.0	12.5	15.0
	2†	0.41	2.30	7.25	2.30	2.30				
Degraded	**44***	**37.70**	**49.24**	**63.31**	**49.24**	**49.24**	**7.3**	**2.0**	**7.5**	**35.0**
	44†	**38.79**	**50.67**	**65.15**	**50.67**	**50.67**				
Other	27*	21.33	30.22	41.67	30.22	30.22	4.6	2.0	4.9	14.0
	27†	21.95	31.09	42.88	31.09	31.09				
Spurious operation	2*	0.40	2.24	7.04	2.24	2.24	21.0	7.0	21.0	35.0
	2†	0.41	2.30	7.25	2.30	2.30				
Valve leakage in closed position	15*	10.35	16.79	25.85	16.79	16.79	10.4	2.0	10.4	24.0
	15†	10.65	17.27	26.60	17.27	17.27				
All modes	**50***	**43.60**	**55.96**	**70.83**	**55.96**	**55.96**	**8.2**	**2.0**	**8.4**	**35.0**
	50†	**44.87**	**57.58**	**72.88**	**57.58**	**57.58**				

Comments

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Taxonomy no	Item
4.4.10.1.2	Control and Safety Equipment Valves Relief Gate (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.0788	0.0768	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**7***	**41.67**	**88.79**	**166.79**	**88.79**	**88.79**	**5.7**	**2.0**	**5.7**	**16.0**
	7†	**42.76**	**91.12**	**171.17**	**91.12**	**91.12**				
Other	2*	4.50	25.37	79.85	25.37	25.37	3.5	3.0	3.5	4.0
	2†	4.62	26.03	81.94	26.03	26.03				
Valve leakage in closed position	5*	24.99	63.42	133.37	63.42	63.42	6.6	2.0	6.6	16.0
	5†	25.64	65.08	136.87	65.08	65.08				
All modes	**7***	**41.67**	**88.79**	**166.79**	**88.79**	**88.79**	**5.7**	**2.0**	**5.7**	**16.0**
	7†	**42.76**	**91.12**	**171.17**	**91.12**	**91.12**				

Comments

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Taxonomy no		Item
4.4.10.2		Control and Safety Equipment Valves Relief Globe

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1478	0.1074	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.02	2.95 4.03	11.34 15.48	4.18 5.70	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.4.10.2.1	Control and Safety Equipment Valves Relief Globe (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
3	1	0.1478	0.1074	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.01 0.01	1.58 2.16	6.05 8.30	2.23 3.06	0.00 0.00	-	-	-	-

Comments

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Taxonomy no	Item
4.4.10.3	Control and Safety Equipment Valves Relief PSV - Conventional

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
170	2	5.1485	4.8847	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**23***	**0.42**	**3.84**	**10.15**	**3.21**	**4.47**	**6.3**	**5.0**	**6.3**	**11.0**
	23†	**0.45**	**4.05**	**10.70**	**3.39**	**4.71**				
Fail to close on demand	3*	0.09	0.57	1.38	0.42	0.58	6.0	6.0	6.0	6.0
	3†	0.10	0.60	1.46	0.44	0.61				
Fail to open on demand	14*	0.32	2.46	6.29	1.96	2.72	6.5	5.0	6.5	11.0
	14†	0.33	2.59	6.63	2.06	2.87				
Valve leakage in closed position	6*	0.17	1.11	2.74	0.84	1.17	6.0	6.0	6.0	6.0
	6†	0.18	1.17	2.89	0.88	1.23				
Degraded	**65***	**7.43**	**11.94**	**17.31**	**3.03**	**12.63**	**6.6**	**4.0**	**6.6**	**16.0**
	65†	**7.80**	**12.57**	**18.27**	**3.21**	**13.31**				
Spurious operation	65*	7.43	11.94	17.31	3.03	12.63	6.6	4.0	6.6	16.0
	65†	7.80	12.57	18.27	3.21	13.31				
Incipient	**99***	**4.11**	**15.29**	**32.29**	**8.93**	**19.23**	**6.6**	**2.0**	**6.6**	**14.0**
	99†	**4.32**	**16.11**	**34.04**	**9.42**	**20.27**				
Valve leakage in closed position	99*	4.11	15.29	32.29	8.93	19.23	6.6	2.0	6.6	14.0
	99†	4.32	16.11	34.04	9.42	20.27				
All modes	**187***	**2.06**	**23.99**	**66.77**	**21.72**	**36.32**	**6.5**	**2.0**	**6.5**	**16.0**
	187†	**2.17**	**25.28**	**70.38**	**22.90**	**38.28**				

Comments

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Taxonomy no	Item
4.4.10.3.1	Control and Safety Equipment Valves Relief PSV - Conventional (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
148	2	4.4737	4.2445	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**22***	**0.44**	**4.18**	**11.15**	**3.55**	**4.92**	**6.3**	**5.0**	**6.3**	**11.0**
	22†	**0.47**	**4.41**	**11.75**	**3.74**	**5.18**				
Fail to close on demand	3*	0.10	0.65	1.59	0.48	0.67	6.0	6.0	6.0	6.0
	3†	0.11	0.69	1.68	0.51	0.71				
Fail to open on demand	14*	0.34	2.79	7.22	2.26	3.13	6.5	5.0	6.5	11.0
	14†	0.36	2.94	7.61	2.38	3.30				
Valve leakage in closed position	5*	0.16	1.07	2.64	0.81	1.12	6.0	6.0	6.0	6.0
	5†	0.17	1.13	2.78	0.85	1.18				
Degraded	**58***	**7.02**	**12.10**	**18.29**	**3.46**	**12.96**	**6.4**	**4.0**	**6.4**	**12.0**
	58†	**7.38**	**12.74**	**19.29**	**3.66**	**13.66**				
Spurious operation	58*	7.02	12.10	18.29	3.46	12.96	6.4	4.0	6.4	12.0
	58†	7.38	12.74	19.29	3.66	13.66				
Incipient	**97***	**3.52**	**16.54**	**37.47**	**10.88**	**21.68**	**6.4**	**2.0**	**6.4**	**13.0**
	97†	**3.70**	**17.43**	**39.51**	**11.47**	**22.85**				
Valve leakage in closed position	97*	3.52	16.54	37.47	10.88	21.68	6.4	2.0	6.4	13.0
	97†	3.70	17.43	39.51	11.47	22.85				
All modes	**177***	**1.86**	**25.66**	**73.44**	**24.16**	**39.56**	**6.4**	**2.0**	**6.4**	**13.0**
	177†	**1.96**	**27.04**	**77.42**	**25.48**	**41.70**				

Comments

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Taxonomy no	Item
4.4.10.3.2	Control and Safety Equipment Valves Relief PSV - Conventional (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.2454	0.2328	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.20**	**4.08**	**19.34**	**4.08**	**4.08**	**6.0**	**6.0**	**6.0**	**6.0**
	1†	**0.21**	**4.30**	**20.38**	**4.30**	**4.30**				
Valve leakage in closed position	1*	0.20	4.08	19.34	4.08	4.08	6.0	6.0	6.0	6.0
	1†	0.21	4.30	20.38	4.30	4.30				
Degraded	**7***	**13.39**	**28.53**	**53.59**	**28.53**	**28.53**	**8.0**	**6.0**	**8.0**	**16.0**
	7†	**14.11**	**30.07**	**56.49**	**30.07**	**30.07**				
Spurious operation	7*	13.39	28.53	53.59	28.53	28.53	8.0	6.0	8.0	16.0
	7†	14.11	30.07	56.49	30.07	30.07				
Incipient	**2***	**1.45**	**8.15**	**25.65**	**8.15**	**8.15**	**13.5**	**13.0**	**13.5**	**14.0**
	2†	**1.52**	**8.59**	**27.04**	**8.59**	**8.59**				
Valve leakage in closed position	2*	1.45	8.15	25.65	8.15	8.15	13.5	13.0	13.5	14.0
	2†	1.52	8.59	27.04	8.59	8.59				
All modes	**10***	**22.11**	**40.75**	**69.12**	**40.75**	**40.75**	**8.9**	**6.0**	**8.9**	**16.0**
	10†	**23.30**	**42.96**	**72.85**	**42.96**	**42.96**				

Comments

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Taxonomy no		Item
4.4.10.3.3		Control and Safety Equipment Valves Relief PSV - Conventional Unknown

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
14	1	0.4294	0.4074	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.00	1.11	4.26	1.57	0.00	-	-	-	-
	0†	0.00	1.17	4.49	1.66	0.00				

Comments

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Taxonomy no	Item
4.4.10.4	Control and Safety Equipment Valves Relief PSV - Conventional w/bellows

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
32	2	0.6747	0.4284	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.03**	**1.35**	**4.19**	**1.48**	**1.48**	**15.0**	**30.0**	**30.0**	**30.0**
	1†	**0.02**	**2.17**	**7.34**	**2.70**	**2.33**				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	15.0	30.0	30.0	30.0
	1†	0.02	2.17	7.34	2.70	2.33				
Degraded	**7***	**0.71**	**8.38**	**23.41**	**7.63**	**10.38**	**5.4**	**2.0**	**10.6**	**30.0**
	7†	**0.15**	**14.03**	**45.69**	**16.63**	**16.34**				
Delayed operation	3*	0.92	4.05	8.97	2.57	4.45	4.7	5.0	9.0	14.0
	3†	0.62	6.40	17.36	5.58	7.00				
External leakage - Process medium	1*	0.03	1.35	4.19	1.48	1.48	1.0	2.0	2.0	2.0
	1†	0.02	2.17	7.34	2.70	2.33				
Spurious operation	2*	0.05	2.57	7.98	2.83	2.96	9.5	7.0	18.5	30.0
	2†	0.68	4.39	10.82	3.30	4.67				
Valve leakage in closed position	1*	0.03	1.35	4.19	1.48	1.48	4.0	8.0	8.0	8.0
	1†	0.02	2.17	7.34	2.70	2.33				
Incipient	**5***	**1.06**	**6.38**	**15.39**	**4.64**	**7.41**	**5.2**	**6.0**	**10.2**	**16.0**
	5†	**0.21**	**10.21**	**31.62**	**11.17**	**11.67**				
Delayed operation	2*	0.05	2.57	7.98	2.83	2.96	4.0	7.0	7.5	8.0
	2†	0.68	4.39	10.82	3.30	4.67				
Spurious operation	3*	0.92	4.05	8.97	2.57	4.45	6.0	6.0	12.0	16.0
	3†	0.62	6.40	17.36	5.58	7.00				
All modes	**13***	**0.22**	**14.39**	**45.37**	**16.26**	**19.27**	**6.1**	**2.0**	**11.9**	**30.0**
	13†	**0.16**	**25.48**	**89.11**	**32.89**	**30.35**				

Comments

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Taxonomy no	Item
4.4.10.4.1	Control and Safety Equipment Valves Relief PSV - Conventional w/bellows (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
25	2	0.5158	0.3394	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**5***	**0.47**	**8.26**	**24.40**	**8.12**	**9.69**	**4.4**	**5.0**	**8.4**	**14.0**
	5†	**0.11**	**14.51**	**49.42**	**18.19**	**14.73**				
Delayed operation	3*	0.99	5.32	12.47	3.70	5.82	4.7	5.0	9.0	14.0
	3†	0.13	8.73	27.61	9.91	8.84				
Spurious operation	1*	0.02	1.78	5.73	2.08	1.94	4.0	7.0	7.0	7.0
	1†	0.01	2.92	11.09	4.09	2.95				
Valve leakage in closed position	1*	0.02	1.78	5.73	2.08	1.94	4.0	8.0	8.0	8.0
	1†	0.01	2.92	11.09	4.09	2.95				
Incipient	**5***	**0.47**	**8.26**	**24.40**	**8.12**	**9.69**	**5.2**	**6.0**	**10.2**	**16.0**
	5†	**0.11**	**14.51**	**49.42**	**18.19**	**14.73**				
Delayed operation	2*	0.53	3.59	8.93	2.74	3.88	4.0	7.0	7.5	8.0
	2†	0.36	5.84	17.08	5.66	5.89				
Spurious operation	3*	0.99	5.32	12.47	3.70	5.82	6.0	6.0	12.0	16.0
	3†	0.13	8.73	27.61	9.91	8.84				
All modes	**10***	**0.16**	**15.60**	**51.09**	**18.64**	**19.39**	**4.8**	**5.0**	**9.3**	**16.0**
	10†	**0.15**	**28.96**	**104.71**	**38.69**	**29.46**				

