INTERNATIONAL STANDARD

ISO 14224

First edition
1999-07-15

Petroleum and natural gas industries — Collection and exchange of reliability and maintenance data for equipment

Industries du pétrole et du gaz naturel — Recueil et échange de données de fiabilité et de maintenance des équipements

Reference number
ISO 14224:1999(E)

Contents

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed in Switzerland

Foreword

ISO (the International Organization for standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 14224 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries.*

Annexes A, B, C and D of this International Standard are for information only.

Introduction

This International Standard has been prepared based on know-how and experience gained through the data collection project OREDA[1)], which has been carried out by several major oil companies since the early 1980s. During these years, a large amount of data have been collected and substantial knowledge in reliability data collection accumulated. The text of this International Standard relating to downhole equipment is based on know-how and experience gained through the WELLMASTER [2)] project.

In the petroleum and natural gas industry, great attention is being paid to safety, reliability and maintainability of equipment. Various analyses are used to estimate the risk of hazards, pollution or damage to equipment. For such analyses, Reliability and Maintenance (RM) data are vital.

More emphasis has recently been put on cost-effective design and maintenance for new plants and existing installations. In this respect data on failures, failure mechanisms and maintenance have become of increased importance.

Data collection is an investment. By standardization and improved facility information management systems that allow electronic collection and transfer of data, quality can be improved. A cost-effective way to maximize the amount and type of data is through industry cooperation. To make it possible to collect, exchange and analyse data based on common ground, a standard is required. This International Standard gives recommendations to the petroleum and natural gas industry on specification and execution of RM data collection, both as a separate exercise and in the day-to-day recording of historical data in maintenance management systems.

1) Guideline for Data Collection.

2) User's Guide and Reliability Data Collection Guidelines for Well Completion Equipment (1995): ISBN 82-595-8586-3.

Petroleum and natural gas industries — Collection and exchange of reliability and maintenance data for equipment

1 Scope

This International Standard provides a comprehensive basis for the collection of Reliability and Maintenance (RM) data in a standard format in the areas of drilling, production, refining and transport by pipeline of petroleum and natural gas.

This International Standard presents guidelines for the specification, collection and quality assurance of RM data, facilitating the collection of RM data. The data will enable the user to quantify the reliability of the equipment and to compare the reliability of equipment with similar characteristics.

By analysing the data, reliability parameters can be determined for use in design, operation and maintenance. However, this International Standard is not applicable to the method of analysis for RM data.

The main objectives of this International Standard are:

a) to specify the data to be collected for analysis of:

- system design and configuration;
- safety, reliability and availability of systems and plants;
- life cycle cost;
- planning, optimization and execution of maintenance.

b) to specify data in a standardized format in order to:

- permit exchange of RM data between plants, owners, manufacturers and contractors;
- ensure that RM data are of sufficient quality for the intended analysis.

This International Standard is applicable to all equipment types used in the petroleum and natural gas industry, such as process equipment (used on onshore and offshore installations), subsea equipment, well-completion equipment and drilling equipment. In annex A several examples are included.

This International Standard is applicable to data collected in the operational phase.

Due to the variety of different uses for RM data, it is stressed that, for each data collection programme, attention should be given to the appropriate level of data required.

NOTE It is recognized that to strengthen the goal of this International Standard, a normative reference detailing all the taxonomy codes for each of these equipment classes is appropriate. However, since no comprehensive taxonomy listing covering all equipment classes exists at the time of publication of this International Standard, a sample of taxonomies for process equipment, subsea equipment, well-completion equipment and drilling equipment is contained in informative annex A.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60050-191:1990, *International Electrotechnical Vocabulary. Chapter 191: Dependability and quality of service*.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1.1
availability
ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

[IEC 60050-191:1990]

3.1.2
active maintenance time
that part of the maintenance time during which a maintenance action is performed on an item, either automatically or manually, excluding logistic delays

[IEC 60050-191:1990]

NOTE For more specific information, refer to Figure 191-10 "Maintenance time diagram" in IEC 60050-191.

3.1.3
corrective maintenance
maintenance carried out after fault recognition and intended to put an item into a state in which it can perform a required function

[IEC 60050-191:1990]

NOTE For more specific information, refer to Figure 191-10 "Maintenance time diagram" in IEC 60050-191.

3.1.4
critical failure
failure of an equipment unit which causes an immediate cessation of the ability to perform its required function

NOTE For well-completion equipment, see additional information in A.4.5.

3.1.5
data acquirer
person or organization in charge of the data collection process

3.1.6
demand
activation of the function (includes both operational and test activation)

3.1.7
down state
state of an item characterized either by a fault or by a possible inability to perform a required function during preventive maintenance

[IEC 60050-191:1990]

3.1.8
down time
time interval during which an item is in a down state

[IEC 60050-191:1990]

NOTE For more specific information, refer to Figure 191-10 "Maintenance time diagram" in IEC 60050-191.

3.1.9
equipment class
class of equipment units

EXAMPLE All pumps.

NOTE For well-completion equipment, see additional information in A.4.5.

3.1.10
equipment unit
specific equipment unit within an equipment class as defined within the main boundary

EXAMPLE A pump.

3.1.11
equipment unit redundancy
⟨on the equipment unit level⟩ existence of more than one means for performing the required function

EXAMPLE 3×50 %.

3.1.12
failure
termination of the ability of an item to perform a required function

[IEC 60050-191:1990]

3.1.13
failure cause
circumstances during design, manufacture or use which have led to a failure

[IEC 60050-191:1990]

NOTE Identification of the failure cause normally requires some in-depth investigation to uncover the underlying human or organizational factors as well as the technical cause.

3.1.14
failure descriptor
apparent, observed cause of a failure

NOTE As normally reported into the maintenance management system.

3.1.15
failure mechanism
physical, chemical or other process which has led to a failure

[IEC 60050-191:1990]

3.1.16
failure mode
observed manner of failure

3.1.17
fault
state of an item characterized by inability to perform a required function, excluding such inability during preventive maintenance or other planned actions, or due to lack of external resources

[IEC 60050-191:1990]

3.1.18
item
any part, component, device, subsystem, functional unit, equipment or system that can be individually considered

[IEC 60050-191:1990]

3.1.19
maintainable item
item that constitutes a part, or an assembly of parts, that is normally the lowest level in the hierarchy during maintenance

3.1.20
maintenance
combination of all technical and administrative actions, including supervisory actions, intended to retain an item in, or restore it to, a state in which it can perform a required function

[IEC 60050-191:1990]

3.1.21
maintenance man-hour
accumulated durations of the individual maintenance times, expressed in hours, used by all maintenance personnel for a given type of maintenance action or over a given time interval

[IEC 60050-191:1990]

NOTE For more specific information, refer to Figure 191-10 "Maintenance time diagram" in IEC 60050-191.

3.1.22
non-critical failure
failure of an equipment unit which does not cause an immediate cessation of the ability to perform its required function

NOTE For well-completion equipment, see additional information in A.4.5.

3.1.23
operating state
state when an item is performing a required function

[IEC 60050-191:1990]

3.1.24
operating time
time interval during which an item is in an operating state

[IEC 60050-191:1990]

NOTE For well-completion equipment, see additional information in A.4.5.

3.1.25
preventive maintenance
maintenance carried out at predetermined intervals or according to prescribed criteria, and intended to reduce the probability of failure or the degradation of the functioning of an item

[IEC 60050-191:1990]

3.1.26
redundancy
⟨in an item⟩ existence of more than one means for performing a required function

[IEC 60050-191:1990]

3.1.27
reliability
performance
ability of an item to perform a required function under given conditions for a given time interval

[IEC 60050-191:1990]

3.1.28
required function
function, or combination of functions, of an item which is considered necessary to provide a given service

[IEC 60050-191:1990]

3.1.29
severity class
effect on equipment unit function

3.1.30
subunit
assembly of items that provides a specific function that is required for the equipment unit within the main boundary to achieve its intended performance

3.1.31
surveillance period
interval of time between the start date and end date of data collection

3.2 Abbreviations

BEN	Benchmarking
LCC	Life Cycle Cost
MI	Maintainable Item
OREDA	Project for collection of oil and gas industry equipment reliability and maintenance data
PM	Preventive Maintenance
QRA	Quantitative Risk Assessment
RAM	Reliability, Availability and Maintainability analysis
RCM	Reliability-Centred Maintenance
RM	Reliability and Maintenance
WELLMASTER	Reliability data collection for well-completion equipment

4 Quality of data

4.1 Definition of data quality

Confidence in the collected RM data, and hence any analysis, is strongly dependent on the quality of the data collected. High-quality data is characterized by:

— completeness of data in relation to specification;

— compliance with definitions of reliability parameters, data types and formats;

— accurate input, transfer, handling and storage of data (manually or electronic).

4.2 Guidance for obtaining quality data

To obtain high quality data, the following measures shall be emphasized before the data collection process starts:

— investigate the data sources to make sure the required inventory data can be found and the operational data are complete;

— define the objective for collecting the data in order to collect relevant data for the intended use. Examples of analyses where such data may be used are: Quantitative Risk Analysis (QRA); Reliability, Availability and Maintainability Analysis (RAM); Reliability-Centred Maintenance (RCM); Life Cycle Cost (LCC);

— investigate the source(s) of the data to ensure that relevant data of sufficient quality is available;

— identify the installation date, population and operating period(s) for the equipment from which data may be collected;

— a pilot exercise of the data collection methods and tools (manual, electronic) is recommended to verify the feasibility of the planned data collection procedures;

— prepare a plan for the data collection process, e.g. schedules, milestones, sequence and number of equipment units, time periods to be covered, etc.;

— train, motivate and organize the data collection personnel;

— plan for quality assurance of the data collection process. This shall as a minimum include procedures for quality control of data and recording and correcting deviations. An example of a checklist is included in Annex C.

During and after the data collection exercise, analyse the data to check consistency, reasonable distributions, proper codes and correct interpretations. The quality control process shall be documented. When merging individual data bases it is imperative that each data record has a unique identification.

4.3 Data source systems

The facility maintenance management system constitutes the main source of RM data. The quality of the data which can be retrieved from this source is dependent on the way RM data is reported in the first place. Reporting of RM data according to this International Standard shall be allowed for in the facility maintenance management system, thereby providing a more consistent and sound basis for transferring RM data to equipment RM databases.

The level of detail of RM data reported and collected shall be closely linked to the production and safety importance of the equipment. Prioritization shall be based on regularity, safety and other criticality evaluations.

Those responsible for reporting RM data will derive benefit from the use of these data. Involvement of these staff in determining and communicating these benefits is a requirement for quality RM data.

5 Equipment boundary and hierarchy

5.1 Boundary description

A clear boundary description is imperative for collecting, merging and analysing RM data from different industries, plants or sources. The merging and analysis will otherwise be based on incompatible data.

For each equipment class, a boundary shall be defined indicating what RM data are to be collected.

An example of a boundary diagram for a pump is shown in Figure 1.

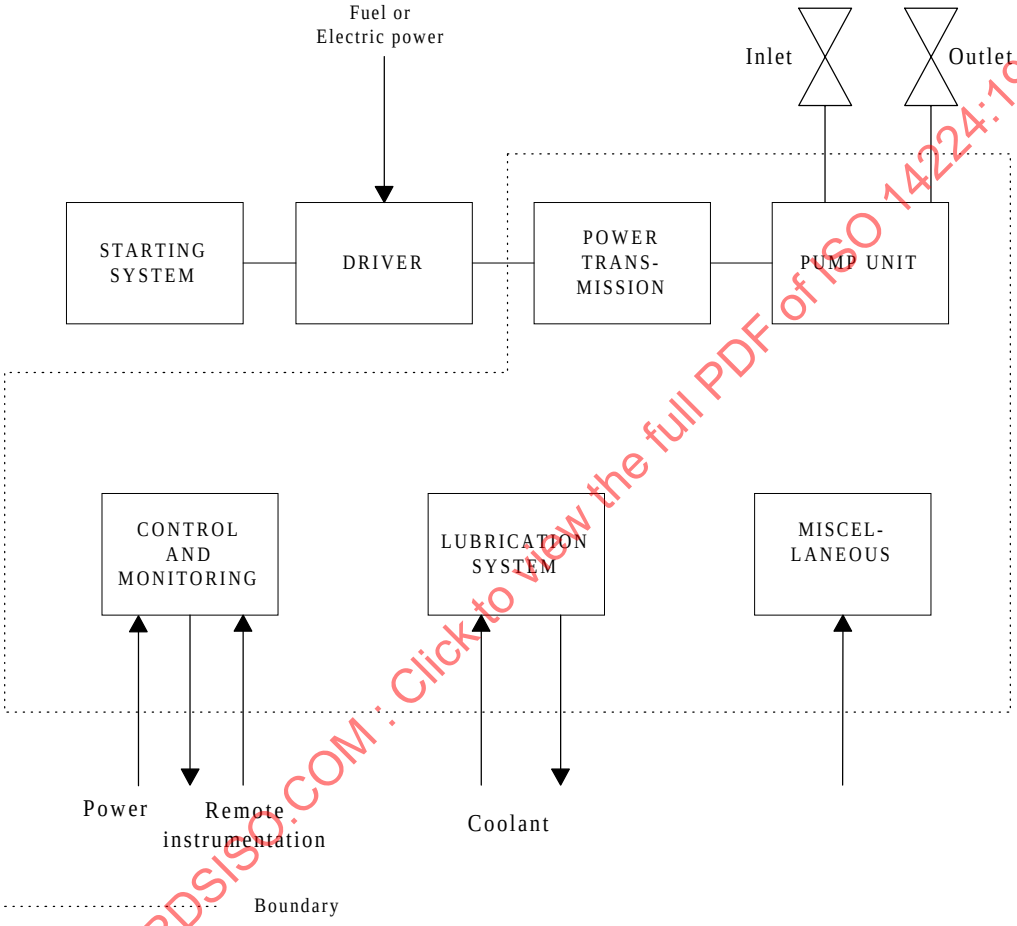


Figure 1 — Example of boundary diagram (pumps)

The boundary diagram shall show the subunits and the interfaces to the surroundings. Additional textual description shall, when needed for clarity, state in more detail what shall be considered inside and outside the boundaries.

Due attention shall be paid to the location of the instrument elements. In the above example, the central control and monitoring items are typically included within the “Control and monitoring” subunit, while individual instrumentation (trip, alarm, control) is typically included within the appropriate subunit, e.g. lubrication system.

5.2 Guidance for defining an equipment hierarchy

Preparation of a hierarchy for the equipment is recommended. The highest level is the equipment unit class. The number of levels for subdivision will depend on the complexity of the equipment unit and the use of the data. Reliability data need to be related to a certain level within the equipment hierarchy in order to be meaningful and comparable. For example, the reliability data “severity class” shall be related to the equipment unit, while the failure cause shall be related to the lowest level in the equipment hierarchy.

A single instrument may need no further breakdown, while several levels are required for a compressor. For data used in availability analyses, the reliability at the equipment unit level may be the only desirable data needed, while an RCM analysis will need data on failure mechanism at maintainable item level.

A subdivision into three levels for an equipment unit will normally be sufficient. An example is shown in Figure 2, viz. equipment unit, subunit and maintainable items.