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Taxonomy no	Item
4.4.10.4.2	Control and Safety Equipment Valves Relief PSV - Conventional w/bellows (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	1	0.1589	0.0890	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.31**	**6.29**	**29.86**	**6.29**	**6.29**	**15.0**	**30.0**	**30.0**	**30.0**
	1†	**0.56**	**11.24**	**53.31**	**11.24**	**11.24**				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
Degraded	**2***	**2.23**	**12.58**	**39.61**	**12.58**	**12.58**	**8.0**	**2.0**	**16.0**	**30.0**
	2†	**3.99**	**22.47**	**70.73**	**22.47**	**22.47**				
External leakage - Process medium	1*	0.31	6.29	29.86	6.29	6.29	1.0	2.0	2.0	2.0
	1†	0.56	11.24	53.31	11.24	11.24				
Spurious operation	1*	0.31	6.29	29.86	6.29	6.29	15.0	30.0	30.0	30.0
	1†	0.56	11.24	53.31	11.24	11.24				
All modes	**3***	**5.16**	**18.88**	**48.80**	**18.88**	**18.88**	**10.3**	**2.0**	**20.7**	**30.0**
	3†	**9.21**	**33.71**	**87.13**	**33.71**	**33.71**				

Comments

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Taxonomy no	Item
4.4.10.5	Control and Safety Equipment Valves Relief PSV - Pilot operated

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
34	3	1.1545	0.8041	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.19**	**2.27**	**6.35**	**2.07**	**2.60**	-	**4.0**	**6.7**	**8.0**
	3†	**0.07**	**3.28**	**10.16**	**3.60**	**3.73**				
External leakage - Process medium	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Fail to close on demand	1*	0.00	0.77	2.80	1.03	0.87	-	4.0	4.0	4.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Degraded	**5***	**0.02**	**3.44**	**12.07**	**4.46**	**4.33**	**3.0**	**4.0**	**6.6**	**10.0**
	5†	**0.02**	**5.15**	**19.53**	**7.20**	**6.22**				
Delayed operation	1*	0.00	0.77	2.80	1.03	0.87	-	6.0	6.0	6.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	3*	0.19	2.27	6.35	2.07	2.60	3.0	4.0	6.3	10.0
	3†	0.07	3.28	10.16	3.60	3.73				
Valve leakage in closed position	1*	0.00	0.77	2.80	1.03	0.87	-	8.0	8.0	8.0
	1†	0.00	1.13	4.39	1.63	1.24				
Incipient	**7***	**0.66**	**5.26**	**13.50**	**4.21**	**6.06**	**2.0**	**1.0**	**8.0**	**24.0**
	7†	**0.56**	**7.79**	**22.35**	**7.36**	**8.71**				
Other	1*	0.00	0.77	2.80	1.03	0.87	-	24.0	24.0	24.0
	1†	0.00	1.13	4.39	1.63	1.24				
Spurious operation	4*	0.33	3.16	8.45	2.69	3.46	1.0	1.0	6.3	14.0
	4†	1.59	4.83	9.51	2.49	4.97				
Valve leakage in closed position	2*	0.23	1.59	3.98	1.22	1.73	3.0	2.0	3.5	5.0
	2†	0.35	2.33	5.75	1.76	2.49				
All modes	**15***	**0.05**	**9.89**	**36.61**	**13.52**	**12.99**	**2.3**	**1.0**	**7.3**	**24.0**
	15†	**0.06**	**15.29**	**58.36**	**21.51**	**18.65**				

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Taxonomy no	Item
4.4.10.5.1	Control and Safety Equipment Valves Relief PSV - Pilot operated (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
17	2	0.3461	0.2896	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Incipient	**1***	**0.02**	**5.01**	**19.02**	**7.01**	**2.89**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.03**	**11.05**	**43.51**	**16.20**	**3.45**				
Spurious operation	1*	0.02	5.01	19.02	7.01	2.89	1.0	1.0	1.0	1.0
	1†	0.03	11.05	43.51	16.20	3.45				
All modes	**1***	**0.02**	**5.01**	**19.02**	**7.01**	**2.89**	**1.0**	**1.0**	**1.0**	**1.0**
	1†	**0.03**	**11.05**	**43.51**	**16.20**	**3.45**				

Comments

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Taxonomy no	Item
4.4.10.5.2	Control and Safety Equipment Valves Relief PSV - Pilot operated (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
17	2	0.8083	0.5145	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**3***	**0.79**	**3.40**	**7.51**	**2.14**	**3.71**	-	**4.0**	**6.7**	**8.0**
	3†	**1.25**	**5.35**	**11.81**	**3.37**	**5.83**				
External leakage - Process medium	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
Fail to close on demand	1*	0.02	1.13	3.55	1.27	1.24	-	4.0	4.0	4.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
Degraded	**5***	**0.46**	**5.24**	**14.51**	**4.71**	**6.19**	**3.0**	**4.0**	**6.6**	**10.0**
	5†	**0.71**	**8.23**	**22.89**	**7.44**	**9.72**				
Delayed operation	1*	0.02	1.13	3.55	1.27	1.24	-	6.0	6.0	6.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	3*	0.79	3.40	7.51	2.14	3.71	3.0	4.0	6.3	10.0
	3†	1.25	5.35	11.81	3.37	5.83				
Valve leakage in closed position	1*	0.02	1.13	3.55	1.27	1.24	-	8.0	8.0	8.0
	1†	0.03	1.78	5.58	1.99	1.94				
Incipient	**6***	**0.35**	**6.14**	**18.11**	**6.02**	**7.42**	**3.0**	**2.0**	**9.2**	**24.0**
	6†	**0.54**	**9.64**	**28.56**	**9.51**	**11.66**				
Other	1*	0.02	1.13	3.55	1.27	1.24	-	24.0	24.0	24.0
	1†	0.03	1.78	5.58	1.99	1.94				
Spurious operation	3*	0.79	3.40	7.51	2.14	3.71	-	4.0	8.0	14.0
	3†	1.25	5.35	11.81	3.37	5.83				
Valve leakage in closed position	2*	0.02	2.15	6.97	2.53	2.47	3.0	2.0	3.5	5.0
	2†	0.04	3.38	10.97	3.99	3.89				
All modes	**14***	**0.12**	**13.30**	**44.34**	**16.25**	**17.32**	**3.0**	**2.0**	**7.7**	**24.0**
	14†	**0.18**	**20.93**	**69.88**	**25.62**	**27.21**				

Comments

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Taxonomy no	Item
4.4.11	Control and Safety Equipment Valves Shut-off

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
67	5	1.3664	1.3404	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**11***	**3.86**	**7.34**	**11.74**	**2.43**	**8.05**	**14.0**	**2.0**	**14.5**	**37.0**
	11†	**3.93**	**7.49**	**11.96**	**2.47**	**8.21**				
Fail to close on demand	6*	0.35	3.54	9.62	3.09	4.39	14.2	2.0	13.2	37.0
	6†	0.36	3.61	9.80	3.15	4.48				
Fail to open on demand	5*	0.29	3.06	8.36	2.69	3.66	13.8	10.0	16.2	26.0
	5†	0.30	3.12	8.49	2.73	3.73				
Degraded	**18***	**0.39**	**19.70**	**61.13**	**21.63**	**13.17**	**24.0**	**2.0**	**13.6**	**70.0**
	18†	**0.40**	**20.38**	**63.26**	**22.39**	**13.43**				
Abnormal instrument reading	1*	0.01	0.94	3.12	1.14	0.73	-	6.0	6.0	6.0
	1†	0.01	0.95	3.07	1.11	0.75				
External leakage - Process medium	2*	0.00	4.04	17.18	6.62	1.46	-	2.0	2.0	2.0
	2†	0.00	4.21	17.80	6.84	1.49				
External leakage - Utility medium	5*	0.29	3.06	8.36	2.69	3.66	27.3	7.0	22.5	62.0
	5†	0.30	3.12	8.49	2.73	3.73				
Internal leakage	2*	0.01	1.47	5.58	2.06	1.46	12.0	4.0	9.5	15.0
	2†	0.01	1.49	5.58	2.06	1.49				
Other	4*	0.01	8.58	35.97	13.76	2.93	-	2.0	2.0	2.0
	4†	0.01	8.96	37.28	14.21	2.98				
Spurious operation	1*	0.01	0.63	2.02	0.73	0.73	14.0	14.0	14.0	14.0
	1†	0.01	0.64	2.06	0.75	0.75				
Structural deficiency	1*	0.00	1.78	7.79	3.04	0.73	-	6.0	6.0	6.0
	1†	0.00	1.85	8.08	3.15	0.75				
Unknown	1*	0.01	0.63	2.02	0.73	0.73	2.0	2.0	2.0	2.0
	1†	0.01	0.64	2.06	0.75	0.75				
Valve leakage in closed position	1*	0.01	0.63	2.02	0.73	0.73	58.0	70.0	70.0	70.0
	1†	0.01	0.64	2.06	0.75	0.75				
Incipient	**7***	**0.82**	**3.97**	**9.07**	**2.64**	**5.12**	**7.3**	**2.0**	**7.3**	**29.0**
	7†	**0.76**	**4.02**	**9.38**	**2.77**	**5.22**				
Abnormal instrument reading	7*	0.82	3.97	9.07	2.64	5.12	7.3	2.0	7.3	29.0
	7†	0.76	4.02	9.38	2.77	5.22				
Unknown	**2***	**0.09**	**1.22**	**3.46**	**1.14**	**1.46**	**40.0**	**51.0**	**57.5**	**64.0**
	2†	**0.09**	**1.24**	**3.54**	**1.16**	**1.49**				
Unknown	2*	0.09	1.22	3.46	1.14	1.46	40.0	51.0	57.5	64.0
	2†	0.09	1.24	3.54	1.16	1.49				
All modes	**38***	**3.60**	**26.65**	**67.54**	**20.93**	**27.81**	**17.0**	**2.0**	**15.1**	**70.0**
	38†	**3.54**	**27.39**	**70.00**	**21.78**	**28.35**				

Comments

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Shut-off

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Actuating device	15.79	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00
Bonnet	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
Cabling & junction boxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Control unit	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other actuator components	0.00	0.00	0.00	2.63	0.00	2.63	0.00	0.00	0.00
Other valve components	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00	5.26
Packing	0.00	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.00
Subunit	0.00	0.00	0.00	0.00	10.53	7.89	0.00	0.00	0.00
Unknown	2.63	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
Valve body w/internals	0.00	0.00	2.63	0.00	2.63	0.00	0.00	0.00	0.00
Total	21.05	0.00	5.26	13.16	15.79	13.16	0.00	0.00	5.26

Maintainable item versus failure mode, continued
Item: Valves described by application - Shut-off

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Actuating device	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	21.05
Bonnet	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	3.95
Cabling & junction boxes	0.00	0.00	10.53	0.00	0.00	0.00	0.00	0.00	10.53
Closure member (Ball/gate/disc/etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Control unit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Other actuator components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Other valve components	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89
Packing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Subunit	2.63	0.00	0.00	0.00	0.00	0.00	0.00	5.26	26.32
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	7.89
Valve body w/internals	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	6.58
Total	2.63	0.00	10.53	0.00	0.00	2.63	2.63	7.89	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

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Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Shut-off

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Control failure	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Faulty signal/indication/alarm	7.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	7.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	10.53	0.00	0.00	0.00	0.00	2.63
Material failure - general	0.00	0.00	5.26	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	2.63	13.16	5.26	0.00	0.00	0.00
No signal/indication/alarm	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Out of adjustment	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Wear	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00
Total	21.05	0.00	5.26	13.16	15.79	13.16	0.00	0.00	5.26

Failure descriptior versus failure mode, continued
Item: Valves described by application - Shut-off

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Control failure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Corrosion	0.00	0.00	10.53	0.00	0.00	0.00	2.63	0.00	15.79
Faulty signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89
Instrument failure - general	0.00	0.00	0.00	0.00	0.00	2.63	0.00	2.63	13.16
Leakage	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.79
Material failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26
Mechanical Failure - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	23.68
No signal/indication/alarm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	5.26
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Total	2.63	0.00	10.53	0.00	0.00	2.63	2.63	7.89	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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Taxonomy no
4.4.11.1

Item
Control and Safety Equipment
Valves
Shut-off
Ball

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time * 0.9808	Operational time † 0.9634	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**10***	**3.19**	**9.13**	**17.55**	**4.49**	**10.20**	**13.8**	**2.0**	**14.4**	**37.0**
	10†	**3.20**	**9.29**	**17.96**	**4.62**	**10.38**				
Fail to close on demand	5*	0.31	4.39	12.60	4.15	5.10	13.8	2.0	12.6	37.0
	5†	0.33	4.47	12.79	4.21	5.19				
Fail to open on demand	5*	0.31	4.39	12.60	4.15	5.10	13.8	10.0	16.2	26.0
	5†	0.33	4.47	12.79	4.21	5.19				
Degraded	**16***	**1.74**	**27.94**	**81.69**	**27.08**	**16.31**	**19.8**	**2.0**	**10.6**	**70.0**
	16†	**1.79**	**28.97**	**84.76**	**28.10**	**16.61**				
Abnormal instrument reading	1*	0.00	1.51	6.03	2.25	1.02	-	6.0	6.0	6.0
	1†	0.00	1.52	6.02	2.25	1.04				
External leakage - Process medium	2*	0.01	5.44	21.86	8.21	2.04	-	2.0	2.0	2.0
	2†	0.01	5.69	22.73	8.51	2.08				
External leakage - Utility medium	3*	0.03	2.90	9.41	3.42	3.06	13.0	8.0	10.5	13.0
	3†	0.04	2.95	9.48	3.43	3.11				
Internal leakage	2*	0.00	2.21	8.94	3.37	2.04	12.0	4.0	9.5	15.0
	2†	0.00	2.23	8.98	3.37	2.08				
Other	4*	0.03	11.71	45.85	17.03	4.08	-	2.0	2.0	2.0
	4†	0.04	12.27	47.62	17.62	4.15				
Spurious operation	1*	0.01	0.89	2.83	1.02	1.02	14.0	14.0	14.0	14.0
	1†	0.01	0.90	2.88	1.04	1.04				
Structural deficiency	1*	0.00	2.36	9.88	3.78	1.02	-	6.0	6.0	6.0
	1†	0.00	2.46	10.29	3.93	1.04				
Unknown	1*	0.01	0.89	2.83	1.02	1.02	2.0	2.0	2.0	2.0
	1†	0.01	0.90	2.88	1.04	1.04				
Valve leakage in closed position	1*	0.01	0.89	2.83	1.02	1.02	58.0	70.0	70.0	70.0
	1†	0.01	0.90	2.88	1.04	1.04				
Incipient	**7***	**0.11**	**4.99**	**15.38**	**5.41**	**7.14**	**7.3**	**2.0**	**7.3**	**29.0**
	7†	**0.10**	**5.07**	**15.76**	**5.59**	**7.27**				
Abnormal instrument reading	7*	0.11	4.99	15.38	5.41	7.14	7.3	2.0	7.3	29.0
	7†	0.10	5.07	15.76	5.59	7.27				
All modes	**33***	**7.44**	**37.48**	**86.54**	**25.42**	**33.65**	**13.0**	**2.0**	**11.1**	**70.0**
	33†	**7.39**	**38.59**	**89.91**	**26.55**	**34.25**				

Comments

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Taxonomy no		Item
4.4.11.1.1		Control and Safety Equipment Valves Shut-off Ball (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	1	0.2098	0.2049	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**1.69**	**9.53**	**30.00**	**9.53**	**9.53**	**10.5**	**10.0**	**11.5**	**13.0**
	2†	**1.73**	**9.76**	**30.73**	**9.76**	**9.76**				
Fail to close on demand	1*	0.24	4.77	22.62	4.77	4.77	13.0	13.0	13.0	13.0
	1†	0.24	4.88	23.16	4.88	4.88				
Fail to open on demand	1*	0.24	4.77	22.62	4.77	4.77	8.0	10.0	10.0	10.0
	1†	0.24	4.88	23.16	4.88	4.88				
Incipient	**4***	**6.51**	**19.07**	**43.64**	**19.07**	**19.07**	**2.5**	**2.0**	**2.5**	**3.0**
	4†	**6.66**	**19.53**	**44.69**	**19.53**	**19.53**				
Abnormal instrument reading	4*	6.51	19.07	43.64	19.07	19.07	2.5	2.0	2.5	3.0
	4†	6.66	19.53	44.69	19.53	19.53				
All modes	**6***	**12.46**	**28.60**	**56.43**	**28.60**	**28.60**	**5.2**	**2.0**	**5.5**	**13.0**
	6†	**12.76**	**29.29**	**57.79**	**29.29**	**29.29**				

Comments

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Taxonomy no	Item
4.4.11.1.2	Control and Safety Equipment Valves Shut-off Ball (5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
12	1	0.3149	0.3073	

Failure mode	No of failures	Failure rate (per 10^6 hours)					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**6***	**8.30**	**19.05**	**37.60**	**19.05**	**19.05**	**14.8**	**2.0**	**15.7**	**37.0**
	6†	**8.51**	**19.53**	**38.53**	**19.53**	**19.53**				
Fail to close on demand	3*	2.60	9.53	24.62	9.53	9.53	14.0	2.0	14.0	37.0
	3†	2.67	9.76	25.24	9.76	9.76				
Fail to open on demand	3*	2.60	9.53	24.62	9.53	9.53	15.7	10.0	17.3	26.0
	3†	2.67	9.76	25.24	9.76	9.76				
Degraded	**5***	**6.26**	**15.88**	**33.39**	**15.88**	**15.88**	**21.3**	**2.0**	**25.0**	**70.0**
	5†	**6.41**	**16.27**	**34.22**	**16.27**	**16.27**				
External leakage - Utility medium	2*	1.13	6.35	19.99	6.35	6.35	13.0	13.0	13.0	13.0
	2†	1.16	6.51	20.49	6.51	6.51				
Internal leakage	1*	0.16	3.18	15.07	3.18	3.18	12.0	15.0	15.0	15.0
	1†	0.16	3.25	15.44	3.25	3.25				
Unknown	1*	0.16	3.18	15.07	3.18	3.18	2.0	2.0	2.0	2.0
	1†	0.16	3.25	15.44	3.25	3.25				
Valve leakage in closed position	1*	0.16	3.18	15.07	3.18	3.18	58.0	70.0	70.0	70.0
	1†	0.16	3.25	15.44	3.25	3.25				
Incipient	**3***	**2.60**	**9.53**	**24.62**	**9.53**	**9.53**	**13.7**	**4.0**	**13.7**	**29.0**
	3†	**2.67**	**9.76**	**25.24**	**9.76**	**9.76**				
Abnormal instrument reading	3*	2.60	9.53	24.62	9.53	9.53	13.7	4.0	13.7	29.0
	3†	2.67	9.76	25.24	9.76	9.76				
All modes	**14***	**26.87**	**44.45**	**69.49**	**44.45**	**44.45**	**16.5**	**2.0**	**18.1**	**70.0**
	14†	**27.54**	**45.56**	**71.21**	**45.56**	**45.56**				

Comments

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Taxonomy no	Item
4.4.11.1.3	Control and Safety Equipment Valves Shut-off Ball (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**14.0**	**14.0**	**14.0**	**14.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				
Spurious operation	1*	1.90	38.05	180.56	38.05	38.05	14.0	14.0	14.0	14.0
	1†	1.95	39.05	185.29	39.05	39.05				
All modes	**1***	**1.90**	**38.05**	**180.56**	**38.05**	**38.05**	**14.0**	**14.0**	**14.0**	**14.0**
	1†	**1.95**	**39.05**	**185.29**	**39.05**	**39.05**				

Comments

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Taxonomy no	Item
4.4.11.1.4	Control and Safety Equipment Valves Shut-off Ball (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
15	3	0.2719	0.2716	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**2***	**0.04**	**6.42**	**22.30**	**8.23**	**7.36**	-	**8.0**	**13.5**	**19.0**
	2†	**0.04**	**6.43**	**22.33**	**8.24**	**7.36**				
Fail to close on demand	1*	0.03	3.38	11.23	4.11	3.68	-	8.0	8.0	8.0
	1†	0.03	3.39	11.25	4.12	3.68				
Fail to open on demand	1*	0.03	3.38	11.23	4.11	3.68	-	19.0	19.0	19.0
	1†	0.03	3.39	11.25	4.12	3.68				
Degraded	**6***	**1.75**	**38.01**	**114.04**	**38.30**	**22.07**	-	**2.0**	**4.0**	**8.0**
	6†	**1.75**	**38.10**	**114.32**	**38.39**	**22.09**				
Abnormal instrument reading	1*	0.03	3.38	11.23	4.11	3.68	-	6.0	6.0	6.0
	1†	0.03	3.39	11.25	4.12	3.68				
External leakage - Process medium	1*	0.04	9.31	35.63	13.13	3.68	-	2.0	2.0	2.0
	1†	0.04	9.34	35.71	13.16	3.68				
External leakage - Utility medium	1*	0.03	3.38	11.23	4.11	3.68	-	8.0	8.0	8.0
	1†	0.03	3.39	11.25	4.12	3.68				
Internal leakage	1*	0.03	3.38	11.23	4.11	3.68	-	4.0	4.0	4.0
	1†	0.03	3.39	11.25	4.12	3.68				
Other	2*	0.13	21.58	75.81	27.99	7.36	-	2.0	2.0	2.0
	2†	0.13	21.64	75.98	28.05	7.36				
All modes	**8***	**3.58**	**41.89**	**116.72**	**37.99**	**29.42**	-	**2.0**	**6.4**	**19.0**
	8†	**3.59**	**41.99**	**117.01**	**38.08**	**29.46**				

Comments

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Taxonomy no	Item
4.4.11.1.5	Control and Safety Equipment Valves Shut-off Ball (30.1-40) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
8	2	0.1579	0.1541	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Degraded	**4***	**0.16**	**36.40**	**136.13**	**50.24**	**25.34**	-	**2.0**	**3.3**	**6.0**
	4†	**0.17**	**39.12**	**147.19**	**54.30**	**25.96**				
External leakage - Process medium	1*	0.08	7.91	26.00	9.49	6.33	-	-	-	-
	1†	0.07	8.48	28.71	10.56	6.49				
Other	2*	0.09	17.41	62.94	23.26	12.67	-	2.0	2.0	2.0
	2†	0.09	18.69	68.48	25.30	12.98				
Structural deficiency	1*	0.08	7.91	26.00	9.49	6.33	-	6.0	6.0	6.0
	1†	0.07	8.48	28.71	10.56	6.49				
All modes	**4***	**0.16**	**36.40**	**136.13**	**50.24**	**25.34**	-	**2.0**	**3.3**	**6.0**
	4†	**0.17**	**39.12**	**147.19**	**54.30**	**25.96**				

Comments

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Taxonomy no	Item
4.4.11.2	Control and Safety Equipment Valves Shut-off Gate

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
23	4	0.3856	0.3770	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.03**	**2.26**	**7.20**	**2.59**	**2.59**	**16.0**	**16.0**	**16.0**	**16.0**
	1†	**0.03**	**2.32**	**7.36**	**2.65**	**2.65**				
Fail to close on demand	1*	0.03	2.26	7.20	2.59	2.59	16.0	16.0	16.0	16.0
	1†	0.03	2.32	7.36	2.65	2.65				
Degraded	**2***	**0.28**	**4.38**	**12.76**	**4.23**	**5.19**	**34.5**	**7.0**	**34.5**	**62.0**
	2†	**0.28**	**4.47**	**13.09**	**4.34**	**5.31**				
External leakage - Utility medium	2*	0.28	4.38	12.76	4.23	5.19	34.5	7.0	34.5	62.0
	2†	0.28	4.47	13.09	4.34	5.31				
Unknown	**2***	**0.28**	**4.38**	**12.76**	**4.23**	**5.19**	**40.0**	**51.0**	**57.5**	**64.0**
	2†	**0.28**	**4.47**	**13.09**	**4.34**	**5.31**				
Unknown	2*	0.28	4.38	12.76	4.23	5.19	40.0	51.0	57.5	64.0
	2†	0.28	4.47	13.09	4.34	5.31				
All modes	**5***	**3.74**	**11.32**	**22.22**	**5.80**	**12.97**	**33.0**	**7.0**	**40.0**	**64.0**
	5†	**3.82**	**11.58**	**22.73**	**5.93**	**13.26**				

Comments

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Taxonomy no	Item
4.4.11.2.1	Control and Safety Equipment Valves Shut-off Gate (1.1-5.0) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
1	1	0.0263	0.0256	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0* 0†	0.03 0.03	7.10 7.27	27.25 27.91	10.03 10.28	0.00 0.00	-	-	-	-

Comments

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Taxonomy no
4.4.11.2.2

Item
Control and Safety Equipment
Valves
Shut-off
Gate
(5.1-10) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
7	2	0.1314	0.1278	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Critical	**1***	**0.14**	**6.92**	**21.49**	**7.61**	**7.61**	**16.0**	**16.0**	**16.0**	**16.0**
	1†	**0.14**	**7.11**	**22.08**	**7.82**	**7.82**				
Fail to close on demand	1*	0.14	6.92	21.49	7.61	7.61	16.0	16.0	16.0	16.0
	1†	0.14	7.11	22.08	7.82	7.82				
Degraded	**2***	**0.60**	**13.32**	**39.98**	**13.45**	**15.22**	**34.5**	**7.0**	**34.5**	**62.0**
	2†	**0.63**	**13.69**	**41.09**	**13.81**	**15.64**				
External leakage - Utility medium	2*	0.60	13.32	39.98	13.45	15.22	34.5	7.0	34.5	62.0
	2†	0.63	13.69	41.09	13.81	15.64				
Unknown	**1***	**0.14**	**6.92**	**21.49**	**7.61**	**7.61**	**45.0**	**51.0**	**51.0**	**51.0**
	1†	**0.14**	**7.11**	**22.08**	**7.82**	**7.82**				
Unknown	1*	0.14	6.92	21.49	7.61	7.61	45.0	51.0	51.0	51.0
	1†	0.14	7.11	22.08	7.82	7.82				
All modes	**4***	**8.22**	**27.67**	**56.49**	**15.22**	**30.44**	**32.5**	**7.0**	**34.0**	**62.0**
	4†	**0.56**	**25.43**	**78.45**	**27.61**	**31.29**				