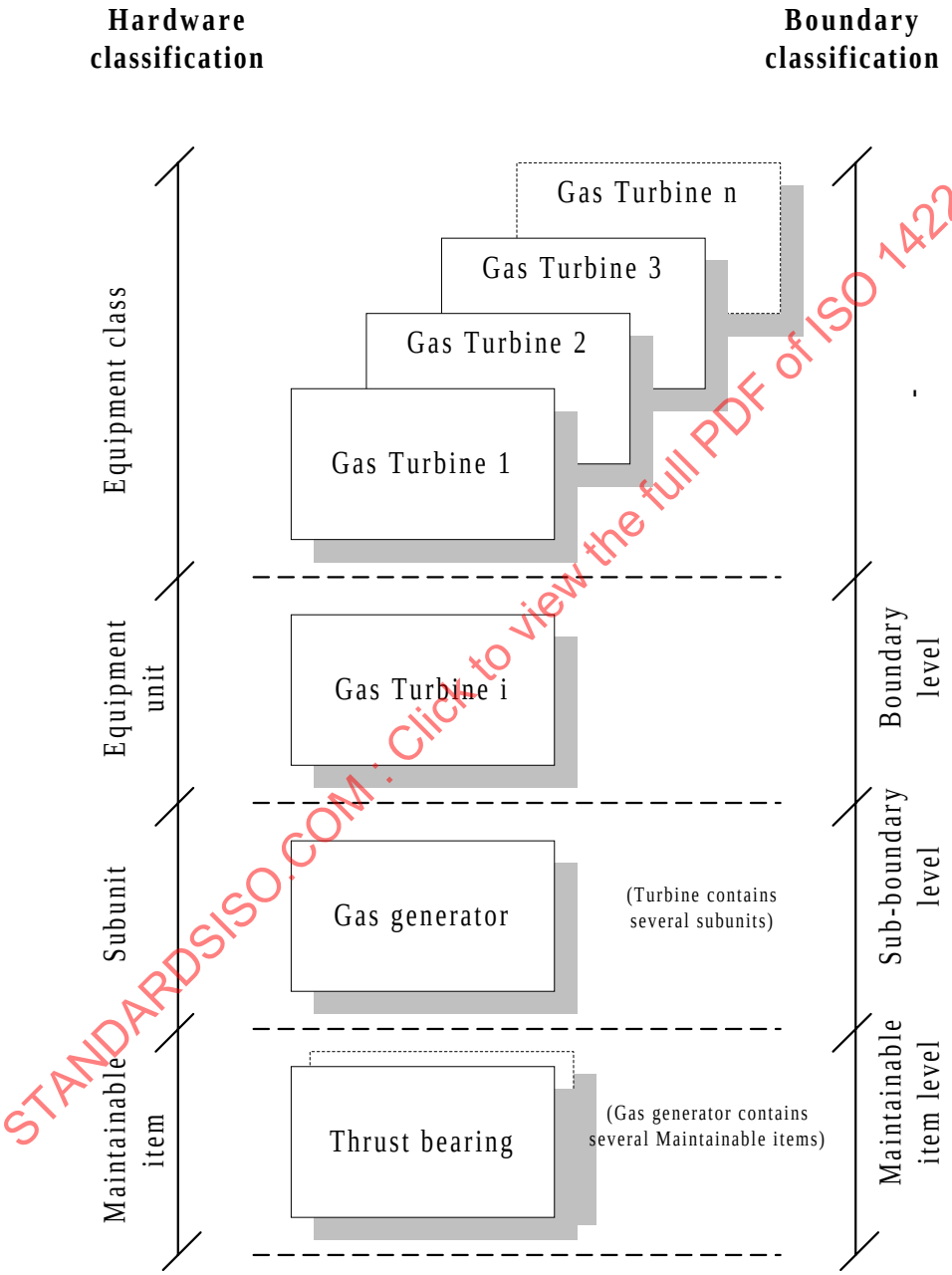


Figure 2 — Example of equipment hierarchy

6 Information structure

6.1 Data categories

The RM data shall be collected in an organized and structured way. The major data categories for equipment, failure and maintenance data are given below.

a) Equipment data

The description of equipment is characterized by:

1) identification data, e.g. equipment location, classification, installation data, equipment unit data;

2) design data, e.g. manufacturer's data, design characteristics;

3) application data, e.g. operation, environment.

These data categories shall be general for all equipment classes, e.g. type classification, and specific for each equipment unit, e.g. number of stages for a compressor. This shall be reflected in the database structure. For more details see Table 1.

b) Failure data

These data are characterized by:

1) identification data, failure record and equipment location;

2) failure data for characterizing a failure, e.g. failure date, maintainable items failed, severity class, failure mode, failure cause, method of observation.

For more details see Table 2.

c) Maintenance data

These data are characterized by:

1) identification data; e.g. maintenance record, equipment location, failure record;

2) maintenance data; parameters characterizing a maintenance, e.g. date of maintenance, maintenance category, maintenance activity, items maintained, maintenance man hours per discipline, active maintenance time, down time.

For more details see Table 3.

The type of failure and maintenance data shall normally be common for all equipment classes, with exceptions where specific data types need to be collected, e.g. subsea equipment.

Corrective maintenance events shall be recorded in order to describe the corrective action following a failure. Preventive maintenance records are required to retain the complete lifetime history of an equipment unit.

6.2 Data format

Each record, e.g. a failure event, shall be identified in the database by a number of attributes. Each attribute describes one piece of information, e.g. the failure mode. It is recommended that each piece of information be coded where possible. The advantages of this approach versus free text are:

— facilitation of queries and analysis of data;

— ease of data input;

— consistency check undertaken at input, by having pre-defined codes.

The range of pre-defined codes shall be optimized. A short range of codes may be too general to be useful. A long range of codes may give a more precise description, but will slow the input process and may not be used fully by the data acquirer. Examples of this are given in annex A and annex B for different equipment types and codes.

The disadvantage of a pre-defined list of codes versus free text is that some detailed information may be lost. It is recommended that free text be included to provide supplementary information. A free-text field with additional information is also useful for quality control of data.

Table 1 — Equipment data

Main categories	Subcategories	Data
Identification	Equipment location	Equipment tag number (*)
	Classification	Equipment unit class, e.g. compressor (see annex A) (*) Equipment type (see annex A) (*) Application (see annex A)(*)
	Installation data	Installation code or name (*) Installation category, e.g. platform, subsea, refinery (*) Operation category, e.g. manned, remote controlled (*) Geographic area, e.g. Southern North Sea, Adriatic Sea, Gulf of Mexico, continental Europe, Middle East
	Equipment unit data	Equipment unit description (nomenclature) Unique number, e.g. serial number Subunit redundancy, e.g. number of redundant subunits
Design	Manufacturer's data	Manufacturer's name (*) Manufacturer's model designation (*)
	Design characteristics	Relevant for each equipment class, e.g. capacity, power, speed, pressure, see annex A (*)
Application	Operation (normal use)	Equipment unit redundancy, e.g. 3 × 50 % Mode while in the operating state, e.g. continuous running, standby, normally closed/open, intermittent Date the equipment unit was installed or date of production start-up Surveillance period (calendar time)(*) The accumulated operating time during the surveillance period Number of demands during the surveillance period as applicable Operating parameters as relevant for each equipment class, e.g. operating power, operating speed, see annex A
	Environmental factors	Ambient conditions (severe, moderate, benign) [a] Interior environment (severe, moderate, benign) [b]
Remarks	Additional information	Additional information in free text as applicable Source of data, e.g. process and instrumentation diagram, data sheet, maintenance system

[a] Features to be considered, e.g. degree of protective enclosure, vibration, salt spray or other corrosive external fluids, dust, heat, humidity.

[b] Features to be considered, e.g. for compressor, benign (gas - clean and dry), moderate (some droplets corrosion), severe (sour gas, high CO_2, high particle content).

Table 2 — Failure data

Category	Data	Description
Identification	Failure record (*)	Unique failure identification
	Equipment location (*)	Tag number
Failure data	Failure date (*)	Date of failure detection (year/month/day)
	Failure mode (*)	At equipment unit level (see annex A)
	Impact of failure on operation	Zero, partial or total (safety consequences may also be included)
	Severity class (*)	Effect on equipment unit function: critical failure, non-critical failure
	Failure descriptor	The descriptor of the failure (see Table B.1)
	Failure cause	Cause of the failure (see Table B.2)
	Subunit failed	Name of subunit that failed (see examples in annex A)
	Maintainable item(s) failed	Specify the failed maintainable item(s) (see annex A)
	Method of observation	How the failure was detected (see Table B.3)
Remarks	Additional information	Give more details, if available, on the circumstances leading to the failure, additional information on failure cause, etc.

Table 3 — Maintenance data

Category	Data	Description
Identification	Maintenance record (*)	Unique maintenance identification
	Equipment location (*)	Tag number
	Failure record (*)	Corresponding failure identification (corrective maintenance only)
Maintenance data	Date of maintenance (*)	Date when maintenance action was undertaken
	Maintenance category	Corrective maintenance or preventive maintenance
	Maintenance activity	Description of maintenance activity (see Table B.4)
	Impact of maintenance on operation	Zero, partial or total, (safety consequences may also be included)
	Subunit maintained	Name of subunit maintained (see annex A) [a]
	Maintainable item(s) maintained	Specify the maintainable item(s) that were maintained (see annex A)
Maintenance resources [b]	Maintenance man-hours, per discipline [b]	Maintenance man-hours per discipline (mechanical, electrical, instrument, others)
	Maintenance man-hours, total	Total maintenance man-hours
Maintenance time	Active maintenance time	Time duration for active maintenance work on the equipment [c]
	Down time	Time interval during which an item is in a down state
Remarks	Additional information	Give more details, if available, on the maintenance action, e.g. abnormal waiting time, relation to other maintenance tasks

[a] For corrective maintenance, the subunit maintained will normally be identical with the one specified on the failure event report (see 7.2).

[b] For subsea equipment, the following apply:

— type of main resource(s) and number of days used, e.g. drilling rig, diving vessel, service vessel (*);

— type of supplementary resource(s) and number of hours used, e.g. divers, ROV/ROT, platform personnel.

[c] This information is desirable for RAM and RCM analyses. It is currently infrequently recorded in the maintenance management systems. The reporting of this information shall be improved.

6.3 Database structure

The data collected shall be organized and linked in a database to provide easy access for updates, queries and analysis, e.g. statistics, lifetime analysis. An example of how the information in the database may be logically structured is shown in Figure 3.

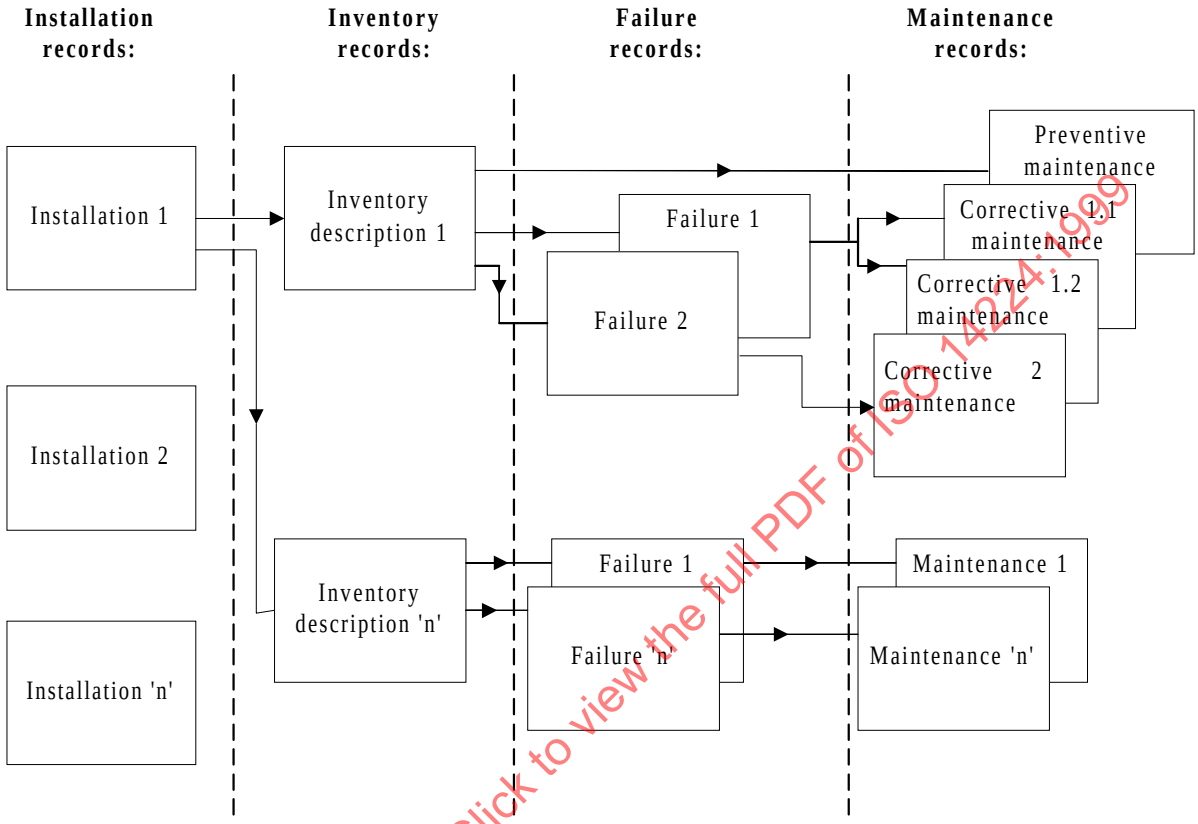


Figure 3 — Database structure

7 Equipment, failure and maintenance data

7.1 Equipment data

The classification of equipment into technical, operational and environmental parameters is the basis for the collection of RM data. This information is also necessary to determine if the data are suitable or valid for various applications. There are some data which are common to all equipment classes and some data which are specific for each equipment class.

To ensure that the objectives of this International Standard are met, a minimum of data shall be collected. These data are identified by an asterisk (*) in Tables 1, 2 and 3.

Table 1 contains the data common to all equipment classes. In addition some data which are specific for each equipment class shall be reported. Annex A gives examples of such data for some equipment classes. In the examples in annex A, priority data are indicated.

The minimum data needed to meet the objectives of this International Standard are identified by (*). However, certain additional data categories may significantly improve the potential uses for RM data, see annex D.

NOTE Some features under main category “Application” in Table 1 may vary with time. Some of this information is linked with information gathered from the production consequence upon failure or maintenance. This information has a significant bearing on the interpretation of down time.

7.2 Failure data

A uniform definition of failure and a method of classifying failures are essential when data from different sources (plants and operators) need to be combined in a common RM database.

A common report for all equipment classes shall be used for reporting failure data. The data are given in Table 2.

The minimum data needed to meet the objectives of this International Standard are identified by (*). However, certain additional data categories may significantly improve the potential uses for RM data, see annex D.

7.3 Maintenance data

Maintenance is carried out:

a) to correct a failure (corrective maintenance). The failure shall be reported as described in 7.2;

b) as a planned and normally periodic action to prevent failure from occurring (preventive maintenance).

A common report for all equipment classes shall be used for reporting maintenance data. The data required are given in Table 3.

The minimum data needed to meet the objectives of this International Standard are identified by (*). However, certain additional data categories may significantly improve the potential uses for RM data, see annex D.

Annex A
(informative)

Equipment class attributes

A.1 Advisory notes

A.1.1 General

Annex A gives examples in Tables A.1 to A.66 on how some typical oil and gas equipment may be categorized as to taxonomy, boundary definition, inventory data and failure modes. These data are specific for each equipment unit. Data common for all equipment units are shown in annex B.

In this categorization, a standardization approach has been applied to classification and subdivision of units. This means that the total number of different data categories and definitions are reduced, while at the same time there are fewer tailor-made definitions and codes for each individual equipment unit. The user should therefore apply those categories and codes which are applicable to the specific equipment unit for which data are being collected. For equipment units of special design, a more tailor-made categorization than that shown in these examples may be required.

In the tables in which equipment is broken down into “subunit” and “maintainable items” (e.g. Table A.2), it is recommended to include additional “maintainable items”, as needed, to cover instrumentation, and an “unknown” category in case information is not available.

A.1.2 Boundary definitions

The purpose of the boundary definition is to ensure a common understanding of what equipment is to be included within the boundary of a particular system, and hence which failures and maintenance to record. For definition of the boundaries, the following rules are recommended:

a) exclude connected items from the equipment unit boundary, unless specifically included by the boundary specification. Failures that occur in a connection (e.g. leak), and which cannot be solely related to the *connected item*, should be included within the bounday definition;

b) when a driver and the driven unit use a common subunit (e.g. lubrication system), relate failure on this subunit, as a general rule, to the *driven unit*;

c) include instrumentation only where it has a specific control and/or monitoring function for the equipment unit in question and/or is locally mounted on the equipment unit. Control and supervisory instrumentation of more general use (e.g. SCADA-systems) should not, as a rule, be included.

A.1.3 Failure modes

In annex A, a list of relevant failure modes is given for each equipment unit. The failure modes should be related to the equipment unit level in the hierarchy. The failure modes used can be categorized in three types:

a) the desired *function is not obtained* (e.g. fail to start);

b) there is a deviation in a specified *function outside accepted limits* (e.g. high output);

c) there is a *failure indication* observed, but there is no immediate and critical impact on equipment unit function (e.g. leakage).

For the latter category the failure mode should describe the *failure indication on equipment unit level*, while the failure descriptor should describe the *cause of failure on the lowest level within the equipment hierarchy* for which this information is known.