Comments

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Taxonomy no	Item
4.4.11.2.3	Control and Safety Equipment Valves Shut-off Gate (10.1-20) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
10	2	0.1489	0.1447	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
Unknown	**1***	**0.12**	**6.14**	**19.02**	**6.73**	**6.71**	**35.0**	**64.0**	**64.0**	**64.0**
	1†	**0.13**	**6.32**	**19.56**	**6.91**	**6.91**				
Unknown	1*	0.12	6.14	19.02	6.73	6.71	35.0	64.0	64.0	64.0
	1†	0.13	6.32	19.56	6.91	6.91				
All modes	**1***	**0.12**	**6.14**	**19.02**	**6.73**	**6.71**	**35.0**	**64.0**	**64.0**	**64.0**
	1†	**0.13**	**6.32**	**19.56**	**6.91**	**6.91**				

Comments

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Taxonomy no	Item
4.4.11.2.4	Control and Safety Equipment Valves Shut-off Gate (20.1-30) inch

Population	Installations	Aggregated time in service (10^6 hours)		No of demands
		Calendar time *	Operational time †	
5	2	0.0790	0.0788	

Failure mode	No of failures	Failure rate (per 10^6 hours).					Active rep.hrs	Repair (manhours)		
		Lower	Mean	Upper	SD	n/τ		Min	Mean	Max
All modes	0*	0.02	4.06	15.59	5.74	0.00	-	-	-	-
	0†	0.02	4.10	15.73	5.79	0.00				

Comments

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Taxonomy no		Item									
4.4.12		Control and Safety Equipment Valves Unknown									
Population	Installations	Aggregated time in service (10^6 hours)						No of demands			
		Calendar time * 4.5101			Operational time † 4.5062						
Failure mode		No of failures	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active rep.hrs	Repair (manhours) Min	Mean	Max
Critical		**20***	**2.94**	**4.43**	**6.44**	**4.43**	**4.43**	**4.8**	**0.5**	**14.4**	**50.0**
		20†	**2.94**	**4.44**	**6.45**	**4.44**	**4.44**				
Fail to close on demand		5*	0.44	1.11	2.33	1.11	1.11	10.3	26.0	38.0	50.0
		5†	0.44	1.11	2.33	1.11	1.11				
Fail to open on demand		4*	0.30	0.89	2.03	0.89	0.89	3.3	4.0	4.0	4.0
		4†	0.30	0.89	2.03	0.89	0.89				
Fail to regulate		9*	1.04	2.00	3.48	2.00	2.00	1.7	0.5	1.8	3.0
		9†	1.04	2.00	3.49	2.00	2.00				
Low output		1*	0.01	0.22	1.05	0.22	0.22	2.0	3.0	3.0	3.0
		1†	0.01	0.22	1.05	0.22	0.22				
Other		1*	0.01	0.22	1.05	0.22	0.22	-	-	-	-
		1†	0.01	0.22	1.05	0.22	0.22				
Degraded		**11***	**1.37**	**2.44**	**4.04**	**2.44**	**2.44**	**2.7**	**1.0**	**2.5**	**4.0**
		11†	**1.37**	**2.44**	**4.04**	**2.44**	**2.44**				
Delayed operation		1*	0.01	0.22	1.05	0.22	0.22	-	-	-	-
		1†	0.01	0.22	1.05	0.22	0.22				
External leakage - Utility medium		2*	0.08	0.44	1.40	0.44	0.44	3.5	3.0	3.0	3.0
		2†	0.08	0.44	1.40	0.44	0.44				
Low output		2*	0.08	0.44	1.40	0.44	0.44	1.0	1.0	1.0	1.0
		2†	0.08	0.44	1.40	0.44	0.44				
Minor in-service problems		4*	0.30	0.89	2.03	0.89	0.89	4.0	4.0	4.0	4.0
		4†	0.30	0.89	2.03	0.89	0.89				
Other		1*	0.01	0.22	1.05	0.22	0.22	4.0	4.0	4.0	4.0
		1†	0.01	0.22	1.05	0.22	0.22				
Plugged/Choked		1*	0.01	0.22	1.05	0.22	0.22	2.0	2.0	2.0	2.0
		1†	0.01	0.22	1.05	0.22	0.22				
Incipient		**8***	**0.88**	**1.77**	**3.20**	**1.77**	**1.77**	**3.7**	**3.0**	**4.8**	**12.0**
		8†	**0.88**	**1.78**	**3.20**	**1.78**	**1.78**				
Abnormal instrument reading		4*	0.30	0.89	2.03	0.89	0.89	5.0	12.0	12.0	12.0
		4†	0.30	0.89	2.03	0.89	0.89				
Fail to regulate		1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0
		1†	0.01	0.22	1.05	0.22	0.22				
Minor in-service problems		1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0
		1†	0.01	0.22	1.05	0.22	0.22				
Other		1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0
		1†	0.01	0.22	1.05	0.22	0.22				
Unknown		1*	0.01	0.22	1.05	0.22	0.22	3.0	3.0	3.0	3.0
		1†	0.01	0.22	1.05	0.22	0.22				
All modes		**39***	**6.50**	**8.65**	**11.29**	**8.65**	**8.65**	**3.9**	**0.5**	**7.4**	**50.0**
		39†	**6.51**	**8.65**	**11.30**	**8.65**	**8.65**				
Comments											

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Maintainable item versus failure mode, to be continued
Item: Valves described by application - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Unknown	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00
Total	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00

Maintainable item versus failure mode, continued
Item: Valves described by application - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Unknown	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0
Total	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0

The figures are percentages of the total failure rate for the actual maintainable item/failure mode combination.

Failure descriptior versus failure mode, to be continued
Item: Valves described by application - Unknown

	AIR	DOP	ELP	ELU	FTC	FTO	FTR	HIO	INL
Blockage/plugged	0.00	0.00	0.00	0.00	5.13	2.56	0.00	0.00	0.00
Corrosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Instrument failure - general	10.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leakage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical Failure - general	0.00	0.00	0.00	5.13	2.56	2.56	25.64	0.00	0.00
Miscellaneous - general	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00
Out of adjustment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	2.56	0.00	0.00	2.56	5.13	0.00	0.00	0.00
Wear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.26	2.56	0.00	5.13	12.82	10.26	25.64	0.00	0.00

Failure descriptior versus failure mode, continued
Item: Valves described by application - Unknown

	LCP	LOO	OTH	PLU	SER	SPO	STD	UNK	Sum
Blockage/plugged	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	10.26
Corrosion	0.00	0.00	2.56	0.00	2.56	0.00	0.00	0.00	5.13
Instrument failure - general	0.00	0.00	0.00	0.00	7.69	0.00	0.00	0.00	17.95
Leakage	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Mechanical Failure - general	0.00	2.56	0.00	0.00	0.00	0.00	0.00	2.56	41.03
Miscellaneous - general	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
Out of adjustment	0.00	2.56	2.56	0.00	2.56	0.00	0.00	0.00	7.69
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.26
Wear	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	2.56
Total	0.00	7.69	7.69	2.56	12.82	0.00	0.00	2.56	100.0

The figures are percentages of the total failure rate for the actual failure descriptor/failure mode combination.

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SUBSEA EQUIPMENT

Common Components

There are several components that are being used on more than one equipment unit as shown in Table 18. The following tables present reliability data for those components.

List of failure modes

ELP	External leakage - process medium
ELU	External leakage - utility medium
FTC	Fail to close/lock
FTF	Fail to function on demand
FTO	Fail to open/unlock
ILU	Internal leakage - utility medium
LCP	Leakage in closed position
OTH	Other
PLU	Plugged/choked
SPO	Spurious operation
TRF	Transmission failure
UNK	Unknown

Table 18 Failure data for common components

Taxonomy no		Item Common components										
Component	No of units		Severity class				Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Accumulator - subsea	59	1		1			0.00003	0.8279	3.9222	1.5981	0.9336	
Chemical injection coupling	347	8		8			0.0008	0.3900	1.5604	0.5842	0.6068	12
Coating - external	39						0.0006	0.1589	0.6036	0.2247	-	
Connector	606	3	1		2		0.0003	0.2535	1.0438	0.3957	0.1188	19
Hydraulic coupling	2816	9	6	3			0.0076	0.0827	0.2258	0.0724	0.0904	12.33
Piping (hard pipe)	88	1	1				0.0002	0.3704	1.5971	0.6183	0.3196	
Power/signal coupler	407	10	7	2	1		0.0374	0.6061	1.7671	0.5832	0.6560	9
Valve, check	91						0.0002	0.0610	0.2319	0.0863	-	
Valve, control	176						0.0001	0.0334	0.1269	0.0472	-	
Valve, process isolation	898	18	13	4	1		0.1555	0.5652	1.1823	0.3245	0.5040	35.67
Valve, utility isolation	334	3	3				0.0037	0.4335	1.5707	0.5651	0.2729	10

Comments

For components with no failures, n is set to 0.5 based on a non-informative prior.

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Table 19 No. of Components versus Equipment unit

Component	Control system	Flowline	Manifold	Riser	Running tool	Wellhead & X-mas tree
Accumulator - subsea	58				1	
Chemical injection coupling	198		19			130
Coating - external		38		1		
Connector		91	216	81	6	212
Hydraulic coupling	1359		87			1370
Piping (hard pipe)			39			49
Power/signal coupler	366					41
Valve, check			14			77
Valve, control			13			163
Valve, process isolation		17	309		4	568
Valve, utility isolation			148			186

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Component versus failure mode

Component	FTC	ELP	ELU	FTO	SPO	UNK	ILU	LCP	OTH	PLU	TRF	Total
Accumulator - subsea							1					1
Chemical injection coupling			8									8
Connector		2							1			3
Hydraulic coupling			6			1			2			9
Piping (hard pipe)										1		1
Power/signal coupler											10	10
Valve, process isolation	3	1	1	4	1			2	6			18
Valve, utility isolation	1			1				1				3
Total	**4**	**3**	**15**	**5**	**1**	**1**	**1**	**3**	**9**	**1**	**10**	**53**

Failure descriptor versus failure mode

Component	Descriptor	UNK	ELP	ELU	FTC	FTO	ILU	LCP	OTH	PLU	SPO	TRF	Total
Accumulator - subsea	Leakage						1						1
Chemical injection coupling	Leakage			8									8
Connector	Leakage		2										2
	Other								1				1
Hydraulic coupling	Clearance/ alignment failure	1											1
	Corrosion			1									1
	Leakage			1									1
	Material failure - general			1									1
	Miscellaneous - general								2				2
	Unknown			3									3
Piping (hard pipe)	Blockage									1			1
Power/signal coupler	Earth/isolation fault											3	3
	Electrical failure - general											5	5
	Other											2	2
Valve, process isolation	Blockage				1	1							2
	Clearance/ alignment failure				2								2
	External influence - general					1					1		2
	Leakage		1	1		1		2	5				10
	Material failure - general					1							1
	Mechanical Failure - general								1				1
Valve, utility isolation	Leakage				1			1					2
	Sticking					1							1
Total		**1**	**3**	**15**	**4**	**5**	**1**	**3**	**9**	**1**	**1**	**10**	**53**

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Control Systems

The boundary definition is shown in Figure 23 and subdivision in subunits and components is shown in Table 21. The boundary definition applies to subsea production/injection control systems, controlling both single satellite wells and more complex subsea production facilities such as multi-well manifold template systems.

The subsea control system comprises the surface installed master control station and hydraulic/electric power units, as well as the umbilical(s) and the control equipment installed subsea on the tree or the template (e.g. SDU and SCM).