A.2 Process equipment

A.2.1 Combustion engines (piston)

Table A.1 — Taxonomy classification — Combustion engines

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Combustion engines - piston (diesel/gas engines)	CE	Diesel engine	DE	Main power	MP
		Gas engine	GE	Essential power	EP
				Emergency power	EM
				Water injection	WI
				Oil handling	OH
				Gas handling	GH
				Water fire-fighting	FF
				Material handling	MH

NOTE In Table A.1 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

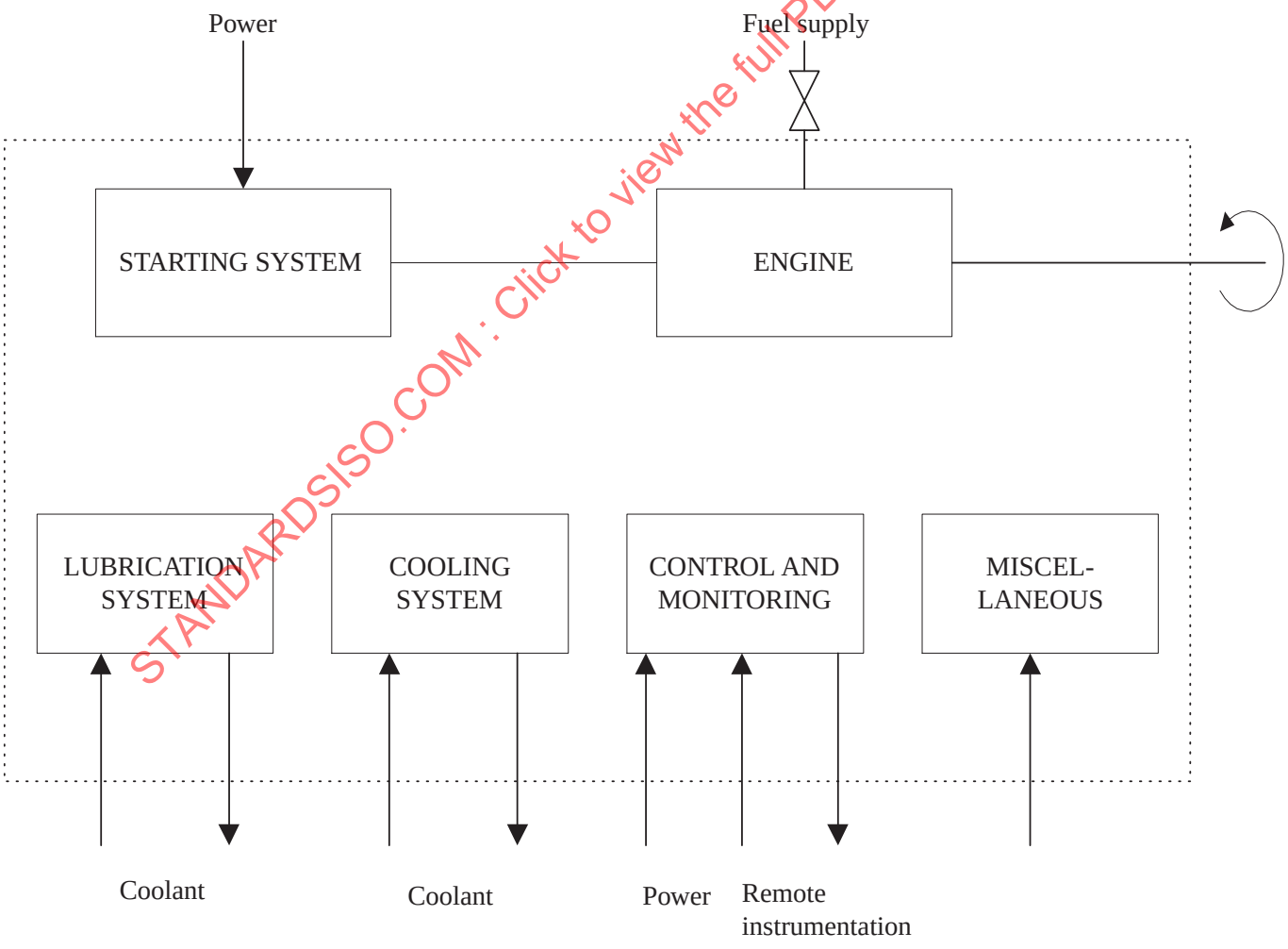


Figure A.1 — Equipment boundary — Combustion engines

Table A.2 — Equipment unit subdivision — Combustion engines

Equipment unit	Combustion engines					
Subunit	Start system	Combustion engine unit	Control and monitoring	Lubrication system	Cooling system	Miscel-laneous
Maintainable items	Start energy (battery, air) Starting unit Start control	Air inlet Turbocharger Fuel pumps Injectors Fuel filters Exhaust Cylinders Pistons Shaft Thrust bearing Radial bearing Seals Piping Valves	Control Actuating device Monitoring Valves Internal power supply	Reservoir Pump w/motor Filter Cooler Valves Piping Oil Temperature control	Heat exchanger Fan and motor Filter Valves Piping Pump Temperature control	Hood Others Flange joints

Table A.3 — Equipment unit specific data — Combustion engines

Name	Description	Unit or code list
Driver application (*)	Name of driven unit	Pump, generator, compressor
Corresponding driven unit	Specify identification number of driven unit	Numeric
Power- design (*)	Max. rated output (design)	kW
Power - operating (*)	Specify the approximate power at which the unit has been operated for most of surveillance time	kW
Speed (*)	Design speed	r/min
Number of cylinders	Specify number of cylinders	Integer
Cylinder configuration	Type	Inline, vee, flat
Starting system (*)	Type	Electric, hydraulic, pneumatic
Fuel	Type	Gas, light oil, medium oil, heavy oil, dual
Air inlet filtration type	Type	Free text
Engine aspiration type (*)	Type of engine aspiration	Turbo, natural
(*) Indicates high-priority information.		

Table A.4 — Failure modes — Combustion engines

Equipment unit	Code	Definition	Description
Combustion engine	FTS	Fail to start on demand	Unable to start the engine
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected shutdown of engine
	OWD	Operation without demand	Undesired start
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	HIO	High output	Overspeed/output above specification
	LOO	Low output	Output below desired specification
	ERO	Erratic output	Oscillating or hunting
	ELF	External leakage - fuel	Fuel gas or diesel leak
	ELU	External leakage utility medium	Lube oil, coolant, etc.
	INL	Internal leakage	E.g. internal cooling water leakage
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in cylinder head, support
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.2 Compressors

Table A.5 — Taxonomy classification — Compressors

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Compressor	CO	Centrifugal	CE	Gas processing	GP
		Reciprocating	RE	Gas export	GE
		Screw	SC	Gas injection	GI
		Blowers/fans	BL	Lift gas compression	GL
		Axial	AX	Compressed air	AI
				Refrigeration	RE

NOTE In Table A.5 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

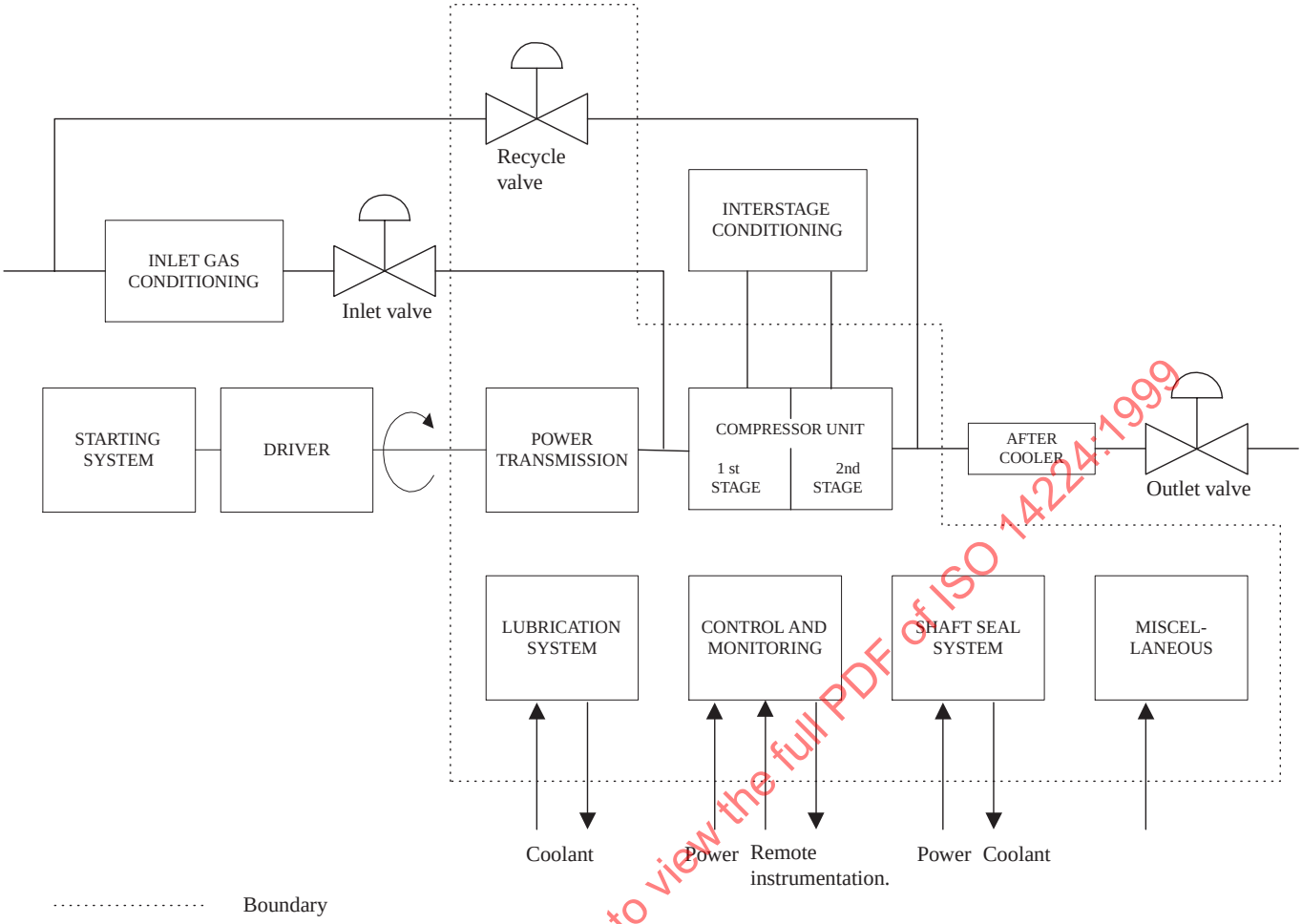


Figure A.2 — Equipment boundary — Compressors

Table A.6 — Equipment unit subdivision — Compressors

Equipment unit	**Compressors**					
Subunit	Power transmission	Compressor	Control and monitoring	Lubrication system	Shaft seal system	Miscel-laneous
Maintainable items	Gearbox/variable drive Bearings Coupling to the driver Lubrication Seals Coupling to the driven unit	Casing Rotor with impellers Balance piston Interstage seals Radial bearing Thrust bearing Shaft seals Internal piping Valves Antisurge system including recycle valve and controllers Piston Cylinder liner Packing	Control Actuating device Monitoring Valves Internal power supply	Oil tank with heating system Pump with motor Check valves Coolers Filters Piping Valves Lube oil	Oil tank with heating Reservoir Pump with motor/gear Filters Valves Buffer gas Seal oil Dry gas seal Seal gas Scrubber	Base frame Piping, pipe support and bellows Control-isolation and check valves Coolers Silencers Purge air Magnetic bearing control system Flange joints Others

NOTE The maintainable Items listed in Table A.6 should be applied as relevant for the compressor type.

Table A.7 — Equipment unit specific data — Compressors

Name	Description	Unit or code list
Corresponding driver (*)	Specify unique record identification number when relevant	Numeric
Gas handled (*)	Average molar mass (specific gravity × 28,96)	g/mol
Suction pressure - design (*)	First stage	pascal (bar)
Suction pressure - operating	First stage	pascal (bar)
Discharge pressure - design (*)	Last stage	pascal (bar)
Discharge pressure - operating (*)	Last stage	pascal (bar)
Flowrate - design (*)		m^3/h
Flowrate - operating		m^3/h
Discharge temperature - design (*)		°C
Discharge temperature - operating		°C
Power - design (*)	Design power	kW
Utilization (*)	% utilization compared to design	%
Polytrophic head		kJ/kg
Number of casings (*)	Number of casings in the train	Integer
Number of stages (*)	Number of compressor stages (not impellers) in this train	Integer
Body type	Type	Vertical split case (barrel type), axial split case
Shaft sealing	Type	Mechanical, oil, dry gas-packed, dry gland, labyrinth, combined
Inter cooler fitted	Specify if cooler is fitted	Yes/no
Shaft seal system (*)	Separate, combined, dry, etc.	Separate, combined, dry
Radial bearing (*) Thrust bearing (*)	Type (specify in comment field whether any thrust pressure regulator is installed)	Antifrictional, journal, magnetic
Speed	Design speed	r/min
Type of driver (*)	Type	Electric motor, gas turbine, steam turbine, diesel engine, gas engine, turboexpander, integral gas motor
Coupling	Type	Fixed, flexible, hydraulic, disconnect
Reciprocating compressors only:		
Cylinder configuration		Inline, opposed, V, W
Cylinder orientation		Horizontal, vertical, inclined
Working principle (*)		Single-acting, double-acting
Packing type (*)		Lubricated, dry
(*) Indicates high priority information.		

Table A.8 — Failure modes — Compressors

Equipment unit	Code	Definition	Description
Compressor	FTS	Fail to start on demand	Unable to activate compressor
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown action
	SPS	Spurious stop	Unexpected shutdown of compressor
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	HIO	High output	Output pressure/flow above specification
	LOO	Low output	Output pressure/flow below specification
	ERO	Erratic output	Oscillating or unstable pressure/flow
	ELP	External leakage process medium	Process medium escape to environment
	ELU	External leakage utility medium	Lube/seal oil, coolant, etc.
	INL	Internal leakage	E.g. process medium in lube oil
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in support or suspension
	SER	Minor in-service problems	Loose items, discoloration, contamination, etc.
	OTH	Other	None of above apply. Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.3 Control logic units

Table A.9 — Taxonomy classification — Control logic units

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Control logic units	CL	PLC	LC	Fire and gas detection	FG
		Computer	PC	Process shutdown	PS
		Distributed control system	DC	Emergency shutdown	ES
		Relay	RL	Process shutdown and ESD	CS
		Solid state	SS	Process control	PC
		Single loop controller	SL		

NOTE In Table A.9 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

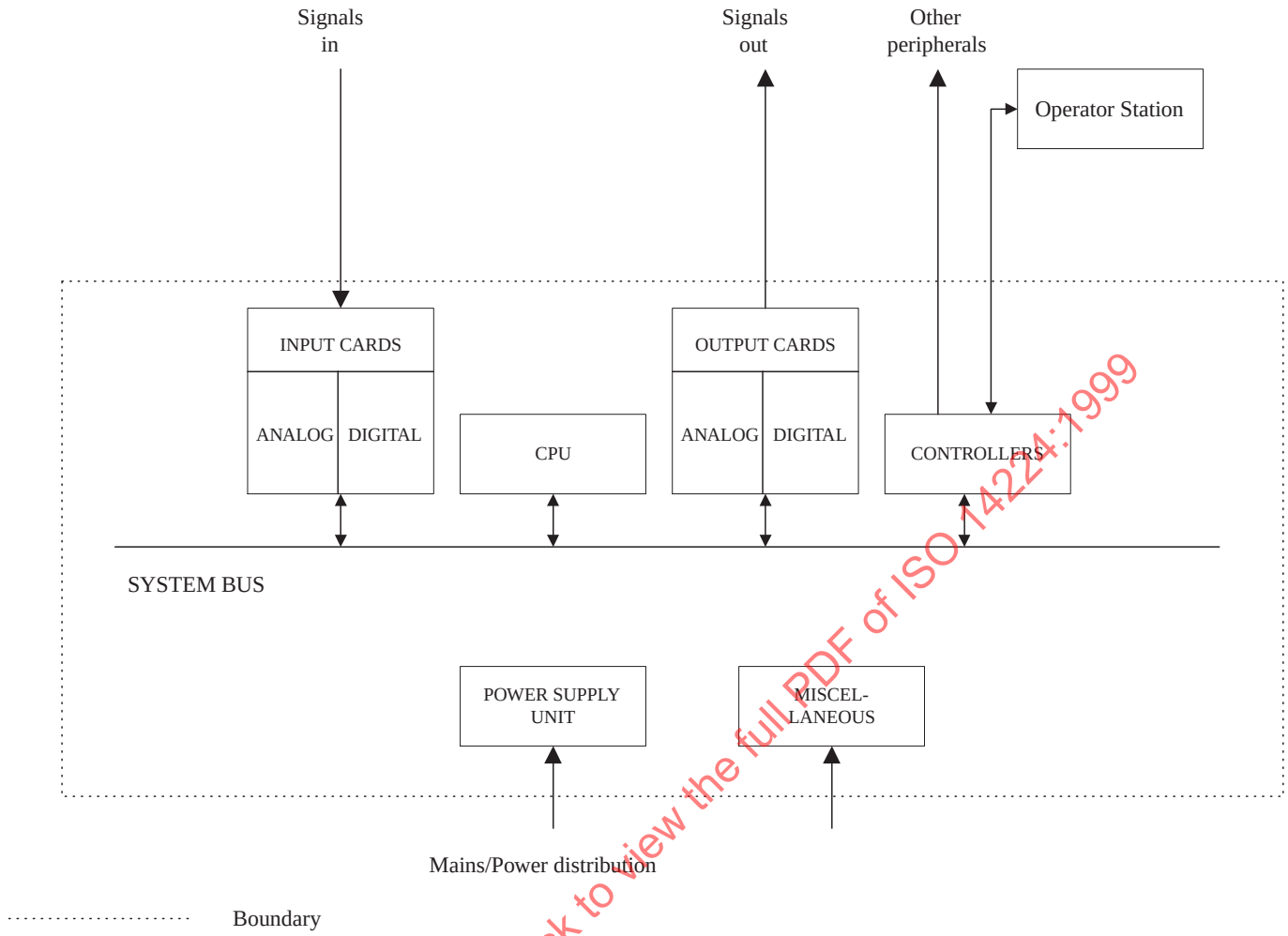


Figure A.3 — Equipment boundary — Control logic units

Table A.10 — Equipment unit subdivision — Control logic units

Equipment unit	**Control logic units**				
Subunit	Analog input cards	Digital input cards	Analog output cards	Digital output cards	Central processor unit
Maintainable items	Input card Connection unit	Input card Connection unit	Output card Connection unit Relay	Output card Connection unit Relay	Central processor unit (CPU) Random access memory (RAM) Watchdog/diagnostics Software
Subunit	Controllers		System bus	Power supply	Miscellaneous
Maintainable items	Internal bus controller Visual display unit control (VDU) Communication control Disk control Printer control		(No subdivision)	(No subdivision)	Others

Table A.11 — Equipment unit specific data — Control logic units

Name	Description	Unit or code list
Application - control logic (*)	Where used	Fire and gas detection, process shutdown, emergency shutdown, process control, monitoring
Central process unit voting (*)	At least *k* out of *n* sensors shall provide signal to initiate safety action - *k* and *n* shall be entered	*k* = '*nn*' (integer) *n* = '*nn*' (integer)
(*) Indicates high priority information.		