Note:

- Installation/workover control systems are not included.
- Downhole sensors are not included.
- Hydraulic or electric lines to the various actuators are considered as a part of the control system, not as part of the valves. The actuators, however, are considered part of the valves, which again can be part of the wellhead and X-mas tree or Manifold equipment class.
- The hydraulic couplings in the tree cap are regarded as part of the X-mas tree, not the control system.
- Electric couplers on the X-mas tree are regarded as part of the control system

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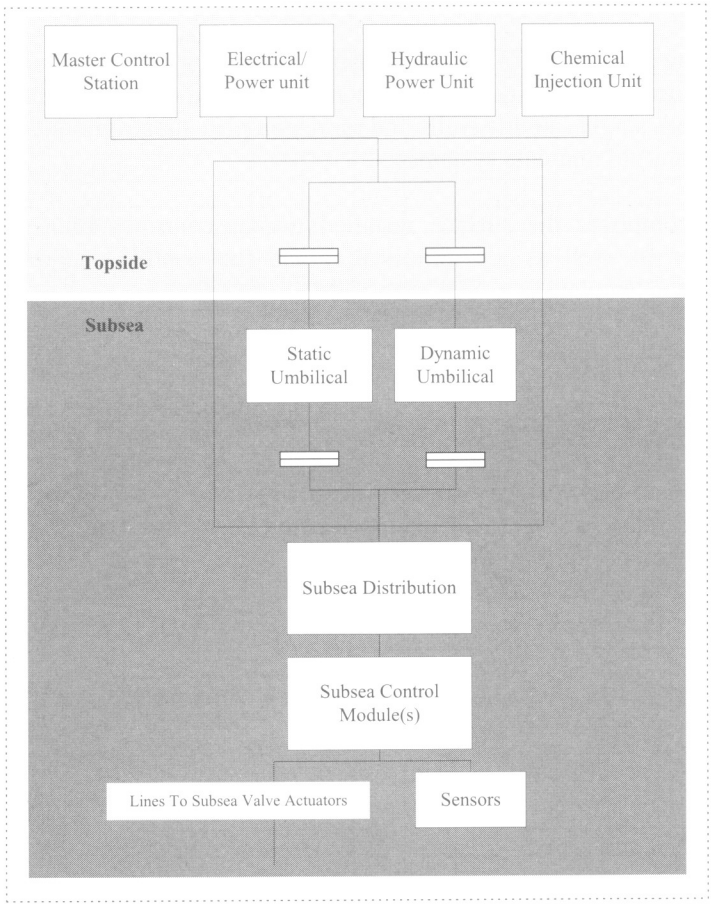

Figure 23 - Control Systems, Boundary definition

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Table 21 Control System, Subdivision into Subunits and Components

CONTROL SYSTEM								
Chemical injection unit (topside)	Electrical power unit (topside)	Hydraulic power unit (topside)	Master control station (topside)	Dynamic umbilical	Static umbilical	Sensors	Subsea control module	Subsea distribut-ion module
Subunit	Power supply unit Subunit	Hydraulic power unit Subunit	Subunit	Hydr./ chemical line Power/ signal line Sheath/ armour Subsea umbilical termina-tion unit Topside umbilical termina-tion unit Unknown	Hydr./ chemical line Power/ signal line Sheath/ armour Subsea umbilical termina-tion unit Topside umbilical termina-tion unit Unknown	Comb. pressure and tempera-ture sensor Flow sensor Pressure sensor Sand detection sensor Tempera-ture sensor Valve position sensor	Accumu-lator – subsea Chemical injection coupling Filter Hydraulic coupling Module base plate Other Power supply unit Power/ signal coupler Soleniod control valve Subsea electronic module Unknown	Accumu-lator – subsea Chemical injection coupling Hydraulic coupling Hydr./ chemical coupling Hydr./ chemical jumper Power/ signal coupler Power/ signal jumper Unknown

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List of failure modes

AIR	Abnormal instrument reading
ELU	External leakage - utility medium
ERO	Erratic output
FTF	Fail to function on demand
FWR	Fail while running
ILU	Internal leakage - utility medium
LOR	Loss of redundancy
NON	No immediate effect
OTH	Other
SCI	Short circuit
SPO	Spurious operation
TRF	Transmission failure
UNK	Unknown

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Taxonomy no		Item: Control system										
Population	Installations	Failure data					Aggregated time in service (10^6 hours)					
17	13						Calendar time 0.8531					
Component	No of units	Severity class					Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Chemical injection unit (topside)	**9**						**0.0019**	**0.4854**	**1.8444**	**0.6864**	-	
Subunit	8						0.0022	0.5419	2.0594	0.7664	-	
Electrical power unit (topside)	**10**	**6**	**5**	**1**			**0.4923**	**11.9261**	**36.7995**	**12.4335**	**10.9766**	**10.2**
Power supply unit	2	4	4				5.2490	21.6396	47.1058	13.3025	20.0541	9.75
Subunit	8	2	2				0.3144	4.9412	14.3384	4.7225	4.6232	12
Hydraulic power unit (topside)	**10**	**6**		**2**	**4**		**1.4211**	**13.8661**	**37.0874**	**11.7749**	**10.9766**	**7**
Hydraulic Power Unit	2	5		3	2		13.6340	25.4930	40.3496	8.2222	25.0677	7
Subunit	7	1			1		0.0277	12.7661	50.9176	19.0370	3.4082	
Master control station (topside)	**9**	**21**	**6**	**5**	**10**		**2.4870**	**59.3623**	**182.813**	**61.7183**	**40.7693**	**7.88**
Subunit	8	21	13	5	3		6.0807	73.9949	205.964	66.6081	45.5186	7.88
Dynamic umbilical	**9**	**2**		**1**	**1**		**0.1081**	**4.2669**	**13.9614**	**4.8281**	**5.1013**	
Hydraulic/chemical line	49						0.0005	0.1149	0.4367	0.1625	-	
Power/signal line	22	1		1			0.0836	0.9179	2.5089	0.8047	0.9994	
Sheath/armour	2						0.0220	5.5056	20.9214	7.7861	-	
Subsea umbilical termination unit	7						0.0035	0.8785	3.3384	1.2424	-	
Topside umbilical termination unit	5	1		1			0.2145	4.1813	12.5260	4.1813	4.1813	
Unknown	2						0.0220	5.5056	20.9214	7.7861	-	
Static umbilical	**40**	**10**	**0**	**2**	**8**		**0.0000**	**4.4905**	**23.6400**	**10.4782**	**6.1930**	**24.44**
Hydraulic/chemical line	248	1		1			0.0000	0.4435	2.0446	0.8196	0.1007	2
Power/signal line	63	8	8				0.2785	2.4052	6.2814	1.9714	3.4281	24
Sheath/armour	12						0.0024	0.6108	2.3210	0.8638	-	
Subsea umbilical termination unit	13	1		1			0.0003	1.9223	8.6998	3.4519	2.1704	50
Topside umbilical termination unit	10						0.0025	0.6248	2.3743	0.8836	-	
Unknown	5						0.0088	2.2023	8.3686	3.1145	-	
Sensors	**57**	**18**	**1**	**5**	**12**		**0.5749**	**9.1973**	**26.7621**	**8.8247**	**7.9969**	**10.8**
Combined pressure and temperature sensor	30	1	1				0.0000	0.9210	4.6702	1.9983	0.8984	12
Flow sensor	35						0.0007	0.1758	0.6679	0.2485	-	
Pressure sensor	294	14	14				0.1316	1.7656	4.9961	1.6276	1.2016	10.5
Sand detection sensor	5						0.0088	2.2023	8.3686	3.1145	-	
Temperature sensor	179	2	2				0.0957	0.2563	0.4797	0.1198	0.2687	
Valve position sensor	8	1	1				0.1926	4.5779	14.0908	4.7561	4.9980	
Subsea control module	**88**	**206**	**23**	**73**	**110**		**3.8233**	**49.5976**	**139.558**	**45.3520**	**71.1444**	**7.17**
Accumulator - subsea	45	1		1			0.0564	2.4156	7.9758	2.7680	2.7002	
Chemical injection coupling	142	8		8			0.0115	1.4074	5.1224	1.8459	1.6708	12
Filter	103						0.0003	0.0745	0.2832	0.1054	-	
Hydraulic coupling	1090	3		3			0.0005	0.0587	0.2132	0.0768	0.0798	12
Module base plate	72						0.0004	0.1100	0.4179	0.1555	-	
Other	5	3	2		1		17.4951	20.3726	23.4321	1.8064	20.3719	24.1
Power supply unit	23						0.0011	0.2674	1.0160	0.3781	-	
Power/signal coupler	284	2		2			0.0002	0.1587	0.6579	0.2501	0.1939	12
Soleniod control valve	1429	63	10	53			0.0000	1.1628	5.6028	2.3078	1.2589	11.64
Subsea electronic module	107	120	117	3			0.0003	12.7556	61.3365	25.2314	32.3840	3.39
Unknown	16	6	1	1		1	22.2084	50.9948	89.3517	20.819	50.9948	20.5
Subsea distribution module	**16**	**18**	**2**	**15**	**1**		**0.5300**	**35.4531**	**122.438**	**43.2359**	**26.4808**	**24.35**
Accumulator - subsea	13*						0.0016	0.3925	1.4913	0.5550	-	

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Taxonomy no		Item										
		Control system										
Population	Installations						Aggregated time in service (10^6 hours)					
17	13		Failure data				Calendar time 0.8531					
Component		No of units		Severity class				Failure rate (per 10^6 hours).					Active repair time (hours)
			#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Chemical injection coupling		56*						0.0005	0.1310	0.4979	0.1853	-	
Hydraulic coupling		269	3	3				0.0035	0.2743	0.9602	0.3408	0.3036	3
Hydraulic/chemical coupling		32	2	2				0.0092	2.3023	8.8341	3.2507	1.2227	16
Hydraulic/chemical jumper		104	2	2				0.0001	0.5856	2.5995	1.0209	0.4822	104
Power/signal coupler		82	8	7		1		0.3846	7.7878	23.4546	7.8465	2.3599	8.25
Power/signal jumper		46	2	2				0.0003	3.4682	16.0250	6.4322	1.1655	43
Unknown		1	1	0	1			2.4204	47.1876	141.362	47.1876	47.1876	
Equipment unit level		**17**	**287**	**14**	**123**	**150**		**5.9259**	**293.274**	**983.143**	**343.205**	**336.422**	**9.15**

Comments

For components with no failures, n is set to 0.5 based on a non-informative prior.

* Mean failure for the common component is used in the estimator.

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Component versus failure mode, Control System

Subunit	Component	ELU	UNK	FTF	SPO	OTH	ERO	FWR	ILU	SCI	TRF	Total
Dynamic umbilical	Power/signal line										1	1
	Topside umbilical termination unit	1										1
Electric power unit	Power supply unit					2	2					4
	Subunit					2						2
Hydraulic power unit	Hydraulic power unit		5									5
	Subunit					1						1
Master control station	Subunit		1	4	6	2	4	3		1		21
Subsea control module	Accumulator – subsea								1			1
	Chemical injection coupling	8										8
	Hydraulic coupling	3										3
	Other			2			1					3
	Power/signal coupler										2	2
	Subsea electronic module			6	5	109						120
	Solenoid control valve	50		9					4			63
	Unkonown	2	2						2			6
Subsea distribution module	Hydraulic/chemical coupling					2						2
	Hydraulic/chemical jumper	2										2
	Hydraulic coupling		1			2						3
	Power/signal coupler										8	8
	Power/signal jumper										2	2
	Unknown									1		1
Sensors	Valve position sensor			1								1
	Pressure sensor			1	1	3	9					14
	Combined pressure and temperature sensor						1					1
	Temperature sensor					1	1					2
Static umbilical	Hydraulic/chemical line	1										1
	Power/signal line										8	8
	Subsea umbilical termination unit	1										1
Total		**68**	**9**	**23**	**12**	**124**	**18**	**3**	**7**	**2**	**21**	**287**

Subunit versus failure mode, Control System

Subunit	ELU	ILU	LOR	NON	OTH	SPO	ERO	FTF	UNK	Total
Dynamic umbilical	1				1					2
Electric power unit						2	2	2		6
Hydraulic power unit	1			2	2				1	6
Master control station				9	2	6	2	1	1	21
Subsea control module	62	9	108	1	5	7	1	11	2	206
Subsea distribution module	2		7		1	4		4		18
Sensors				12		1	5			18
Static umbilical	2			8						10
Total	**68**	**9**	**115**	**32**	**11**	**20**	**10**	**18**	**4**	**287**

Equipment unit versus failure mode, Control System

Equipment unit	ELP	ILP	SPO	ELU	ILU	NON	OTH	AIR	FTF	LOR	Toal
Control system	2	1	24	66	7	18	7	6	18	138	287

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Failure descriptor versus failure mode, Control System

Component	Descriptor	ELU	FTF	OTH	ERO	FWR	ILU	SCI	SPO	TRF	UNK	Total
Accumulator - subsea	Leakage						1					1
Chemical injection coupling	Leakage	8										8
Hydraulic power unit	Control failure										2	2
	Faulty signal/indication/alarm										2	2
	Material failure - general										1	1
Hydraulic/chemical coupling	Miscellaneous - general			2								2
Hydraulic/chemical jumper	Burst	1										1
	Material failure - general	1										1
Hydraulic/chemical line	Leakage	1										1
Hydraulic coupling	Clearance/ alignment failure										1	1
	Miscellaneous - general			2								2
	Unknown	3										3
Other	Blockage		2									2
	Earth/isolation fault				1							1
Valve position sensor	Instrument failure - general		1									1
Power supply unit	Electrical failure - general			2	2							4
Combined pressure and temperature sensor	No signal/indication/alarm				1							1
Pressure sensor	Blockage				1							1
	Faulty signal/indication/alarm				2				1			3
	Instrument failure - general			3	4							7
	No signal/indication/alarm		1		1							2
	Software failure				1							1
Power/signal coupler	Earth/isolation fault									3		3
	Electrical failure - general									5		5
	Other									2		2
Power/signal jumper	Electrical failure - general									2		2
Power/signal line	Earth/isolation fault									9		9
Subsea electronic module	Contamination			1								1
	Control failure		2	106								108
	Earth/isolation fault			2								2
	Faulty signal/indication/alarm		1						5			6
	Leakage		1									1
	No signal/indication/alarm		1									1
	Short circuiting		1									1
Solenoid control valve	Contamination						1					1
	Control failure		2									2
	Faulty signal/indication/alarm		7									7
	Leakage	50					3					53
Subunit	Combined causes		1									1
	Contamination			1								1
	Control failure			2	3	2			1		1	9
	Earth/isolation fault							1				1
	Electrical failure - general		1	1								2
	Faulty signal/indication/alarm					1			2			3
	Instrument failure - general			1								1
	Software failure		2		1				2			5
	Unknown								1			1
Subsea umbilical termination unit	Erosion	1										1
Temperature sensor	Instrument failure - general			1	1							2
Topside umbilical termination unit	Leakage	1										1
Unknown	Burst						2					2
	Earth/isolation fault							1				1

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Component	Descriptor	ELU	FTF	OTH	ERO	FWR	ILU	SCI	SPO	TRF	UNK	Total
	Leakage	2										2
	No cause found										1	1
	Unknown										1	1
Total		**287**	**68**	**23**	**124**	**18**	**3**	**7**	**2**	**12**	**21**	**9**	**287**

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Manifold

The boundary definition is shown in Figure 24 and subdivision in subunits and components is shown in Table 22. The boundary definition applies to manifolds and associated equipment to commingle produced fluids, or distribute fluids or chemicals, to template wells or satellites. Note that the trees and control system are outside the boundary. The manifolds may vary considerably in design from large and complex multi-well template manifolds to simpler free standing manifolds. Note that the template is covered as a separate equipment class in OREDA.

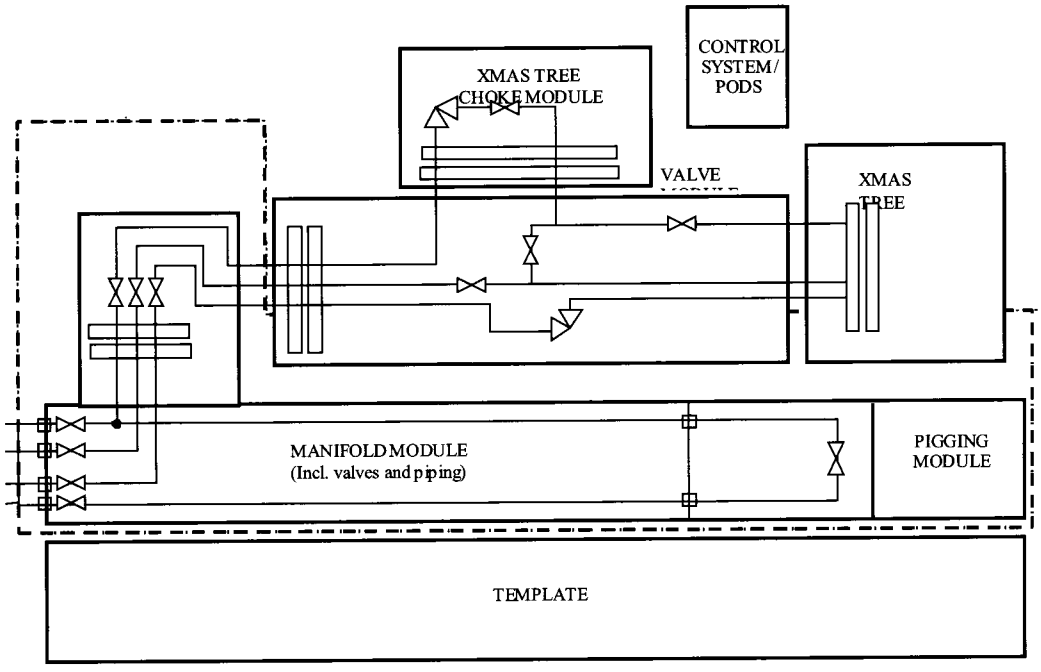

Figure 24 – Manifold, Boundary Definition

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Table 22 Manifold, Subdivision into Subunits and Components

MANIFOLD	
Manifold module	Pigging module
• Chemical injection coupling • Connector • Control valve • Hydraulic coupling • Piping (hard pipe) • Structure - protective • Structure - support • Valve, check • Valve, control • Valve, process isolation • Valve, utility isolation	• Connector • Piping (hard pipe) • Valve, process isolation

List of failure modes

ELP	External leakage - process medium
FTC	Fail to close/lock
FTO	Fail to open/unlock
ILP	Internal leakage - process medium
ILU	Internal leakage - utility medium
LCP	Leakage in closed position
NON	No immediate effect
OTH	Other
SPO	Spurious operation

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Taxonomy no		Item Manifold										
Population	Installations						Aggregated time in service (10^6 hours)					
29	11	Failure data					Calendar time 1.3342					
Component	No of units	#	Severity class C	D	I	U	Failure rate (per 10^6 hours). Lower	Mean	Upper	SD	n/τ	Active repair time (hours) Mean
Manifold module	**29**	**10**	**2**	**7**	**1**		**0.4756**	**7.7643**	**22.6621**	**7.4826**	**7.4950**	7
Chemical injection coupling	19*						0.0010	0.2570	0.9767	0.3635	-	
Connector	214	1	1				0.0001	0.1093	0.4653	0.1791	0.0993	2
Hydraulic coupling	87						0.0002	0.0591	0.2246	0.0836	-	
Piping (hard pipe)	38*						0.0007	0.1792	0.6808	0.2534	-	
Structure - protective	15						0.0017	0.4128	1.5687	0.5838	-	
Structure - support	6						0.0047	1.1738	4.4605	1.6600	-	
Valve, check	14						0.0018	0.4534	1.7228	0.6412	-	
Valve, control	13						0.0014	0.3419	1.2992	0.4835	-	
Valve, process isolation	298	9	8	1			0.0185	0.8313	2.7588	0.9593	0.6708	7.71
Valve, utility isolation	148*						0.0003	0.0849	0.3227	0.1201	-	
Pigging module	**8**						**0.0033**	**0.8347**	**3.1720**	**1.1805**	-	
Connector	2*						0.0010	0.2478	0.9418	0.3505	-	
Piping (hard pipe)	1*						0.0015	0.3643	1.3845	0.5152	-	
Valve, process isolation	11*						0.0017	0.4184	1.5900	0.5917	-	
Equipment level	**29**	**10**	**2**	**7**	**1**		**0.4756**	**7.7643**	**22.6621**	**7.4826**	**7.4950**	7

Comments

For components with no failures, n is set to 0.5 based on a non-informative prior.
* Mean failure for the common component is used in the estimator.

Component versus failure mode, Manifold

Component	ELP	FTO	FTC	OTH	LCP	SPO	Total
Connector	1						1
Valve. process isolation	1	2	1	2	2	1	9
Total	**2**	**2**	**1**	**2**	**2**	**1**	**10**

Subunit versus failure mode, Manifold

Subunit	ELP	ILP	NON	OTH	ILU	Total
Manifold module	2	3	1	1	3	10

Equipment unit versus failure mode, Manifold

Equipment unit	ELP	ILP	SPO	ILU	NON	Total
Manifold	2	3	1	3	1	10

Failure descriptor versus failure mode, Manifold

Component	Descriptor	ELP	FTC	FTO	LCP	SPO	OTH	Total
Connector	Leakage	1						1
Valve. process isolation	Blockage		1					1
	External influence - general			1		1		2
	Leakage	1		1	2		2	6
Total		**2**	**1**	**2**	**2**	**1**	**2**	**10**

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Flowline

The boundary definition is shown in Figure 25 and subdivision in subunits and components is shown in Table 23. The boundary definition applies to all subsea flowlines from a subsea production facility to a receiving terminal, e.g. another subsea production facility or a topside production facility (floating or fixed). Flexible or rigid pipes from the sea floor up to and including the hang-off on the receiving installation belong to the riser equipment class. The connector at the subsea facility is excluded from the boundary.

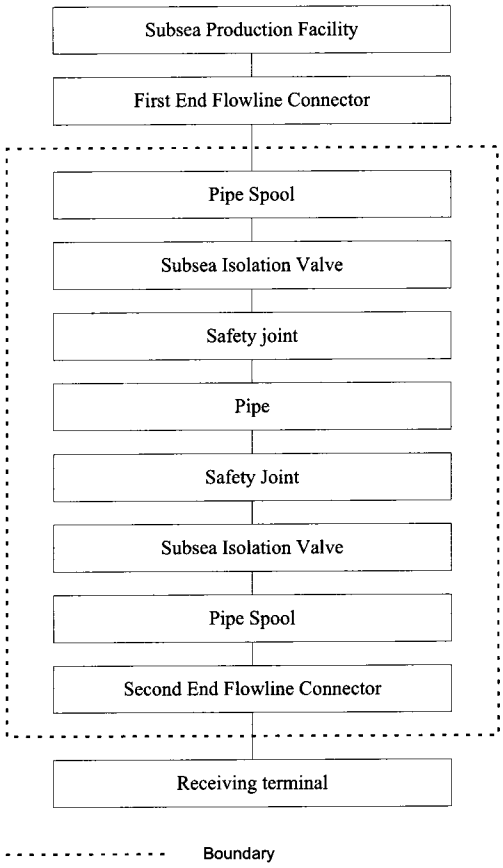

Figure 25 – Flowline, Boundary Definition

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Table 23 Flowline, Subdivision into Subunits and Components

FLOWLINE	
Pipe	Subsea isolation system
• Coating - external • Connector • Flexible pipe spool • Rigid pipe spool • Sealine	• Valve, process isolation • Structure - protective • Structure - support

List of failure modes

ELP External leakage - process medium

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Taxonomy no		Item Flowline										
Population	Installations						Aggregated time in service (10^6 hours)					
59	11	Failure data					Calendar time 2.0850					
Component	No of units		Severity class				Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Pipe	**60**	**1**		**1**			**0.0000**	**0.4402**	**2.2342**	**0.9568**	**0.4803**	**2**
Coating - external	38						0.0006	0.1624	0.6172	0.2297	-	
Connector	91*						0.0004	0.0876	0.3330	0.1239	-	
Flexible pipe spool	26	1	1				0.0059	1.1956	4.5224	1.6546	0.7209	2
Rigid pipe spool	74						0.0003	0.0800	0.3041	0.1132	-	
Sealine	55						0.0005	0.1374	0.5222	0.1943	-	
Subsea isolation system	**16**						**0.0011**	**0.2835**	**1.0774**	**0.4010**	-	
Valve, process isolation	17*						0.0011	0.2727	1.0361	0.3856	-	
Equipment level	**59**	**1**		**1**			**0.0000**	**0.4346**	**2.0982**	**0.8654**	**0.4796**	**2**

Comments
For components with no failures, n is set to 0.5 based on a non-informative prior.
* Mean failure for the common component used in the estimator.

Component versus failure mode, Flowline

Component	ELP
Flexible pipe spool	1

Subunit versus failure mode, Flowline

Subunit	ELP
Pipe	1

Equipment unit versus failure mode, Flowline

Equipment unit	ELP
Flowline	1

Failure descriptor versus failure mode, Flowline

Descriptor	ELP
Leakage	1

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Subsea Isolation System

The boundary definition is shown in Figure 26 and subdivision in subunits and components is shown in Table 24. The subunit that defines the Subsea Isolation Valve (SSIV) configuration is the 'Subsea Isolation System' (SSIS). SSIV includes local accessories e.g. the actuator. The SSIV control system uses the same equipment taxonomy as the current subsea control systems. A SSIS for an installation can consist of several valves e.g. single valve with bypass or two serial valves.