Table A.12 — Failure modes — Control logic units

Equipment unit	Code	Definition	Description
Control logic units	FTF	Fail to function on demand	Fail to activate output function
	OWD	Operates without demand	False alarm
	AOL	Abnormal output - Low	Trend toward FTF failure, e.g low output
	AOH	Abnormal output - High	Trend toward OWD failure, e.g. high output
	ERO	Erratic output	Reading not intelligible, e.g. oscillating
	SER	Minor in-service problems	Some minor repair required
	UNK	Unknown	Inadequate/missing information
	OTH	Other	None of the above apply. Specify in comment field

A.2.4 Electric generators

Table A.13 — Taxonomy classification — Electric generators

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Electric generator	EG	Gas turbine driven	TD	Main power	MP
		Steam turbine driven	SD	Essential power	EP
		Engine driven, e.g. diesel engine, gas engine	MD	Emergency power	EM

NOTE In Table A.13 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

Table A.14 — Equipment unit subdivision — Electric generators

Equipment unit	Electric generators					
Subunit	Power transmission	Electric generator	Control and monitoring	Lubrication system	Cooling system	Miscellaneous
Maintainable items	Gearbox	Stator	Control	Reservoir	Heat exchanger	Hood
	Bearing	Rotor	Actuating device	Pump with motor	Fan with motor	Purge air
	Seals	Excitation	Monitoring	Filter	Filter	Others
	Lubrication	Radial bearing	Valves	Cooler	Valves	
	Coupling to driver		Internal power supply	Valves	Piping	
	Coupling to driven unit	Thrust bearing		Piping	Pump with motor	
				Oil		

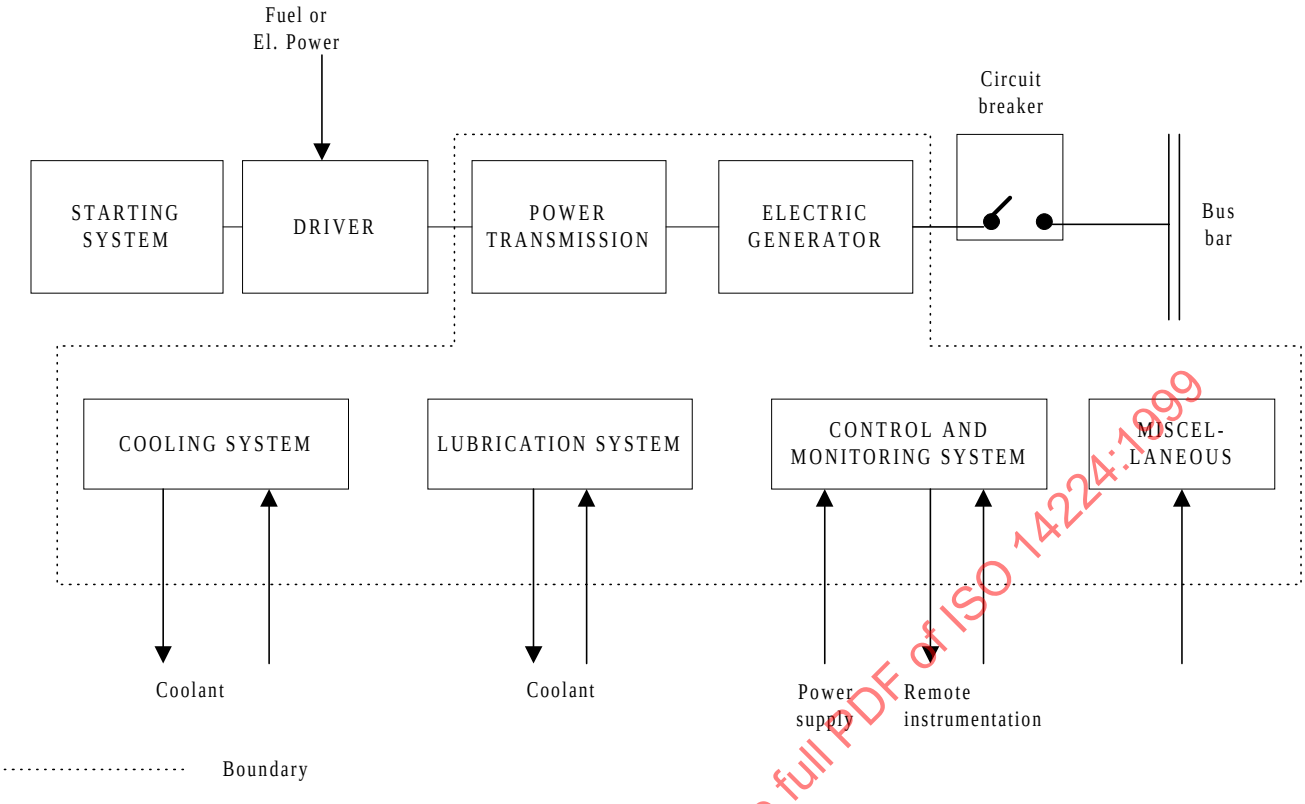


Figure A.4 — Equipment boundary — Electric generators

Table A.15 — Equipment unit specific data — Electric generators

Name	Description	Unit or code list
Corresponding driver (*)	Specify driver identification number when relevant	Numeric
Type of driver (*)	Type	Electric motor, gas turbine, steam turbine, diesel engine, gas engine
Coupling	Specify (fixed, flexible, etc.)	Fixed, flexible, hydraulic, disconnect
Synchronous speed (*)		r/min
Frequency	Design frequency	Hz
Voltage (*)	Design voltage	kV
Power - design	Design power	kW
Power factor	cos φ	Numeric
Excitation control (*)	Type	Automatic, manual
Excitation type (*)	Brushless/slip-ring	Brushless, slip-ring
Degree of protection	Protection class according to IEC 60529	
Insulation class - stator (*)	Insulation class according to IEC 60085	Y, A, E, B, F, H, 200, 220, 250
Temperature rise - stator		°C
Insulation class - rotor	Insulation class according to IEC 60085	Y, A, E, B, F, H, 200, 220, 250
Temperature rise - rotor		°C
Radial bearing(*) Thrust bearing	Type	Antifrictional, journal, magnetic
Lubrication of bearings	Type of bearing lubrication	Grease, oil bath, pressurized oil, oil ring
Generator cooling (*)	Type	Air/air, air/water, open ventilated
(*) Indicates high-priority information.		

Table A.16 — Failure modes — Electric generators

Equipment unit	Code	Definition	Description
Electric generators	FTS	Fail to start on demand	Unable to activate generator
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected shutdown of generator
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	SYN	Fail to synchronise	Unable to synchronise generator
	FOF	Faulty output frequency	
	FOV	Faulty output voltage	
	LOO	Low output	Reduced power delivery
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	ELU	External leakage utility medium	Lube oil, coolant, etc.
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in support or suspension
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.5 Electric motors

Table A.17 — Taxonomy classification — Electric motors

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Electric motor	EM	Alternating current	AC	Water fire-fighting	FF
		Direct current	DC	Water injection	WI
				Oil handling	OH
				Gas handling	GH
				Gas processing	GP
				Chemical injection	CI
				Sea-water lift	SL

NOTE In Table A.17 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

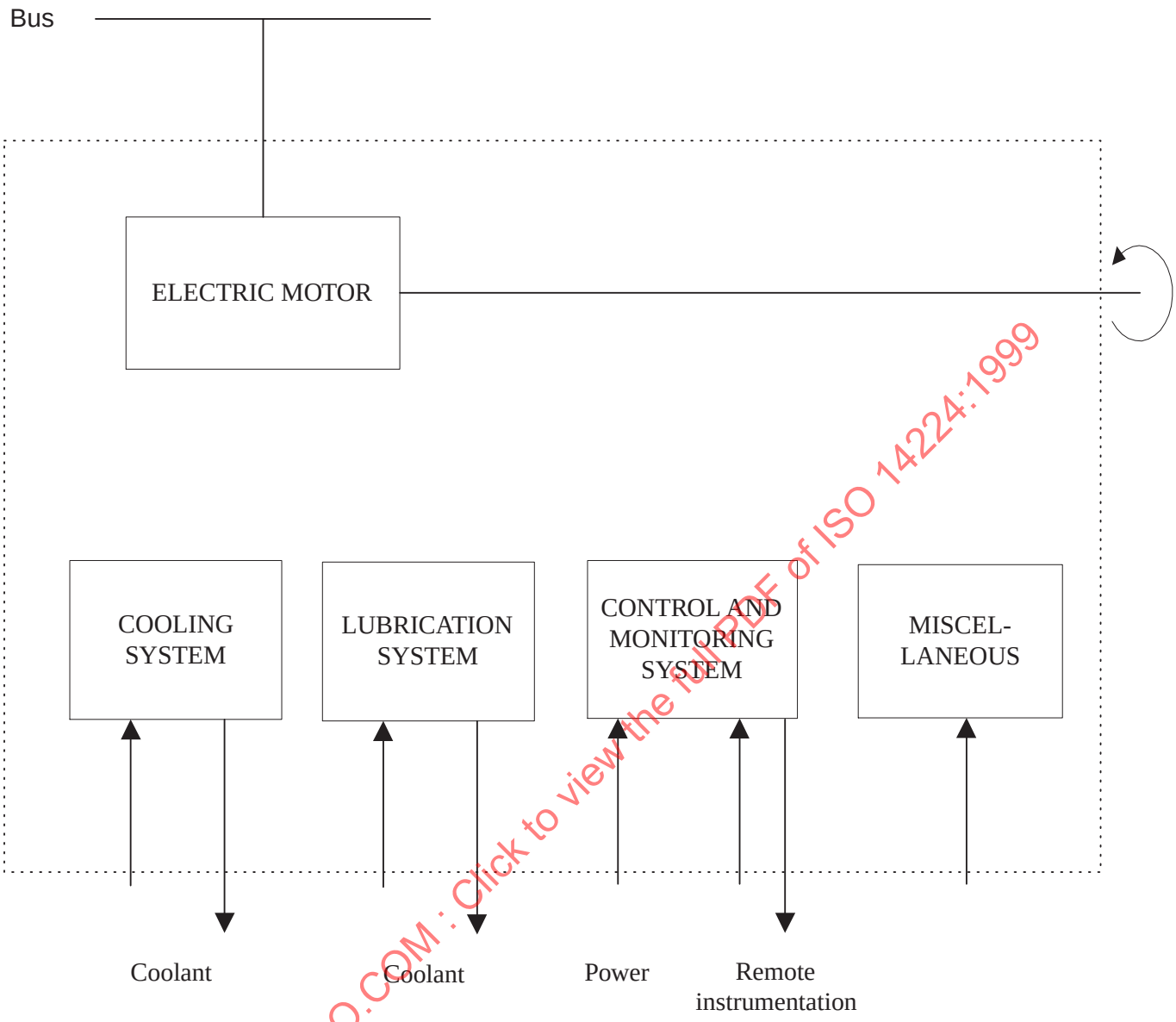


Figure A.5 — Equipment boundary — Electric motors

Table A.18 — Equipment unit subdivision — Electric motors

Subunit	Electric motor	Control and monitoring [a]	Lubrication system	Cooling system	Miscellaneous
Maintainable items	Stator Rotor Excitation Radial bearing Thrust bearing Coupling	Control Actuating device Monitoring Valves Internal power supply	Reservoir Pump with motor Filter Cooler Valves Piping Oil	Heat exchanger Filter Valves Piping Pump with motor Fan with motor	Hood Others

[a] Normally no extra control system for motors. For motors of Ex(p) class (pressurized) the internal pressure is monitored. Temperature may be monitored on large motors.

Table A.19 — Equipment unit specific data — Electric motors

Name	Description	Unit or code list
Corresponding driven unit	Specify driver identification number when relevant	Numeric
Driver application (*)	Type of driven unit	Pump, compressor
Power - design (*)	Max. output (design)	kW
Power - operating	Specify the approximate power at which the unit has been operated for most of surveillance time	kW
Variable speed	Specify if installed or not	Yes/No
Speed (*)	Design speed	r/min
Voltage (*)	Design voltage	V
Motor type (*)	Type	Induction, commutator (d.c.), synchronous
Radial bearing (*) Thrust bearing	Type	Antifrictional, journal, magnetic
Degree of protection (*)	Protection class according to IEC 60529	
Safety class (*)	Explosion/fire classification category, e.g. Ex(d), Ex(e)	e.g.: Ex(d), Ex(e)
(*) Indicates high-priority information.		

Table A.20 — Failure modes — Electric motors

Equipment unit	Code	Definition	Description
Electric motors	FTS	Fail to start on demand	Unable to activate motor
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected stop of motor
	OWD	Operation without demand	Undesired start
	BRD	Breakdown	Serious damage (seizure, breakage, explosion)
	HIO	High output	Output above specification
	LOO	Low output	Reduced power delivery
	ERO	Erratic output	Oscillating
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	ELU	External leakage utility medium	Lube oil, coolant, etc.
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks, wear, fracture
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.6 Fire and gas detectors

Table A.21 — Taxonomy classification — Fire and gas detectors

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Fire and gas detectors	FG	Smoke/Combustion	BS	Fire detection	FD
		Heat	BH		
		Flame	BF		
		Hydrocarbon	AB	Gas detection	GD
		H_2S	AS		

NOTE In Table A.21 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

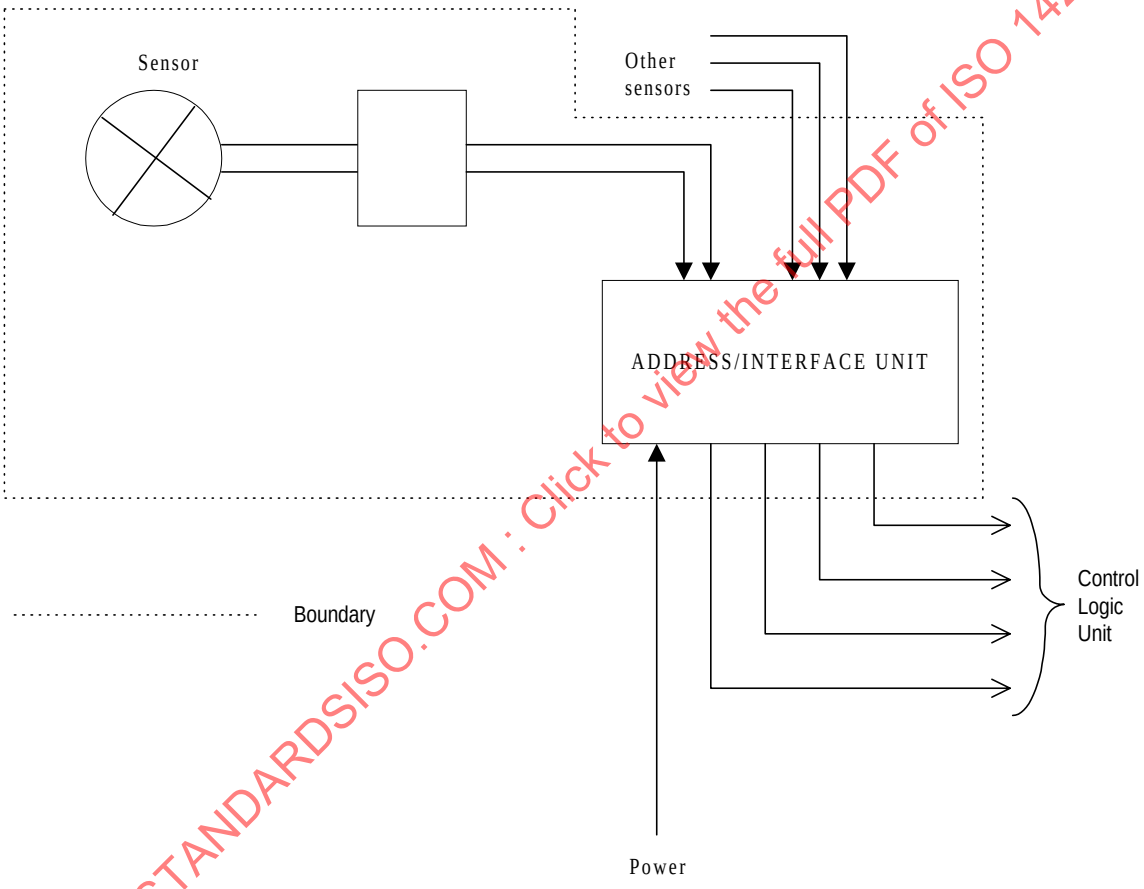


Figure A.6 — Equipment boundary — Fire and gas detectors

Table A.22 — Equipment unit subdivision — Fire and gas detectors

Equipment unit	Fire and gas detectors		
Subunit	Sensor	Interface unit	Miscellaneous
Maintainable items	Mounting socket	Control card	Others
	Detector head	Display	
	Cover	Cabinet	
		Cabling	

Table A.23 — Equipment unit specific data — Fire and gas detectors

Name	Description	Unit or code list
Location on installation (*)	Where installed	Wellhead, christmas tree, wellhead flow line, wellhead injection line, pump, turbine, electric generator, separator, heat exchanger, vessel, header, electric motor, turboexpander, drilling, pipeline, mud processing, utility, living quarter, air inlet, alkylation unit, isomerization units, catalytic crackers, control room, auxiliary room, MCC and switch room
Sensor voting, *k* out of *n*	At least *k* out of *n* sensors shall provide signal to initiate safety action - *k* and *n* shall be entered	*k* = '*nn*' (integer) *n* = '*nn*' (integer)
Loop voting, *i* out of *j*	At least *i* out of *j* loops shall provide signal to carry out safety action - *i* and *j* shall be entered. If there is no voting on loops, leave blank	*i* = '*nn*' (integer) *j* = '*nn*' (integer)
Sensing principle (*)	Type	Catalytic, electrochemical, ionization, photoelectro-chemical, photoelectric beam, IR, UV, IR/UV, rate rise, rate comp, fixed temp, fusible plug
Fail-safe principle (*)	Normally energized, normally de-energized. Normally not applicable for analog equipment	Energized, de-energized
Detector communication†(*)	Type	Conventional, addressable (one-way), smart (two-way)
Self-test feature (*)	Degree of self-testing	No self-test, automatic loop test, built-in test
Detailed operational time	Reflects completeness of source material	Additional comments for the collection of operating time on fire and gas detectors and process sensors
Safety class	Ex standard	Ex(d), Ex(e), None
(*) Indicates high-priority information.		