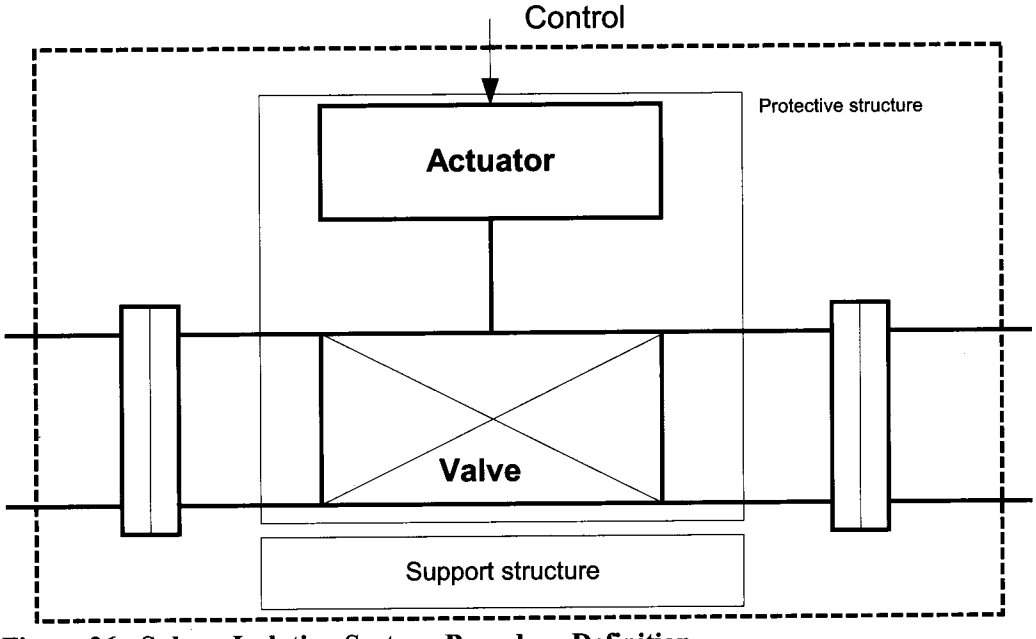

Figure 26 - Subsea Isolation System, Boundary Definition

Table 24 SSIS, Subdivision into Subunits and Components

Subsea isolation system
• Valve, subsea isolation
• Structure – protective
• Structure - support

List of failure modes

DOP	Delayed operation
ELP	External leakage - process medium
INS	Control/signal failure
NON	No immediate effect

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Taxonomy no		Item Pipeline – SSIV										
Population	Installations						Aggregated time in service (10^6 hours)					
85	32	Failure data					Calendar time 2.3683					
Component	No of units		Severity class				Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Subsea isolation system	**85**	**9**		**5**	**4**		**0.0000**	**3.0865**	**17.8947**	**9.6702**	**3.8001**	**29**
Valve, subsea isolation	146	9		5	4		0.0003	2.0040	9.0202	3.5684	2.5014	36
Equipment level	**85**	**9**		**2**	**6**		**0.0000**	**3.0865**	**17.8947**	**9.6702**	**3.8001**	**29**
Comments												

Component versus failure mode, Pipeline

Component	ELP	DOP	INS	Total
Valve, subsea isolation	6	1	2	9

Subunit versus failure mode, Pipeline

Subunit	ELP	NON	DOP	Total
Subsea isolation system	6	2	1	9

Equipment unit versus failure mode, Pipeline

Equipment unit	ELP	NON	Total
Pipeline	5	4	9

Failure descriptor versus failure mode - Valve, subsea isolation

Descriptor	ELP	DOP	INS	Total
Corrosion	1			1
External influence - general	1			1
Instrument failure - general			1	1
Leakage	2			2
Material failure - general	1			1
Mechanical Failure - general	1	1	1	3
Total	**6**	**1**	**2**	**9**

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Risers

The boundary definition is shown in Figure 27 and subdivision in subunits and components is shown in Table 25. The boundary definition applies to fixed and flexible production risers from riser base/manifold on sea bottom to the installation surface tree. The riser components may vary significantly but will mainly include riser joints for rigid risers or single pipe length(s) for flexible risers, connectors and various accessories.

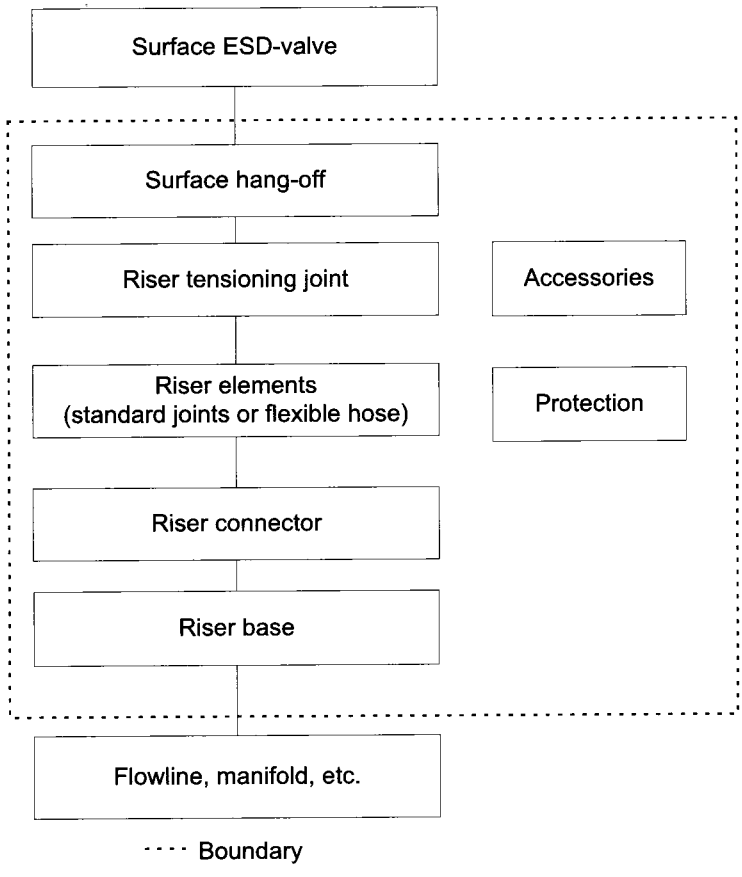

Figure 27 – Risers, Boundary Definition

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Table 25 Riser, Subdivision into Subunits and Components

RISER			
Accessories	Protection	Riser base	Riser elements
• Bend restrictor • Buoyancy device • J/I-tube seal • Stabilizing & guidance equipment • Tension & motion compensation equipment	• Anode • Coating - external	• Gas lift system • Structure • Valve, process isolation • Valve, utility isolation	• Connector • Pipe

List of failure modes

ELP	External leakage - process medium
NON	No immediate effect
STD	Structural failure

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Taxonomy no		Item Riser										
Population	Installations						Aggregated time in service (10^6 hours)					
42	8	Failure data					Calendar time 2.0633					
Component		No of units	Severity class				Failure rate (per 10^6 hours).					Active repair time (hours)
			#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Accessories		1						**0.0332**	**8.3103**	**31.5793**	**11.7526**	-	
No comp.													
Protection		1						**0.0290**	**7.2466**	**27.5370**	**10.2482**	-	
Anode		1						0.0290	7.2466	27.5370	10.2482	-	
Coating - external		1						0.0290	7.2466	27.5370	10.2482	-	
Riser elements		**44**	**5**	**4**	**1**			**0.0000**	**3.0420**	**15.3341**	**6.5293**	**2.3543**	**75.5**
Connector		81*						0.0003	0.0857	0.3257	0.1212	-	
Pipe		44	5	4	1			0.0000	3.3088	16.9069	7.2821	2.3597	75.5
Equipment level		**42**	**5**	**4**	**1**			**0.0000**	**3.1408**	**15.7109**	**6.6488**	**2.4233**	**75.5**

Comments
For components with no failures, n is set to 0.5 based on a non-informative prior.
* Mean failure for the common component is used in the estimator.

Component versus failure mode, Riser

Component	ELP	STD	Total
Pipe	1	4	5

Subunit versus failure mode, Riser

Subunit	ELP	STD	Total
Riser elemets	1	4	5

Equipment unit versus failure mode, Riser

Equipment unit	ELP	NON	STD	Total
Riser	1	1	3	5

Failure descriptor versus failure mode, Riser

Component	Descriptor	ELP	STD	Total
Pipe	Combined causes		4	4
	Fatigue	1		1
Total		**1**	**4**	**5**

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Running Tool

The boundary definition is shown in Figure 28 and subdivision in subunits and components is shown in Table 26. The boundary applies to the running tool itself including the valve block, connectors, soft landing system and the local control and monitoring. The surface HPU and the surface controls are *not* included. The control system items to be included, end with the umbilical topside termination.

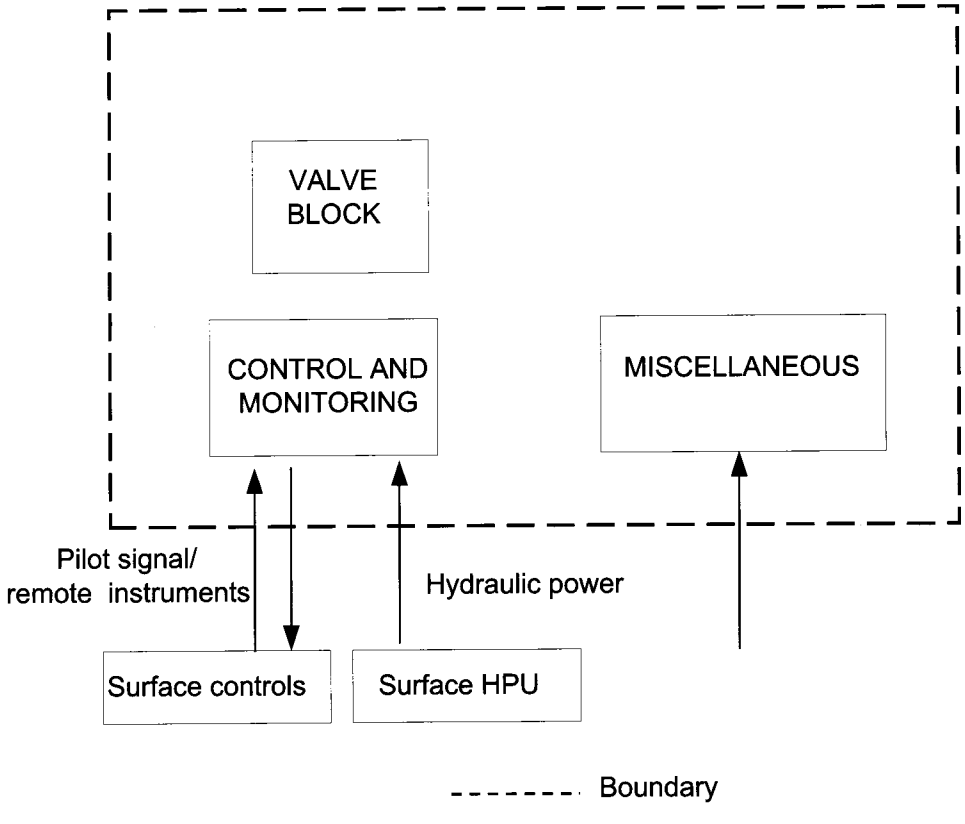

Figure 28 – Running Tool, Boundary Definition

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Table 26 Running tool, Subdivision into Subunits and Components

RUNNING TOOL		
Control & monitoring	Valve block	Miscellaneous
• Accumulator – subsea • Junction plate w/couplers • Pilot control valve • Soleniod control valve • Umbilical	• Ram preventer • Main block • Valve, process isolation • Valve, shear	• Connector • Soft landing system

List of failure modes

ELU	External leakage - utility medium
ILU	Internal leakage - utility medium
NON	No immediate effect
OTH	Other
UNK	Unknown

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Taxonomy no		Item: Running tool										
Population: 6	Installations: 2	Failure data					Aggregated time in service (10^6 hours): Calendar time 0.3032					
Component	No of units	Severity class					Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Control & monitoring	**6**	**2**			**2**		**0.5495**	**6.0086**	**16.4134**	**5.2628**	**6.5959**	**40**
Accumulator – subsea	1*						0.0031	0.7785	2.9583	1.1010	-	
Junction plate w/couplers	7	2			2		0.2438	5.1754	15.6890	5.2628	5.9221	40
Pilot control valve	1						0.0290	7.2466	27.5370	10.2482	-	
Umbilical	1						0.0290	7.2466	27.5370	10.2482	-	
Other	1						0.0290	7.2466	27.5370	10.2482	-	
Valve block	**2**	**1**			**1**		**0.1312**	**10.5391**	**37.0168**	**13.1569**	**11.3323**	
Main block	1						0.0290	7.2466	27.5370	10.2482	-	
Valve, process isolation	4*						0.0019	0.4628	1.7587	0.6545	-	
Valve, shear	5	1			1		0.1174	3.9712	12.7690	4.3856	4.3435	
Other	1						0.0290	7.2466	27.5370	10.2482	-	
Miscellaneous	**6**	**1**			**1**		**0.3345**	**3.1344**	**8.3189**	**2.6314**	**3.2979**	**36**
Connector	6	1			1		0.3345	3.1344	8.3189	2.6314	3.2979	36
Soft landing system	3						0.0070	1.7607	6.6908	2.4900	-	
Other	1						0.0290	7.2466	27.5370	10.2482	-	
Equipment level	**6**	**4**			**4**		**0.7835**	**11.2412**	**32.1558**	**10.5256**	**13.1918**	**38**

Comments
For components with no failures, n is set to 0.5 based on a non-informative prior.
* Mean failure for the common component is used in the estimator.