This set of data fields is included in the specific inventory report for fire and gas detectors and process sensors to keep track of the large variations in the use and the level of detail in the data reported into the facility information management The data fields in Table A.24 indicate the total time during the surveillance period during which different failure categories have been available. This time is recorded in hours as for surveillance time, and will always be less than or equal to the surveillance time.

The data fields are organized in a matrix as shown in Table A.24.

The data fields should be filled in, based on what is *actually* available and not what *should* be available according to operator procedures.

Without this information, analysis of the data may lead to the overall conclusion that the operator which has the most comprehensive history reports, also has the highest estimated failure rate for detectors/sensors. For instance, one operator may not record replacement of a detector head if this is carried out as part of the preventive maintenance. Comparing the failure rate of this operator with the failure rate of another operator that records any replacement would be misleading.

Thus, in order to compare like with like, the part of the total surveillance period during which data on each Restoration Activity/Failure Mode combination has been recorded, should be specified. The various combinations are indicated in the matrix given below; e.g.: If the surveillance period is 10 000 h and t_R is 5 000 h, this means that in half of the surveillance period, data on *replacement* (including all failure modes) have been recorded and are available for the data acquirer(s).

Table A.24 — Data recording times for combinations of repair type/ failure mode for fire and gas detectors and process sensors

Maintenance activity	Failure mode			
	FTF [a] NOO/ VLO [b]	SPO SLL/SHH	HIO/LOO/ SER/OVH OTHERS	ALL MODES
Replace (by maintenance personnel)	t_R^F	t_R^S	t_R^O	t_R
Adjust/Repair/Refit (by maintenance personnel)	t_A^F	t_A^S	t_A^O	t_A
Check (Restart) (by operations personnel)	t_C^F	t_C^S		t_C
All repair activities	t^F	t^S	t^O	t

[a] Failure mode applicable for fire detectors, process sensors and control logic units.

[b] Failure mode applicable for gas detectors.

The failure categories are defined as:

a) t_R Failure events in which the detector subunit has been *replaced*.

b) t_R^F Failure events in which the detector subunit has been replaced due to zero or very low detector output upon test condition (generally recorded in preventive maintenance reports).

c) T_R^S Failure events in which the detector subunit has been replaced due to false alarm signal (generally recorded in corrective maintenance reports).

d) T_R^O Failure events in which the detector subunit has been replaced due to failure modes other than FTF/SPO failure (generally recorded in preventive or corrective maintenance reports).

e) T_A Failure events in which the detector subunit has been repaired/adjusted/refitted.

f) t_A^F Failure events in which the detector subunit has been repaired/adjusted/refitted due to zero or very low detector output upon test condition (generally recorded in preventive maintenance reports).

g) T_A^S Failure events in which the detector subunit has been repaired/adjusted/refitted due to false alarm signal (generally recorded in corrective maintenance reports).

h) T_A^O Failure events in which the detector subunit has been repaired/adjusted/refitted due to failure modes other than FTF/ SPO failure (generally recorded in preventive/corrective maintenance reports or in detailed technical log books).

i) T_C Failure events in which the detector has not responded to a real fire condition or provided false alarm; restart only required to continue operation.

j) t_C^F Failure events in which the detector has not responded to a real fire condition; restart only required to continue operation (generally recorded in dedicated fire (near-miss) reports).

k) T_C^S Failure events in which the detector has provided a false alarm signal; restart only required to continue operation (generally recorded in control room log books or daily activity reports).

l) t^F, t^S, t^O, t Summary of times within each Failure mode category.

Table A.25 — Failure modes — Fire and gas detectors

Equipment unit	Code	Definition	Description
Fire detectors	FTF	Fail to function on demand	Unable to activate detector
	OWD	Operates without demand	False alarm
	AOL	Abnormal output - Low	Trend toward FTF failure, e.g. low output
	AOH	Abnormal output - High	Trend toward OWD failure, e.g. high output
	ERO	Erratic output	Reading not intelligible, e.g. oscillating
	SER	Minor in-service problems	Some minor repair required
	UNK	Unknown	Inadequate/missing information
	OTH	Other	Specify in comment field
Gas detectors	SHH	Spurious high level alarm signal	E.g. 60 % LEL
	SLL	Spurious low level alarm signal	E.g. 20 % LEL
	HIO	High output	E.g. reading 10 % - 20 % LEL without test gas/reading above 80 % LEL on test gas
	HIU	High output, unknown reading	—
	LOO	Low output	E.g. reading between 31 % - 50 % LEL upon test gas [a]
	LOU	Low output, unknown reading	—
	VLO	Very low output	E.g. reading between 11 % - 30 % LEL upon test gas
	NOO	No output	E.g. reading less than 10 % LEL upon test gas
	ERO	Erratic output	Reading not intelligible (e.g. oscillating)
	SER	Minor in-service problems	Some minor repair required

[a] Assuming a nominal set point of 65 % LEL.

A.2.7 Gas turbines

Table A.26 — Taxonomy classification — Gas turbines

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Gas turbine	GT	Industrial	IN	Oil handling	OH
		Aeroderivative	AD	Gas processing	GP
		Light industrial	LI	Gas export	GE
				Gas injection	GI
				Lift gas compression	GL
				Main power	MP
				Essential power	EP
				Emergency power	EM
				Water injection	WI
				Refrigeration	RE

NOTE In Table A.26 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

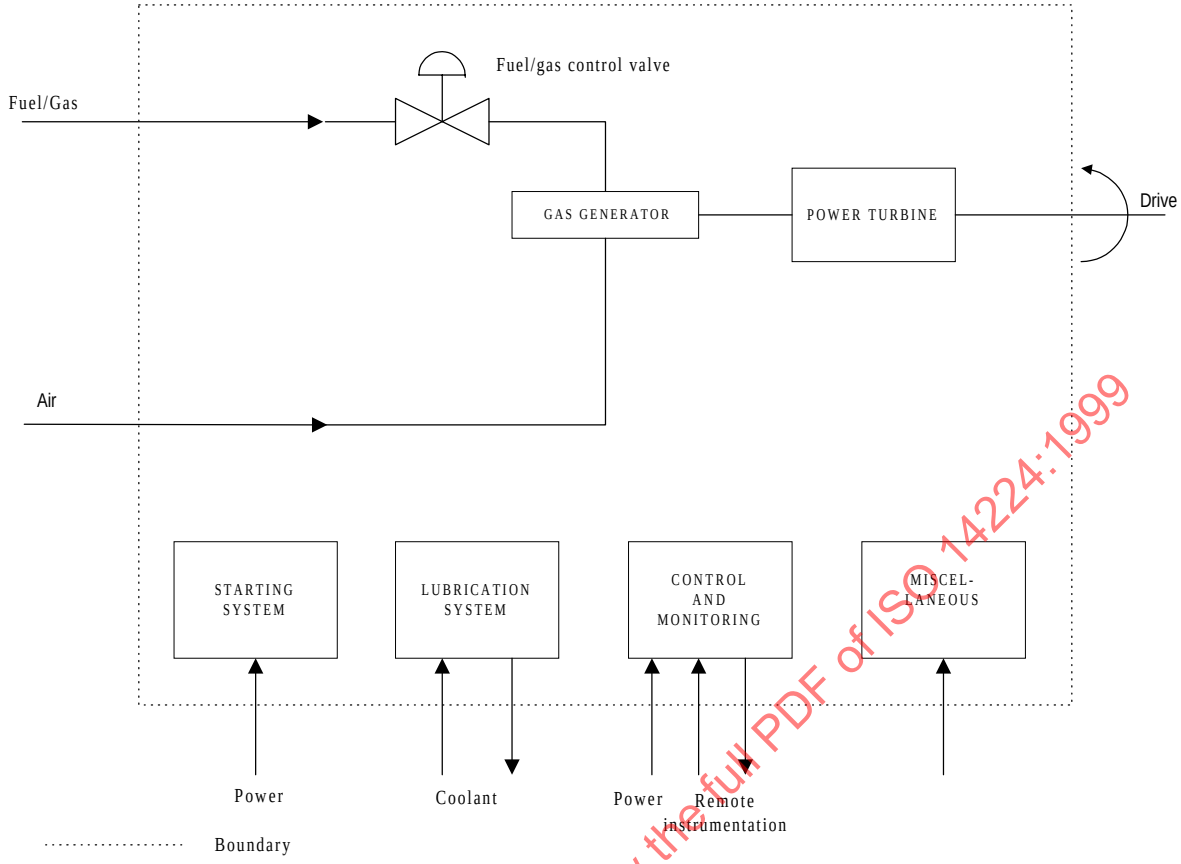


Figure A.7 — Equipment boundary — Gas turbines

Table A.27 — Equipment unit subdivision — Gas turbines

Equipment unit	**Gas turbines**					
Subunit	Starting system	Gas generator	Power turbine	Control and monitoring	Lubrication system	Miscel-laneous
Maintainable items	Start energy (battery, air) Starting unit Start control	Air inlet Compressor rotor Compressor stator Combustion chambers Burners Fuel control Turbine rotor Turbine stator Casing Thrust bearing Radial bearing Seals Valves Piping	Rotor Stator Casing Radial bearing Thrust bearing Seals Exhaust Valves Piping	Control Actuating device Monitoring Valves Internal power supply	Reservoir Pump with motor Filter Cooler Valves Piping Oil	Hood Purge air Flange joints Others Water wash system

Table A.28 — Equipment unit specific data — Gas turbines

Name	Description	Unit or code list
Power - design (*)	ISO power rating	kW
Power - operating (*)	Specify the approximate power at which the unit has been operated for most of the surveillance time	kW
Speed (*)	Design speed (power shaft)	r/min
No. of shafts (*)	Specify number	Number off
Starting system (*)	Specify main starting system	Electric, hydraulic, pneumatic
Backup starting system	Specify if relevant	Electric, hydraulic, pneumatic
Fuel (*)	Fuel type	Gas, oil-light, oil-medium, oil-heavy, dual
Driver application (*)	Type of driven unit	Pump, electric generator, compressor
Corresponding driven unit	Specify driver identification number when relevant	Numeric
Air inlet filtration type	Type	Free text
(*) Indicates high-priority information.		

Table A.29 — Failure modes — Gas turbines

Equipment unit	Code	Definition	Description
Gas turbines	FTS	Fail to start on demand	Unable to activate turbine
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected shutdown of turbine
	OWD	Operation without demand	Undesired start
	FCH	Fail to change between fuel type	Dual fuel engines: Fail to switch from one fuel type to another
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	HIO	High output	E.g. overspeed
	LOO	Low output	Efficiency/power below specification
	ERO	Erratic output	Unstable operation/rpm hunting
	ELF	External leakage - fuel	Fuel gas or diesel leakage
	ELU	External leakage utility medium	Lube/seal oil, coolant, etc.
	INL	Internal leakage	E.g. process medium in lube oil
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in support or suspension
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.8 Heat exchangers

Table A.30 — Taxonomy classification — Heat exchangers

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Heat exchanger	HE	Shell and tube	ST	Oil processing	OP
		Plate	PL	Gas processing	GP
		Double pipe	DP	Gas export	GE
		Bayonet	BY	Cooling system	CW
		Printed circuit	CI	Condensing	CO
		Air cooled	AC		

NOTE In Table A.30 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

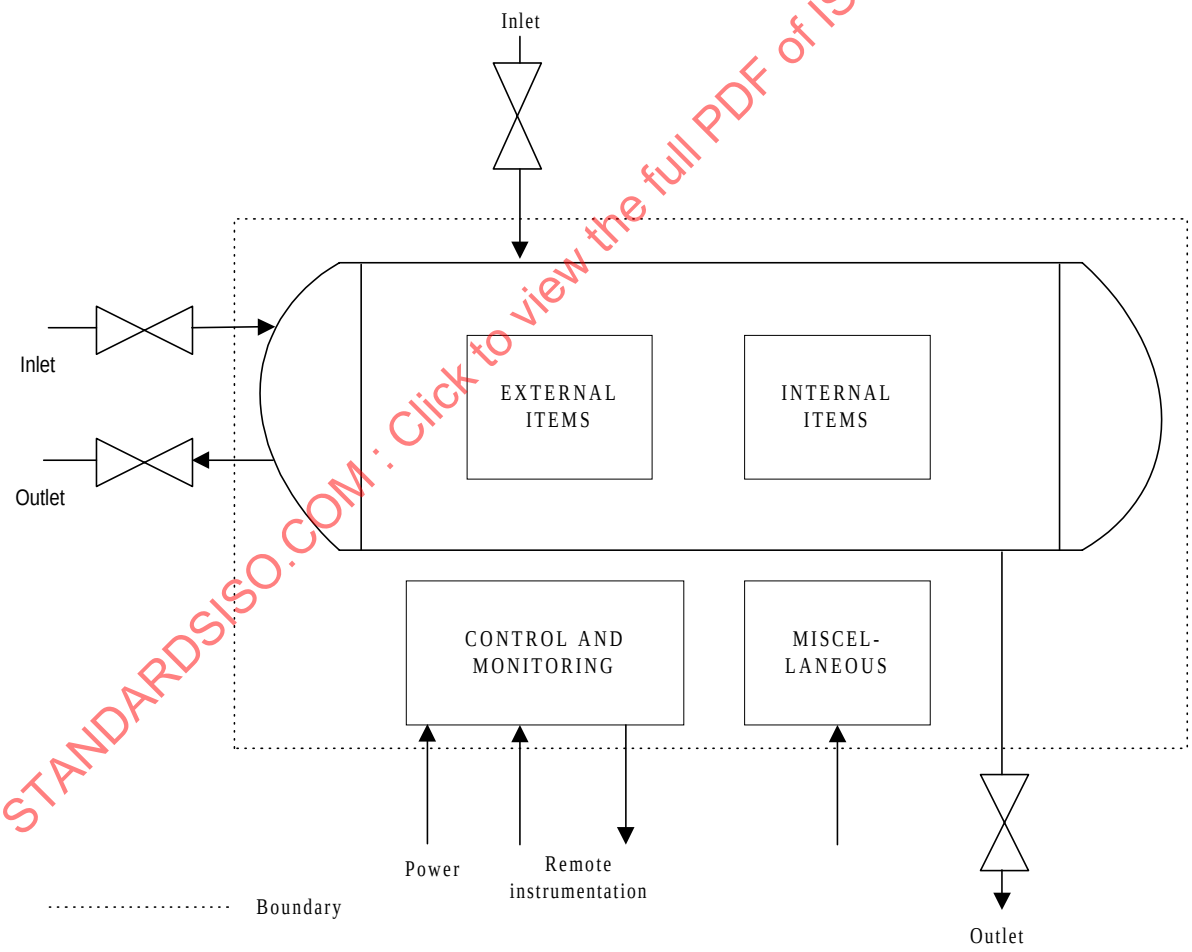


Figure A.8 — Equipment boundary — Heat exchangers

Table A.31 — Equipment unit subdivision — Heat exchangers

Equipment unit	Heat exchangers			
Subunit	External	Internal	Control and monitoring	Miscellaneous
Maintainable items	Support Body/shell Valves Piping	Body/shell Tubes Plates Seals (gaskets)	Control Actuating device Monitoring Valves Internal power supply	Fan [a] Fan motor Others

[a] Applicable for air cooled heat exchangers only.

Table A.32 — Equipment unit specific data — Heat exchangers

Name	Description	Unit or code list
Fluid, hot side (*)	Fluid type	E.g. oil, gas, condensate, freshwater, steam, sea water, crude oil, oily water, flare gas, water/glycol, methanol, nitrogen, chemicals, hydrocarbon, air
Fluid, cold side (*)	Fluid type	E.g. oil, gas, condensate, freshwater, steam, sea water, crude oil, oily water, flare gas, water/glycol, methanol, nitrogen, chemicals, hydrocarbon, air
Rated heat transfer (*)	Design value	kW
Utilisation (*)	Used/rated heat transfer	%
Pressure, hot side (*)	Design pressure	pascal (bar)
Pressure, cold side (*)	Design pressure	pascal (bar)
Temperature drop, hot side	Operating	°C
Temperature rise, cold side	Operating	°C
Size - diameter (*)	External	mm
Size - length (*)	External	mm
Number of tubes/plates		Numeric
Tube/plate material (*)	Specify material type in tubes/plates	Free text
(*) Indicates high-priority information.		

Table A.33 — Failure modes — Heat exchangers

Equipment unit	Code	Definition	Description
Heat exchangers	IHT	Insufficient heat transfer	Insufficient heating/cooling
	ELP	External leakage process medium	Process medium escape to environment
	ELU	External leakage utility medium	Coolant escape to environment
	INL	Internal leakage	Hot/cold side communication
	PLU	Plugged/choked	Partial or full flow restriction due to hydrate, wax, scale, etc.
	STD	Structural deficiency	Reduced strength due to impact, unacceptable corrosion, cracks, etc.
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.9 Process sensors

Table A.34 — Taxonomy classification — Process sensors

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Process sensors	PS	Pressure	PS	Oil processing	OP
		Level	LS	Gas processing	GP
		Temperature	TS	Condensate processing	CP
		Flow	FS	Cooling system	CW
		Speed	SP	Water fire-fighting	FF
		Vibration	VI	Water injection	WI
		Displacement	DI	Oily water treatment	OW
		Analyser	AN	Chemical injection	CI
		Weight	WE	Completion fluid	CF

NOTE In Table A.34 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

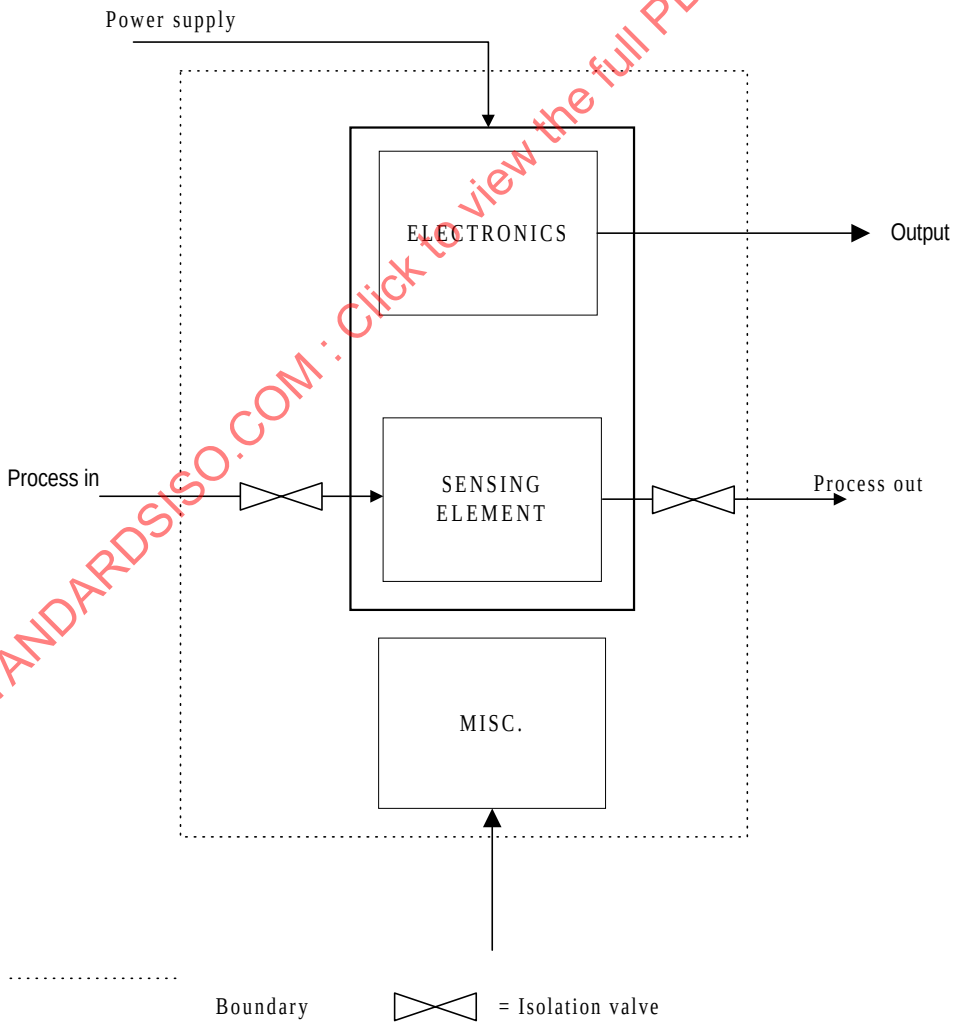


Figure A.9 — Equipment boundary — Process sensors

Table A.35 — Equipment unit subdivision, process sensors

Equipment unit	Process sensors	
Subunit	Sensor and electronics	Miscellaneous
Maintainable items	Sensing element Electronics	Isolation valve Piping Others

Table A.36 — Equipment unit specific data — Process sensors

Name	Description	Unit or code list
Location on installation (*)	Where installed	Wellhead, christmas tree, wellhead flow line, wellhead injection line, pump, turbine, electric generator, separator, heat exchanger, vessel, header, electric motor, turboexpander, drilling, pipeline, mud processing, utility, living quarter, air inlet, alkylation unit, isomerization units, catalytic crackers
Application (*)	Where applied	Shut-off, process control, emergency shutdown, process shutdown, fire and gas detection, non-return, relief, pressure reduction, by-pass, blowdown, monitoring, combined
Pressure - operating	Normal operating pressure	pascal (bar)
Temperature - operating	Normal operating temperature	°C
Sensor voting, *k* out of *n*	At least *k* out of *n* sensors shall provide signal to initiate control/safety action. *k* and *n* shall be entered; if no voting, leave blank	*k* = '*nn*' (integer) *n* = '*nn*' (integer)
Pressure - reference (*)	Applicable only for pressure sensors	Differential, absolute, gauge
Pressure-sensing principle (*)	Applicable for pressure sensors only	Bonded strain, semiconductor, strain, piezoelectric, electromechanical, capacitance, reluctance
Level-sensing principle (*)	Applicable for level sensors only	Differential pressure cell, capacitance, conductive, displacement, diaphragm, sonic, optical, microwave, radio frequency, nuclear
Temperature-sensing principle (*)	Applicable for temperature sensors only	Resistance temperature detector (PT), thermocouple, capillary
Flow-sensing principle (*)	Applicable for flow sensors only	Displacement, differential head (closed conduit/pipe, open channel), velocity, mass
Type - process sensor (*)	Transmitter (converts process parameter, e.g. pressure, into proportional electrical signals - 4 mA to 20 mA or 0 V to 10 V (ref. IEC 60381-2); Transducer (converts process parameters, e.g. pressure, into proportional electrical signals - unamplified output); Switch (converts process parameters, e.g. pressure, into on/off electrical signals)	Transmitter, transducer, switch
Fail-safe principle (*)	Type	Normally energized, normally de-energized. Normally not applicable for analog equipment
Detector communication (*)	Type	Conventional, addressable (one-way), smart (two-way)
Self-test feature (*)	Same as for fire and gas detectors	None, auto-loop, built-in, combination of automatic loop test/built-in test
Detailed operational time	Same as for fire and gas detectors	
Safety class	Ex standard	Ex(d), Ex(e), None
(*) Indicates high-priority information.		

Table A.37 — Failure modes — Process sensors

Equipment unit	Code	Definition	Description
Process sensors	FTF	Fail to function on demand	"Stuck" sensor
	OWD	Operates without demand	False alarm
	AOL	Abnormal output - Low	Trend toward FTF failure, e.g. low output
	AOH	Abnormal output - High	Trend toward OWD failure, e.g. high output
	ERO	Erratic output	Reading not intelligible, e.g. oscillating
	SER	Minor in-service problems	Some minor repair required
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.10 Pumps

Table A.38 — Taxonomy classification — Pumps

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Pump	PU	Centrifugal	CE	Water fire-fighting	FF
		Reciprocating	RE	Water injection	WI
		Rotary	RO	Oil handling	OH
				Gas treatment	GT
				Gas processing	GP
				Chemical injection	CI
				Sea-water lift	SL
				NGL export	NE
				Utility	UT

NOTE In Table A.38 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

Table A.39 — Equipment unit subdivision — Pumps

Equipment unit	Pumps				
Subunit	Power transmission	Pump unit	Control and monitoring	Lubrication system	Miscellaneous
Maintainable items	Gearbox/variable drive	Support	Control	Reservoir	Purge air
	Bearing	Casing	Actuating device	Pump with motor	Cooling/heating system
	Seals	Impeller	Monitoring	Filter	Filter, cyclone
	Lubrication	Shaft	Valves	Cooler	Pulsation damper
	Coupling to driver	Radial bearing	Internal power supply	Valves	Flange joints
	Coupling to driven unit	Thrust bearing		Piping	Others
		Seals		Oil	
		Valves			
		Piping			
		Cylinder liner			
		Piston			
		Diaphragm			

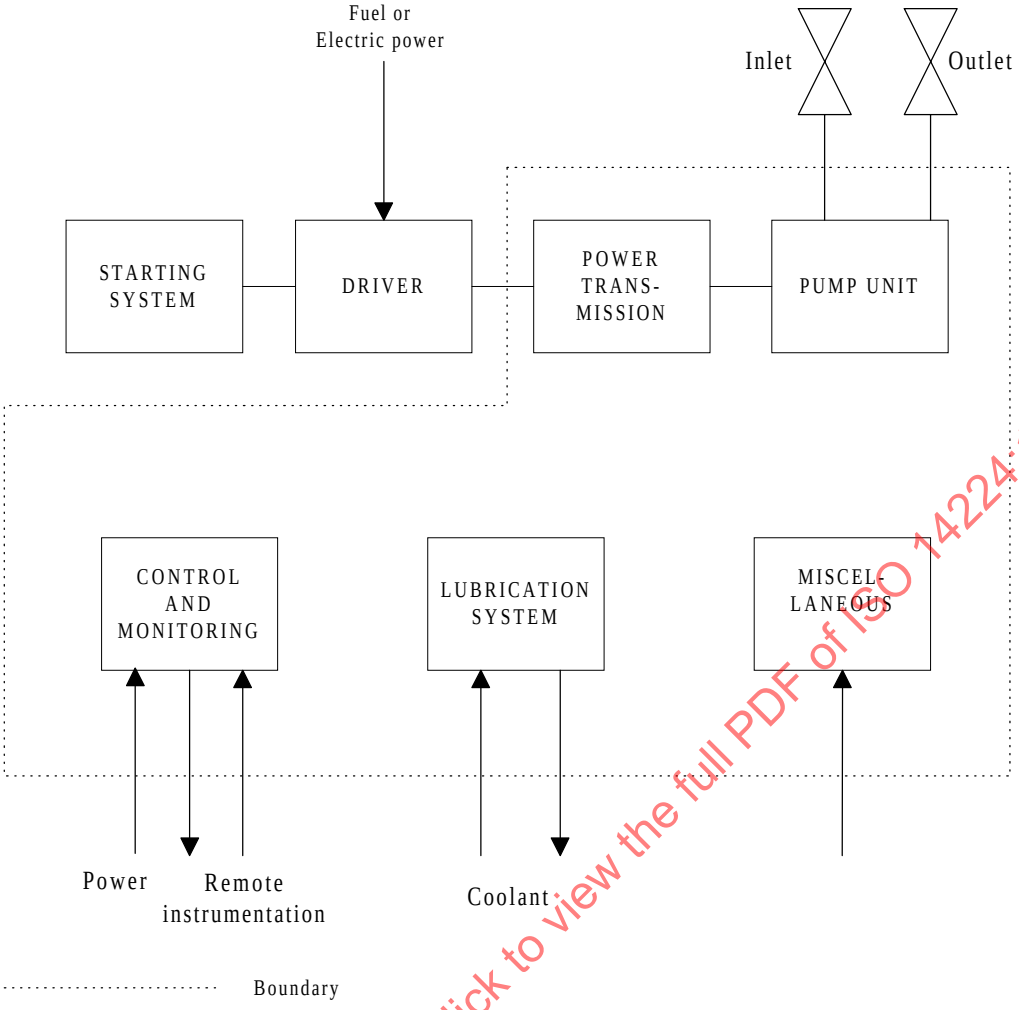


Figure A.10 — Equipment boundary — Pumps

Table A.40 — Equipment unit specific data — Pumps

Name	Description	Unit or code list
Corresponding driver (*)	Specify driver identification number when relevant. Compulsory for fire pumps	
Type of driver (*)	Type	Electric, turbine, diesel, gas engine
Fluid handled (*)	Type	Oil, gas, condensate, freshwater, steam, sea water, crude oil, oily water, flare gas, fuel gas, water/glycol, methanol, nitrogen, chemicals, hydrocarbon-combined, gas/oil, gas/condensate, oil/water, gas/oil/water
Fluid corrosive/erosive (*)	Benign (clean fluids, e.g. air, water, nitrogen) Moderately corrosive/erosive (oil/gas not defined as severe, sea water, occasionally particles) Severe corrosive/erosive [sour gas/oil (high H_2S), high CO_2, high sand content]	Benign, moderate, severe
Application - pump (*)	Where applied	Booster, supply, injection, transfer, lift, dosage, disperse
Pump design	Design characteristic	Axial, radial, composite, diaphragm, plunger, piston, screw, vane, gear, lobe
Power - design (*)	Design/rated power of pump	kW
Utilization of capacity (*)	Normal operating/design capacity	%
Suction pressure - design (*)	Design pressure	pascal (bar)
Discharge pressure - design (*)	Design pressure	pascal (bar)
Speed	Design speed	r/min or strokes/min
Number of stages	Centrifugal: Number of impellers (in all stages) Reciprocating: Number of cylinders Rotary: Number of rotors	Numeric
Body type	Barrel, split casing, etc.	Barrel, split case, axial split, cartridge,
Shaft orientation		Horizontal, vertical
Shaft sealing	Type	Mechanical, oil seal, dry gas, packed, gland, dry seal, labyrinth, combined
Transmission type	Type	Direct, gear, integral,
Coupling	Coupling	Fixed, flexible, hydraulic, magnetic, disconnect
Environment (*)	Submerged or dry-mounted	
Pump cooling	Specify if separate cooling system is installed	Yes/No
Radial bearing Thrust bearing	Type Specify in comment field if thrust pressure regulator installed	Antifrictional, journal, magnetic
Bearing support	Type	Overhung, between bearings, pump casing, split sleeve
(*) Indicates high-priority information.		