Component versus failure mode, Running Tool

Component	ELU	UNK	OTH	Total
Junction plate w/couplers		2		2
Connector			1	1
Valve. shear	1			1
Total	**1**	**2**	**1**	**4**

Subunit versus failure mode, Running Tool

Subunit	ELU	NON	OTH	Total
Control & monitoring	1	1		2
Miscellaneous			1	1
Valve block	1			1
Total	**2**	**1**	**1**	**4**

Equipment unit versus failure mode, Running Tool

Equipment unit	UNK	ILU	OTH	Total
Running tool	1	2	1	4

Failure descriptor versus failure mode, Running Tool

Component	Descriptor	ELU	OTH	UNK	Total
Connector	Other		1		1
Junction plate w/couplers	Leakage			1	1
	Unknown			1	1
Valve. shear	Erosion	1			1
Total		**1**	**1**	**2**	**4**

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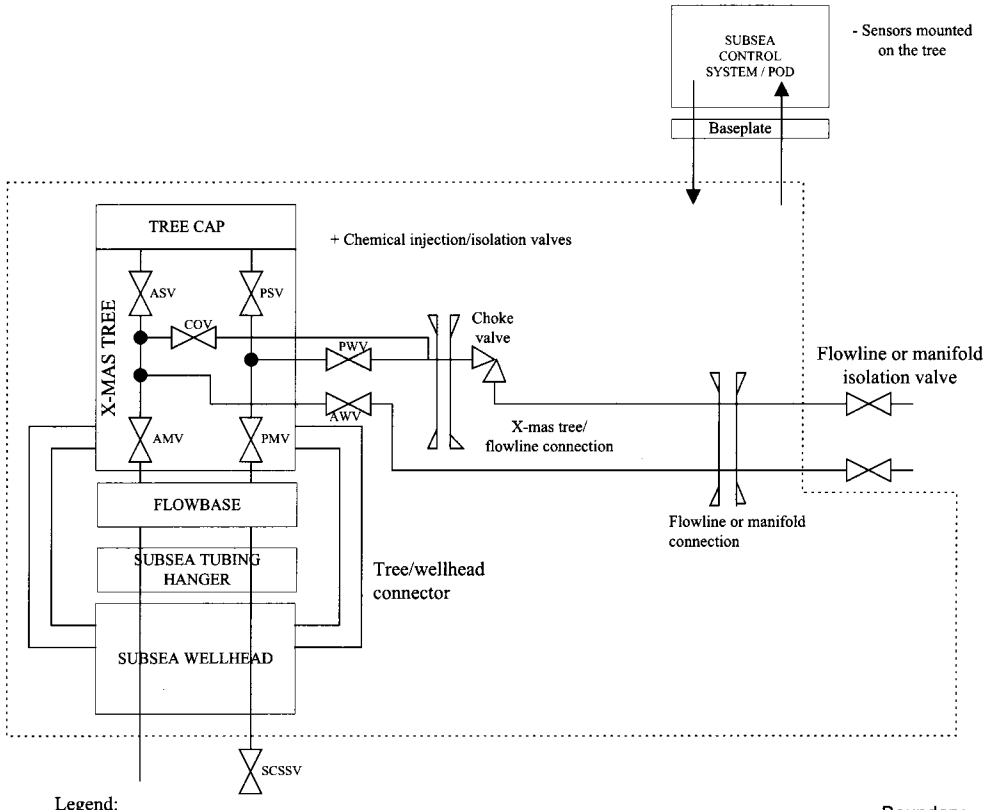
Wellhead and X-mas Tree

The boundary definition is shown in Figure 29 and subdivision in subunits and components is shown in Table 27. The boundary definition applies to both single satellite wells and multiple wells on templates. The equipment boundary includes the subsea wellhead and the tree. Included in the tree are all tree valves and the tree/flowline or tree/manifold connector. The subsea control system is outside the boundary i.e. valves found in the subsea control pod are outside. All control connectors are outside the boundary. Pressure and temperature sensors, and any other detectors mounted on the tree, are outside the boundary.



Legend:

ASV/PSV:	Annulus/Production Swab Valve
AMV/PMV:	Annulus/Production Master Valve
AWV/PWV:	Annulus/Production Wing Valve
COV:	Crossover Valve

SCSSV: Surface Controlled Subsurface Safety Valve

Figure 29 Wellhead and X-mas Tree, Boundary Definition

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Table 27 Wellhead and X-mas Tree, Subdivision into Subunits and Components

WELLHEAD AND X-MAS TREE			
Flowbase	Subsea wellhead	Subsea X-mas tree	Tubing hanger
• Frame • Hub/mandrel • Valve, check • Valve, process isolation • Valve, utility isolation	• Annulus seal assemblies (packoffs) • Casing hangers • Conductor housing • Permanent guidebase (PGB) • Temporary guidebase (TGB) • Wellhead housing (high pressure housing)	•Chemical injection coupling •Connector •Debris cap •Flowspool •Hose (flexible piping) •Hydraulic coupling •Piping (hard pipe) •Tree cap •Tree guide frame •Unknown •Valve, check •Valve, choke •Valve, control •Valve, other •Valve, process isolation •Valve, utility isolation	•Chemical injection coupling •Hydraulic coupling •Power/signal coupler •Tubing hanger body •Tubing hanger isolation plug (H)

Valves are sorted according to functional features, i.e. process isolation, utility isolation, check, choke and control. The following connectors are included within the boundary of the wellhead and X-mas tree:

- Tree to wellhead connector
- Flowspool to sealine/manifold connector
- Tree to flowbase connector (if applicable)

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List of failure modes

ELP	External leakage - process medium
ELU	External leakage - utility medium
FTC	Fail to close/lock
FTF	Fail to function on demand
FTO	Fail to open/unlock
ILP	Internal leakage - process medium
ILU	Internal leakage - utility medium
LCP	Leakage in closed position
LOB	Loss of barrier
LOR	Loss of redundancy
NON	No immediate effect
OTH	Other
PLU	Plugged/choked
SPO	Spurious operation
STD	Structural failure

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Taxonomy no		Item										
		Wellhead & Xmas tree										
Population	Installations						Aggregated time in service (10^6 hours)					
		Failure data					Calendar time 3.0208					
Component	No of units	Severity class					Failure rate (per 10^6 hours).					Active repair time (hours)
		#	C	D	I	U	Lower	Mean	Upper	SD	n/τ	Mean
Flowbase	**38**	**6**		**6**			**0.0002**	**4.7434**	**22.5348**	**9.1977**	**4.9220**	**7.3**
Frame	38	5		5			0.0000	3.6968	20.3459	9.5439	4.1016	7.6
Hub/mandrel	47						0.0007	0.1751	0.6654	0.2476	-	
Valve, check	2						0.0088	2.1961	8.3450	3.1057	-	
Valve, process isolation	18	1	1				0.1272	1.6114	4.5161	1.4650	1.7954	6
Valve, utility isolation	5*						0.0014	0.3479	1.3219	0.4920	-	
Subsea wellhead	**82**						**0.0003**	**0.0839**	**0.3190**	**0.1187**	**-**	
Annulus seal assemblies (packoffs)	130						0.0002	0.0490	0.1862	0.0693	-	
Casing hangers	106						0.0002	0.0590	0.2240	0.0834	-	
Conductor housing	74						0.0004	0.0889	0.3377	0.1257	-	
Other	10						0.0024	0.5900	2.2420	0.8344	-	
Permanent guidebase (PGB)	49						0.0006	0.1524	0.5790	0.2155	-	
Temporary guidebase (TGB)	13						0.0029	0.7206	2.7381	1.0190	-	
Unknown	5						0.0134	3.3613	12.7729	4.7536	-	
Wellhead housing (high pressure housing)	72						0.0004	0.0907	0.3447	0.1283	-	
Subsea X-mas tree	**78**	**50**	**11**	**26**	**13**		**3.2334**	**22.2059**	**55.2296**	**16.9050**	**17.2633**	**32.71**
Chemical injection coupling	124*						0.0003	0.0782	0.2973	0.1106	-	
Connector	212	1			1		0.0000	0.6193	3.1483	1.3502	0.1381	-
Debris cap	44						0.0006	0.1504	0.5716	0.2127	-	
Flowspool	77	1		1			0.0000	0.4525	2.0788	0.8316	0.3594	72
Hose (flexible piping)	20						0.0015	0.3692	1.4031	0.5222	-	
Hydraulic coupling	1266	3	3				0.0001	0.0678	0.2806	0.1066	0.0692	9
Other	25						0.0009	0.2368	0.8998	0.3349	-	
Piping (hard pipe)	49	1	1				0.0000	0.6033	3.4115	1.6847	0.6005	-
Tree cap	76	8		8			0.0005	2.7429	12.2721	4.8396	2.8281	16.875
Tree guide frame	42	2			2		0.1395	1.3889	3.7293	1.1862	1.4530	6
Unknown	6						0.0098	2.4527	9.3203	3.4687	-	
Valve, check	75						0.0003	0.0729	0.2769	0.1031	-	
Valve, choke	75	22	7	15			2.5064	11.3278	25.3340	7.2845	9.0909	34.97
Valve, control	163						0.0001	0.0370	0.1406	0.0523	-	
Valve, other	24	1			1		0.0509	0.9924	2.9730	0.9924	0.9924	
Valve, process isolation	550	8	4	3	1		0.1112	0.4085	0.8577	0.2360	0.3903	92.00
Valve, utility isolation	181	3	3				0.0094	1.0345	3.7338	1.3412	0.5020	10.00
Tubing hanger	**75**	**2**	**2**				**0.0000**	**0.6806**	**3.7118**	**1.7175**	**0.7265**	
Chemical injection coupling	6*						0.0015	0.3647	1.3858	0.5157	-	
Hydraulic coupling	104*						0.0004	0.1124	0.4273	0.1590	-	
Power/signal coupler	41*						0.0008	0.2109	0.8016	0.2983	-	
Tubing hanger body	75	2	2				0.0000	0.6806	3.7118	1.7175	0.7265	
Tubing hanger isolation plug (H)	23						0.0010	0.2605	0.9901	0.3685	-	
Equipment level	**83**	**58**	**10**	**34**	**14**		**3.5222**	**23.0976**	**56.8441**	**17.3006**	**19.2000**	**29.4**

Comments

For components with no failures, n is set to 0.5 based on a non-informative prior.

* Mean failure for the common component is used in the estimator.

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Component versus failure mode, Wellhead & Xmas tree

Subunit	Component	ELP	FTF	FTC	OTH	ILP	LCP	PLU	STD	ELU	FTO	Total
Flowbase	Frame								4	1		5
	Valve, process isolation									1		1
Tubing hanger	Tubing hanger body	1				1						2
Subsea X-mas tree	Connector	1										1
	Flowspool							1				1
	Hydraulic coupling									3		3
	Piping (hard pipe)							1				1
	Tree cap				2					6		8
	Tree guide frame				2							2
	Valve, choke		12	5	3			1			1	22
	Valve, process isolation			2	4						2	8
	Valve, utility isolation			1			1				1	3
	Valve, other			1								1
Total		**2**	**12**	**9**	**11**	**1**	**1**	**3**	**4**	**11**	**4**	**58**

Subunit versus failure mode, Wellhead & Xmas tree

Subunit	ELP	ILP	LOR	NON	LOB	SPO	PLU	ELU	ILU	OTH	STD	Total
Flowbase								2			4	6
Tubing hanger	1	1										2
Subsea X-mas tree	1	8	1	17	1	4	3	9	2	3	1	50
Total	**2**	**9**	**1**	**17**	**1**	**4**	**3**	**11**	**2**	**3**	**5**	**58**

Equipment unit versus failure mode, Wellhead & Xmas tree

Equipment unit	ELP	ILP	SPO	ELU	ILU	LOB	OTH	PLU	STD	NON	Total
Wellhead & Xmas tree	2	8	4	10	1	1	5	3	2	22	58

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Failure descriptor versus failure mode, Wellhead & Xmas tree

Component	Descriptor	ELP	FTF	FTC	FTO	ILP	LCP	PLU	STD	ELU	OTH	Total
Connector	Leakage	1										1
Flowspool	Blockage							1				1
Frame	Corrosion									1		1
	Deformation								1			1
	Material failure - general								2			2
	Vibration								1			1
Hydraulic coupling	Corrosion									1		1
	Leakage									1		1
	Material failure - general									1		1
Piping	Blockage							1				1
Tubing hanger body	Control failure	1										1
	Leakage					1						1
Tree cap	Erosion									6		6
	Looseness										2	2
Tree guide frame	Trawlboard impact										2	2
Valve, choke	Blockage							1				1
	Breakage				1							1
	Clearance/ alignment failure										3	3
	Contamination		2									2
	Control failure		4	4								8
	Leakage		6									6
	Mechanical Failure - general			1								1
Valve, process isolation	Blockage				1							1
	Clearance/ alignment failure			2								2
	Leakage									1	3	4
	Material failure - general				1							1
	Mechanical Failure - general										1	1
Valve, utility isolation	Leakage			1			1					2
	Sticking				1							1
Valve, other	Sticking			1								1
Total		**2**	**12**	**9**	**4**	**1**	**1**	**3**	**4**	**11**	**11**	**58**

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