Table A.41 — Failure modes — Pumps

Equipment unit	Code	Definition	Description
Pumps	FTS	Fail to start on demand	Unable to activate pump
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected shutdown of pump
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	HIO	High output	Output pressure/flow above specification
	LOO	Low output	Output pressure/flow below specification
	ERO	Erratic output	Oscillating or unstable pressure/flow
	ELP	External leakage process medium	Process medium escape to environment
	ELU	External leakage utility medium	Lube/seal oil, coolant, etc.
	INL	Internal leakage	E.g. process medium in lube oil
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	OHE	Overheating	Excessive temperature
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in support or suspension
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.11 Turboexpanders

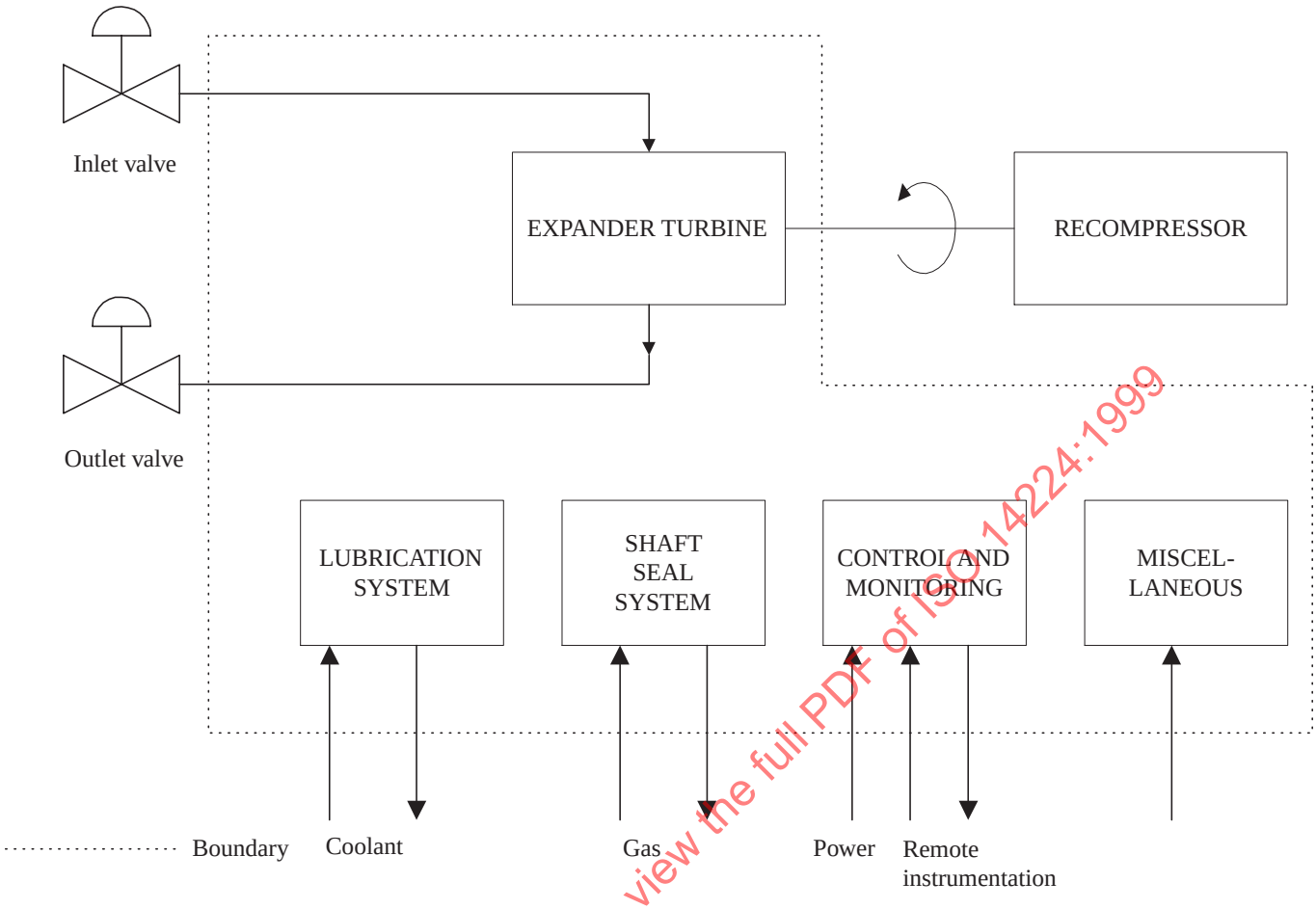
Table A.42 — Taxonomy classification — Turboexpanders

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Turboexpander	TE	Centrifugal	CE	Gas processing	GP
		Axial	AX	Gas treatment	GT
				Electrical generation	EG

NOTE In Table A.42 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

Table A.43 — Equipment unit subdivision — Turboexpanders

Equipment unit	Turboexpander				
Subunit	Expander turbine	Control and monitoring	Lubrication system	Shaft seal system	Miscellaneous
Maintainable items	Rotor w/impellers Inlet vanes Casing Radial bearing Thrust bearing Seals Inlet screen Valves Piping	Control Actuating device Monitoring Valves Internal power supply	Reservoir Pump with motor Filter Cooler Valves Piping Oil	Seal gas equipment Seal gas	Others



Note! Driven units other than recompressors
(e.g. pumps or generators) are outside the boundary

Figure A.11 — Equipment boundary — Turboexpanders

Table A.44 — Equipment unit specific data — Turboexpanders

Name	Description	Unit or code list
Driver application	Type of driven unit	Pump, electric generator, compressor
Power - design (*)	Max. design output power	kW
Power - operating	Specify the approximately power at which the unit has been operated for most of surveillance time	kW
Speed (*)	Design speed	r/min
Inlet flow (*)	Design inlet flow, turbine	kg/h
Inlet temperature (*)	Design inlet temperature, turbine	°C
Inlet pressure (*)	Design inlet pressure, turbine	pascal (bar)
Gas handled	Average molar mass (specific gravity x 28,96)	g/mol
Gas corrosive/erosive (*)	Benign (clean and dry gas) Moderately corrosive/erosive (some particles or droplets, some corrosiveness) Severe corrosive/erosive (sour gas, high CO_2 content, high content of particles)	Benign, moderate, severe
Type of design (*)	Type	Centrifugal, axial
Number of stages	Number of stages (in series)	Numeric
Casing split type	Type	Horizontal/vertical
Shaft sealing	Type	Mechanical, oil, seal, dry gas, packed, gland, dry seal, labyrinth, combined
Flow control turbine	Type	Variable nozzles, nozzle group valves, throttle valve, fixed inlet
Radial bearing Thrust bearing	Bearing type Specify in comment field whether any thrust pressure regulator is installed	Antifrictional, antifrictional magnetic or journal
(*) Indicates high-priority information.		

Table A.45 — Failure modes — Turboexpanders

Equipment unit	Code	Definition	Description
Turboexpander	FTS	Fail to start on demand	Unable to activate turboexpander
	STP	Fail to stop on demand	Unable to stop or incorrect shutdown process
	SPS	Spurious stop	Unexpected shutdown of turboexpander
	BRD	Breakdown	Serious damage (seizure, breakage, explosion, etc.)
	HIO	High output	Overspeed/output above specification
	LOO	Low output	Output below specification
	ERO	Erratic output	Unstable operation/ rpm hunting
	VIB	Vibration	Excessive vibration
	NOI	Noise	Excessive noise
	ELP	External leakage process medium	Process medium escape to environment
	ELU	External leakage utility medium	Lube/seal/hydraulic oil, coolant, etc.
	INL	Internal leakage	E.g. process medium in lube oil
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	E.g. cracks in support or suspension
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.12 Valves

Table A.46 — Taxonomy classification — Valves

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Valves	VA	Ball	BA	Oil processing	OP
		Gate	GA	Oil export	OE
		Globe	GL	Gas processing	GP
		Flapper	FL	Gas export	GE
		Butterfly	BP	Oily water treatment	OW
		Plug	PG	Gas injection	GI
		Multiple orifice	MU	Water injection	WI
		Needle	NE	Chemical injection	CI
		Check	CH	NGL treatment	NT
		Diaphragm	DI	LPG treatment	LT
		Slide	SL	Cooling water	CW
		Eccentric disc	ED	Steam	ST
		3-way	WA		
		PSV-conventional	SC		
		PSV-conventional with bellow	SB		
		PSV-pilot operated	SP		
		PSV-vacuum relief	SV		
		Shuttle	SH		

NOTE In Table A.46 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

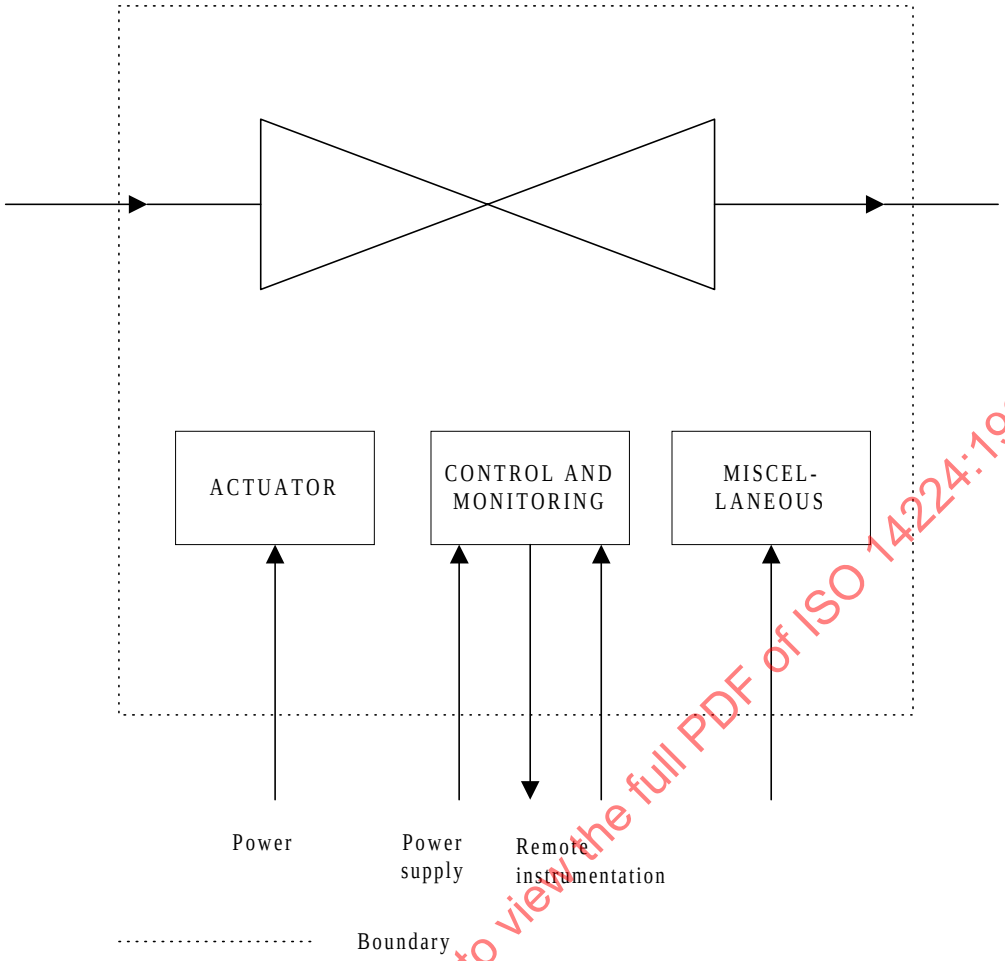


Figure A.12 — Equipment boundary — Valves

Table A.47 — Equipment unit subdivision — Valves

Equipment unit	**Valves**			
Subunit	Valves	Actuator	Control and monitoring	Miscellaneous
Maintainable items	Valve body Bonnet Seat rings Packing Seals Closure member	Diaphragm Spring Case Piston Stem Indicator Seals/gaskets Pilot valve [a] Positioner Electrical motor [b] Gear Solenoid	Control Actuating device Monitoring Valves Internal power supply	Flange joints Others

[a] Applicable for hydraulic/pneumatically actuated valves.

[b] Electric motor actuator only.

Table A.48 — Equipment unit specific data — Valves

Name	Description	Unit or code list
Application (*)	Where applied	Shut-off, process control, emergency shut-down/process shutdown, fire and gas detection, check, relief, pressure reduction, by-pass, blow-down, monitoring, combined
Actuation (*)	Type	Motor, hydraulic, pneumatic, self-acting, self-acting/pilot, manual
Pilot valve configuration	Specify; e.g. 1×3/2 (= Single 3/2 pilot valve), 2×4/3 (= Double 4/3 pilot valve). Applicable for pilot/solenoid-operated valves only	
Location on installation (*)	Where installed	Wellhead, christmas tree, wellhead flow line, wellhead injection line, pump, turbine, generator, separator, heat exchanger, vessel, header, electric motor, diesel motor, turboexpander, drilling, pipeline, mud process, utility, living quarter, air inlet
Fluid handled (*)	Main fluid only	Oil, gas, condensate, freshwater, steam, sea water, crude oil, oily water, flare gas, fuel gas, water/glycol, methanol, nitrogen, chemicals, hydrocarbon combined, gas/oil, gas/condensate, oil/water, gas/oil/water, NGL, LPG, slurry, etc.
Fluid corrosive/ erosive (*)	Benign (clean fluids, e.g. air, water, nitrogen) Moderately corrosive/erosive (oil/ gas not defined as severe, sea water, occasionally particles) Severe corrosive/erosive (sour gas/oil (high H_2S), high CO_2 content, high sand content)	Benign, moderate, severe
Flowing pressure (*)	Normal operating pressure (inlet)	pascal (bar)
Shut-off pressure	Maximum differential pressure when valve closed (design) For safety pressure-relief valves: Set-point opening pressure	pascal (bar)
Fluid temperature		°C
Size (*)	Internal diameter	mm
Type of valve end	Specify	Welded, flanged
Stem sealing	Specify	
(*) Indicates high-priority information.		

Table A.49 — Failure modes — Valves

Equipment unit	Code	Definition	Description
Valves	FTC	Fail to close on demand	Stuck open or fail to close fully
	FTO	Fail to open on demand	Stuck closed or fail to open fully
	FTR	Fail to regulate	"Stuck" valve, control valves only
	OWD	Operates without demand	Undesired closure/opening
	DOP	Delayed operation	Opening/closure time different from specification
	HIO	High output	Faulty regulation, control valves only
	LOO	Low output	Faulty regulation, control valves only
	ELP	External leakage process medium	Process medium escape to environment
	ELU	External leakage utility medium	Actuation fluid, lubrication, etc.
	INL	Internal leakage	Internal leakage of actuating fluid, or valve-actuator communication
	LCP	Leakage in closed position	Leak-through valve in closed position
	PLU	Plugged/Choked	Partial or full flow restriction
	STD	Structural deficiency	Reduced integrity due to impact, unacceptable corrosion, cracks, etc.
	AIR	Abnormal instrument reading	E.g. faulty position indication
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.2.13 Vessels

Table A.50 — Taxonomy classification — Vessels

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Vessel	VE	Stripper	SP	Oil processing	OP
		Separator	SE	Oily water treatment	OW
		Coalescer	CA	Gas processing	GP
		Flash drum	FD	Gas treatment	GT
		Scrubber	SB	Gas export	GE
		Contactor	CO	Flare, vent, blowdown	FL
		Surge drum	SD	NGL treatment	NT
		Hydrocyclone	HY	LPG treatment	LT
				Chemical storage	CS

NOTE In Table A.50 the lists in columns headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

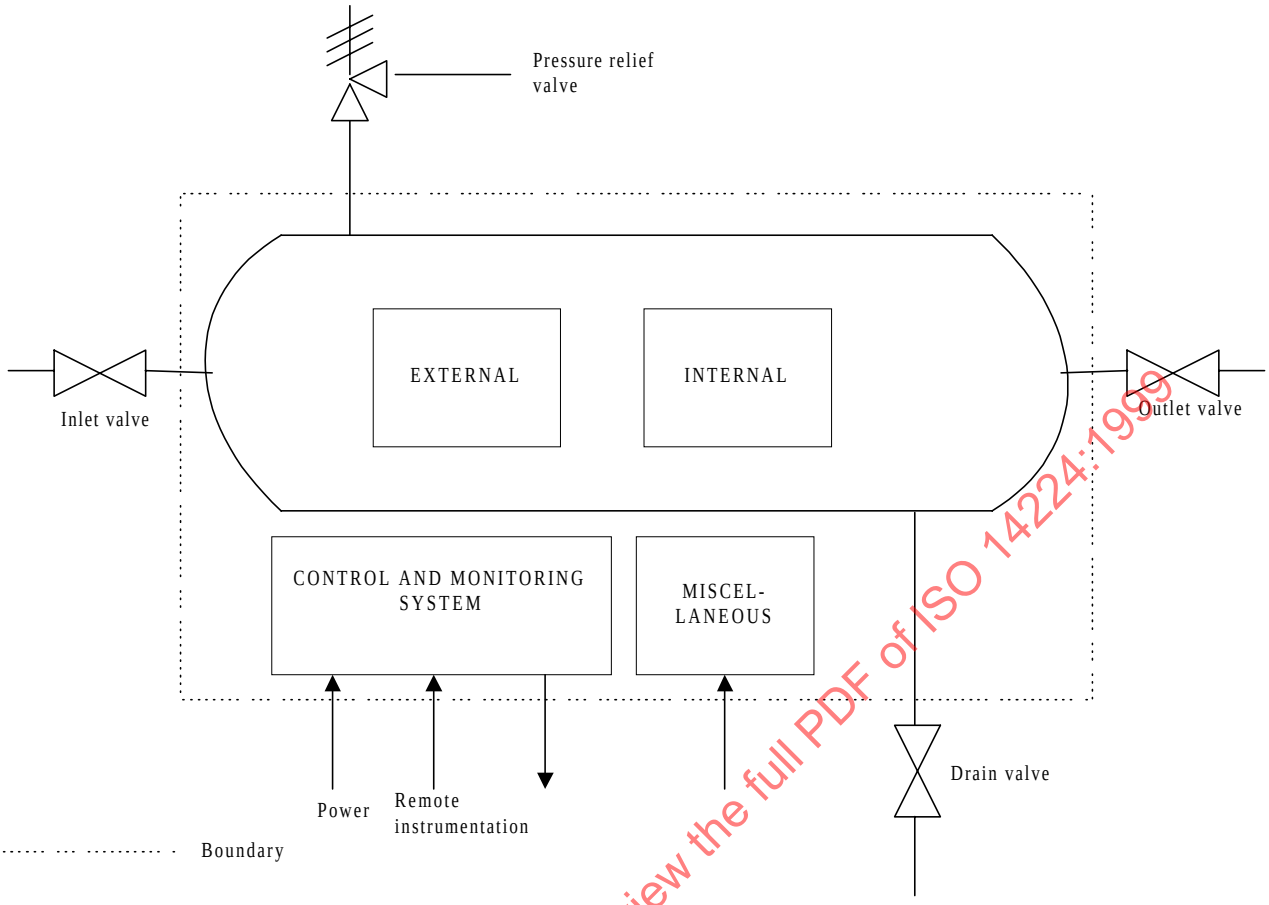


Figure A.13 — Equipment boundary — Vessels

Table A.51 — Equipment unit subdivision — Vessels

Equipment unit	**Vessels**			
Subunit	External items	Internal items	Control and monitoring	Miscellaneous
Maintainable items	Support Body/Shell Valves Piping	Body/Shell Plates, trays, vanes, pads Sand trap system Heater Corrosion protection Distributor Coil	Control Actuating device Monitoring Valves Internal power supply	Others

Table A.52 — Equipment unit specific data — Vessels

Name	Description	Unit or code list
Fluid(s) (*)	Main fluid	Oil, gas, condensate, freshwater, steam, sea water, crude oil, oily water, flare gas, fuel gas, water/glycol, methanol, nitrogen, chemicals, hydrocarbon combined, gas/oil, gas/condensate, oil/water, gas/oil/water
Pressure - design (*)	Design pressure	pascal (bar)
Temperature - design	Design temperature	°C
Pressure - operating (*)	Operating pressure	pascal (bar)
Temperature - operating	Operating temperature	°C
Size - diameter (*)	External	mm
Size - length (*)	External	mm
Body material	Specify type or code	Free text
Orientation		Horizontal/vertical
Number of branches	Pressurized connections only	Number off
Internals	Design principle	Baffles, trays, grid plate, de-mister, heat coil, diverter, de-sander, combined
(*) Indicates high-priority information.		

Table A.53 — Failure modes — Vessels

Equipment unit	Code	Definition	Description
Vessels	ELP	External leakage process medium	Leakage of primary fluid to the environment
	ELU	External leakage utility medium	Leakage of secondary fluid to the environment
	PLU	Plugged/choked	Partial or full flow restriction
	PDE	Parameter deviation	Monitored parameter exceeding tolerances
	AIR	Abnormal instrument reading	E.g. false alarm, faulty reading
	STD	Structural deficiency	Reduced strength due to impact, unacceptable corrosion, cracks, etc.
	SER	Minor in-service problems	Loose items, discoloration, dirt, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information

A.3 Subsea equipment

A.3.1 Wellhead and Xmas trees

Table A.54 — Taxonomy classification — Wellhead and Xmas trees

Equipment class		Type		Application	
Description	Code	Description	Code	Description	Code
Wellhead and Xmas tree	WC	Conventional tree	CT	Injection well	Injection
		Horizontal tree	HZ	Production well	Production

NOTE In Table A. 54 the lists in column headed "Type" and "Application" are typical examples found in the petroleum and natural gas industries. These lists should not be considered exhaustive.

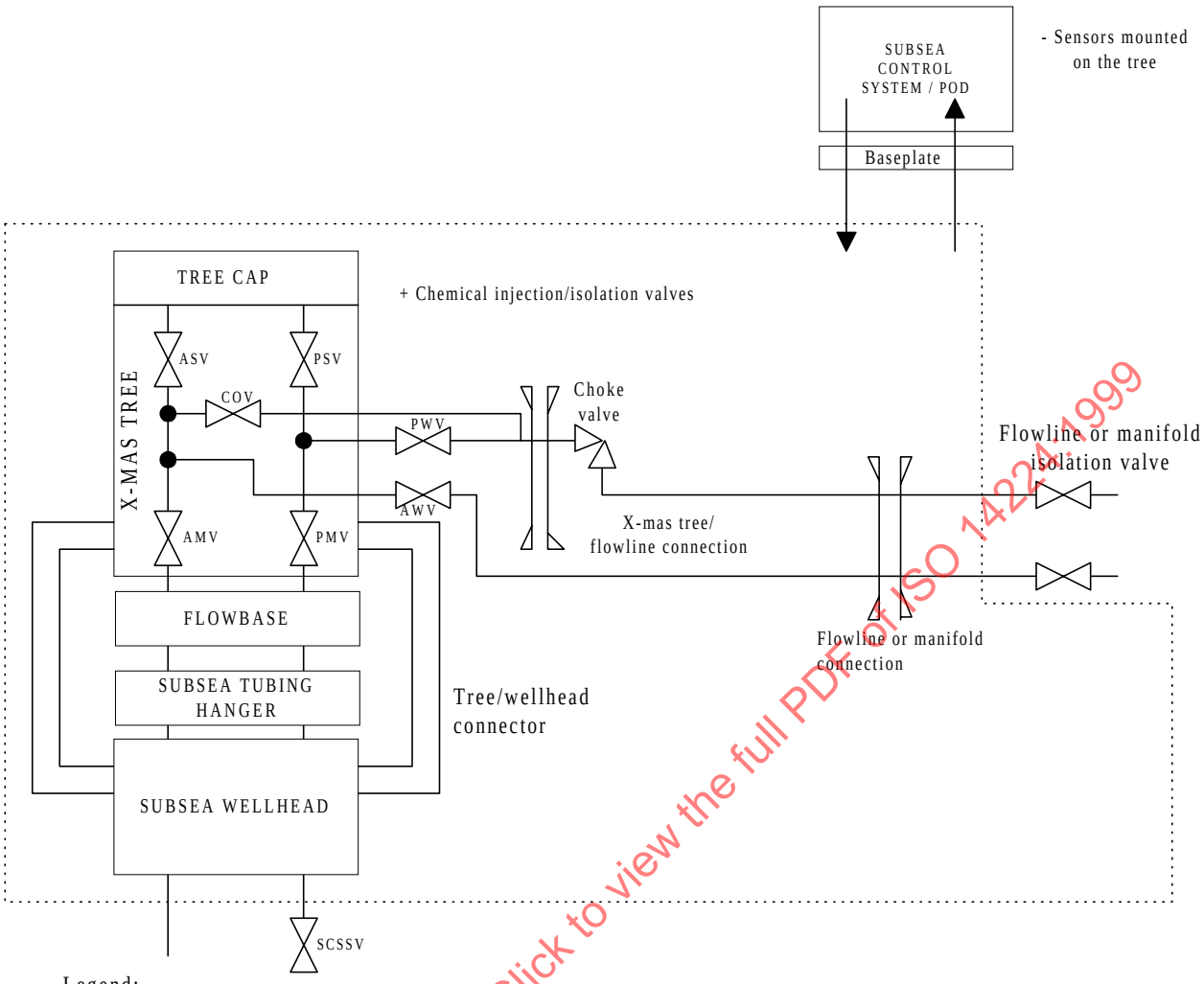


Figure A.14 — Equipment boundary — Wellhead and Xmas trees

Table A.55 — Equipment unit subdivision — Wellhead and Xmas trees

Equipment unit	Wellhead and Xmas trees			
Subunit	Subsea wellhead	Subsea Xmas tree	Tubing hanger	Flowbase
Maintainable items	Permanent Guide base (PGB) Temporary Guide base (TGB) Conductor housing Wellhead housing (high pressure housing) Casing hangers Annulus seal assemblies (Packoffs) Unknown	Flowspool Piping (hard pipe) Hoses (flexible piping) Debris cap Tree guide frame Connector Internal isolation cap Internal tree cap valve Internal tree cap plug Tree cap Valve, check Valve, choke Valve, control Valve, other Valve, process isolation Valve, utility isolation	Tubing hanger body Chemical injection coupler Hydrate coupler Power/signal coupler Tubing hanger isolation plug	Flowspool Frame Hub/mandrel Casing hangers Connector

Table A.56 — Equipment unit specific data — Wellhead and X-mas trees

Name	Description	Unit or code list
Well identification no.(*)	Operator description	
Installation layout (*)	Define well layout	Single satellite, cluster, multiwell manifold template, other
Install/retrieve guide (*)	Guideline/guidelineless	Guideline, guidelineless
Intervention strategy	Diver assisted vs. diverless interventions	Diver assisted, Diverless
Protection type (*)	Overtrawable, trawl-catching, etc.	Trawl-catching, trawl-deflecting, none
Water depth (*)		m
Xmas tree design pressure (*)	Specify Xmas tree design pressure	pascal (bar)
Xmas tree design temperature (*)	Specify Xmas tree design temperature	°C
Xmas tree production bore diameter	Specify diameter of production bore	mm
Xmas tree annulus bore diameter	Specify diameter of annulus bore	mm
Wellhead design pressure (*)	Specify wellhead design pressure	pascal (bar)
Wellhead design temperature (*)	Specify wellhead design temperature	°C
Wellhead size (*)	Specify	mm
Mudline suspension system	Define whether a mudline suspension system exists	Yes, no
Multilateral well	Define	Yes, no
Fluid produced/injected (*)	Main fluid only: oil, gas, condensate, injection water	Oil, gas, condensate, injection water, oil and gas, gas and condensate, oil/gas/ water, CO_2, gas and water, produced water
Fluid corrosiveness (*)	Neutral - clean fluids with no corrosive effects Sweet - moderately corrosive/erosive (oil/ gas not defined as severe, raw sea water, occasional particles) Sour - severely corrosive/erosive [sour gas/oil (high H_2S), high CO_2, high sand content]	Neutral, sweet, sour
Asphaltenes		Yes, no
Scale formation		Yes, no
Wax formation		Yes, no
Hydrate formation		Yes, no
Sand production		Yes, no
(*) Indicates high-priority information.		

Table A.57 — Failure modes — Wellhead and X-mas trees

Equipment unit	Code	Definition	Description
Wellhead and Xmas tree	ELP	External leakage process medium	Process medium leak to sea
	ELU	External leakage utility medium	Hydraulic fluid, methanol, etc.
	ILP	Internal leakage - Process medium	E.g. annulus to production bore communication
	ILU	Internal leakage - Utility medium	E.g. internal leakage of hydraulic fluid or chemicals
	PLU	Plugged/choked	Partial or full flow restriction due to hydrate, scale, wax, etc.
	STD	Structural deficiency	Reduced integrity due to impact, unacceptable corrosion, cracks, etc.
	OTH	Other	Specify in comment field
	UNK	Unknown	Inadequate/missing information
	NON	No immediate effect	

Failure modes should be specified on all three indenture levels of the equipment hierarchy, to enhance the usability of the data in later applications. The failure modes in Table A.57 are related to equipment level, i.e. wellhead and Xmas tree.

A.4 Well-completion equipment

A.4.1 Equipment data

A.4.1.1 Item categories

Well-completion equipment in this context refers to equipment below wellhead level. All major completion equipment items are included, from tubing hanger at the top end to equipment at the bottom of the well.

The following item categories are defined for well-completion equipment:

a) String items

String items are defined as items which are all integral parts of the conduit ("string") used for production or injection of well effluents. The string is built by screwing together a variety of equipment items.

b) Accessories

Accessories are items which must be tied to a "host" string item to define a system. This is done to be able to logically represent string items which are too complex to be given as just a stand-alone item of the string. Only two such "host" string items, or *string items with accessories,* have been defined to date. These are Electrical Submersible Pump (ESP) and Downhole Permanent Gauge (DHPG) systems.

c) Inserted items

Inserted items are defined as items which can be attached (set) inside string items. A typical example is the combination of a lock and wireline-retrievable safety valve set inside a safety valve nipple.

d) Control line/cable

The control line/cable category allows information to be stored for control lines and cables and a variety of parts which are normally associated with control lines or cables. Examples of such parts are packer penetrators, electric connectors for gauges, electric wellhead connectors, etc. This category provides the opportunity to build control line/cable "systems" consisting of the hydraulic control line or cable itself and all associated parts.

Reliability analysis will then subsequently be possible for the control line system when the system has been tied to a specific string item in a completion.

Each control line/cable shall always be connected to one or more string items.

e) Casing

The casing category is included to store information on individual casing string sections and associated casing failures. The casing category represents full lengths of individual casing sections and does not represent individual items threaded into the casing string, compared with the production/injection string.

Sealing elements which are designed to seal off against leakage of hydrocarbons between the various sections of casing string (casing pack-offs) are not included.

A.4.1.2 Standard equipment specifications

Table A.58 — Item database format and name specification

Item category	Data collection format	Predefined item name
String item	Annulus safety valve	Tubing-retrievable surface-controlled annular subsurface safety valve (TR-SCASSV)
	Default	Adjustable union
		Landing nipple
		Millout extension
		Muleshoe
		Nipple for wireline-SCSSV
		Gravel pack screen
		Perforated pup joint
		Pup joint
		Sliding sleeve
		Tubing anchor
		Wireline re-entry guide
	Electrical submersible pump system with accessories	Electrical submersible pump unit (straight)
		Electrical submersible pump unit (y-tool)
	Expansion joint	Expansion joint
	Flow coupling	Flow coupling
	Gauge mandrel with accessories	Permanent gauge mandrel
	Packer type	Production packer
		Downhole packer/hanger
	Seal assembly	Seal assembly (conventional)
		Seal assembly (overshot)
	Side pocket mandrel	Side pocket mandrel (for valve)
	Spacer type	Spacer
	Tubing type	Tubing
	Tubing safety valve	Tubing-retrievable surface-controlled subsurface safety valve (TR-SCSSV)(ball)
		Tubing-retrievable surface-controlled subsurface safety valve (TR-SCSSV)(flapper)
	X-over	X-over
	Y-block	Y-block

Table A.58 (*end*)

Item category	Data collection format	Predefined item name
Accessories	Default	None defined
	Downhole gauge	Permanent gauge
	Intake section	Intake section
	Motor	Electrical submersible pump motor
	Motor lead extension	Motor lead extension
	Motor seal system	Motor seal system
	Pump	Pump with electric drive
Inserted item	Annulus safety valve	Wireline surface-controlled subsurface safety valve (SCSSV)
	Default	Brain (sideguard)
		Lock for wireline surface-controlled annular subsurface safety valve (SCASSV)
	Gas lift valve	Gas lift valve
		Chemical injection valve
	Safety valve	Wireline-SCSSV
Control line/cable	Default	None defined
	Electric connector, gauge	Electric connector downhole gauge
	Electric connector, hanger	Electric connector tubing hanger
	Hydraulic line	Hydraulic control line
	Penetrator	Wellhead penetrator
		Hanger penetrator
		Packer penetrator
	Power cable	Power cable
	Signal cable	Signal/instrument cable
	Surface controller	Surface controller
Casing		

An example of data collection format with associated data field definitions and registration alternatives is shown for a tubing item in Table A.59.

Table A.59 — Data collection format for string item example — Tubing

Name	Description	Unit or code list
Manufacturer (*)	Generic tubing manufacturer's code list applied	
Model	Model designation or part number	
Effective length	Actual length of tubing when integrated in completion string (i.e. exclusive of pin and box)	m
Nominal size	Nominal size of tubing	m
Max. outer diameter	Maximum outer diameter of pipe, not joint	m
Min. inner diameter	Minimum inner diameter of pipe, not joint	m
Material (*)	Tubing material in pipe section	Free text
Joint type (*)		Free text
Connection type (*)		Free text
Grade	Material yield strength and type	
Nominal mass	Mass per unit length	kg/m
Plastic coating (*)	Indication whether or not tubing is internally plastic-coated	With plastic coating Without plastic coating
Coating material (*)		Free text
Remarks	Other information considered relevant	
NOTE Information fields indicated with an asterisk (*) are coded alternative fields.		

A.4.2 Failure data

The failure-reporting format for a well-completion equipment item is shown in Table A.60. The failure-reporting format is nearly identical for all item categories. For control line/cables and string items with accessories, failed parts or failed accessories should be quoted as applicable.

The fields *Remedial action date* and *Remedial action details* are normally left blank when the failure is reported, unless information about the remedial action is available at the time of reporting the failure. Completing these fields is important when a downhole repair is successfully performed, as this will influence reliability calculations.

For string items with accessories it should be noted that a single failure of the host string item may involve failure of more than one component, e.g. an Electrical Submersible Pump (ESP) system failure may be caused by a penetrator and power cable failure.

A control line/cable failure may be specified independently from the connected item(s). This allows subsequent reliability analysis of individual control line/cables.

NOTE If the control line/cable failure causes a knock-on failure of a conventional string item or an inserted item, a failure record should additionally be stored for this item. When this failure is reported for the actual item, reference should be made to the control line failure in the failure cause field for the item(s) served by the control line/cable.

Table A.60 — Failure data report — Well-completion equipment

Data	Description	Codes/comments
Failure mode	Item-specific failure mode as per previous definition. (Ref. *tubing* example, next column)	Burst tubing Collapsed tubing Restriction in tubing Tubing broken/parted Tubing leak Other
Failure effect	Observed direct effect of failure on safety and/or production	Production affected Safety affected Both safety and production affected Operational delay No immediate effect on safety/production
Failure date	Date of detection of equipment failure	
Failure class		Item-related failure Non-item-related failure Other
Failure detection method		Periodic testing Test prior to well intervention Production interference
Failure cause	Used to specify details on underlying and direct causes of failure	Free text information
Remedial action		Item replaced by wireline operation Item replaced by full workover Item replaced by partial workover Item locked open and ran insert item Item repaired by pressure manipulation Item repaired through tubing No remedial action planned/performed Item still downhole in failed condition
Remedial action date	Used to identify the date when *downhole* remedial action was performed.	
Remedial action details		Free text information
Failed control line/cable parts	Applicable only when reporting control line/cable failures. One or more parts may have caused individual control line or cable failures	
Failed accessories	Applicable only to string items with accessories	

A.4.3 Environmental data

Environmental data which should be collected for well-completion equipment are listed in Table A.61. The data are well specific, and will provide a generic reference to the working environment for all equipment in the well. The well environmental are periodical and listed as monthly averages.