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

*Industries du pétrole, de la pétrochimie et du gaz naturel — Recueil et  
échange de données de fiabilité et de maintenance des équipements*

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## 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 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

This second edition cancels and replaces the first edition (ISO 14224:1999), which has been technically modified and extended. Annex B, which contains failure and maintenance notations, has been made normative. Further, additional informative Annexes A, C, D, E and F give recommendations on the use of reliability and maintenance data for various applications.

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## Introduction

This International Standard has been prepared based on ISO 14224:1999, experience gained through its use, and know-how and best practices shared through the international development process.

In the petroleum, natural gas and petrochemical industries, great attention is being paid to safety, reliability and maintainability of equipment. The industry annual cost of equipment unreliability is very large, although many plant owners have improved the reliability of their operating facilities by such attention. A stronger emphasis has recently been put on cost-effective design and maintenance for new plants and existing installations among more industrial parties. In this respect, data on failures, failure mechanisms and maintenance related to these industrial facilities and its operations have become of increased importance. It is necessary that this information be used by, and communicated between, the various parties and its disciplines, within the same company or between companies. Various analysis methodologies are used to estimate the risk of hazards to people and environment, or to analyse plant or system performance. For such analyses to be effective and decisive, equipment reliability and maintenance (RM) data are vital.

These analyses require a clear understanding of the equipment technical characteristics, its operating and environmental conditions, its potential failures and its maintenance activities. It can be necessary to have data covering several years of operation before sufficient data have been accumulated to give confident analysis results and relevant decision support. It is necessary, therefore, to view data collection as a long-term activity, planned and executed with appropriate goals in mind. At the same time, clarity as to the causes of failures is key to prioritizing and implementing corrective actions that result in sustainable improvements in reliability, leading to improved profitability and safety.

Data collection is an investment. Data standardization, when combined with enhanced data-management systems that allow electronic collection and transfer of data, can result in improved quality of data for reliability and maintenance. A cost-effective way to optimize data requirements is through industry co-operation. To make it possible to collect, exchange and analyse data based on common viewpoints, a standard is required. Standardization of data-collection practices facilitates the exchange of information between relevant parties e.g. plants, owners, manufacturers and contractors throughout the world.

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# Petroleum, petrochemical 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 for equipment in all facilities and operations within the petroleum, natural gas and petrochemical industries during the operational life cycle of equipment. It describes data-collection principles and associated terms and definitions that constitute a “reliability language” that can be useful for communicating operational experience. The failure modes defined in the normative part of this International Standard can be used as a “reliability thesaurus” for various quantitative as well as qualitative applications. This International Standard also describes data quality control and assurance practices to provide guidance for the user.

Standardization of data-collection practices facilitates the exchange of information between parties, e.g. plants, owners, manufacturers and contractors. This International Standard establishes requirements that any in-house or commercially available RM data system is required to meet when designed for RM data exchange. Examples, guidelines and principles for the exchange and merging of such RM data are addressed.

Annex A contains a summary of equipment that this International Standard covers.

- This International Standard recommends a minimum amount of data that is required to be collected and it focuses on two main issues:
  - data requirements for the type of data to be collected for use in various analysis methodologies;
  - standardized data format to facilitate the exchange of reliability and maintenance data between plants, owners, manufacturers and contractors.
- The following main categories of data are to be collected:
  - equipment data, e.g. equipment taxonomy, equipment attributes;
  - failure data, e.g. failure cause, failure consequence;
  - maintenance data, e.g. maintenance action, resources used, maintenance consequence, down time.

NOTE Clause 9 gives further details on data content and data format.

- The main areas where such data are used are the following:
  - reliability, e.g. failure events and failure mechanisms;
  - availability/efficiency, e.g. equipment availability, system availability, plant production availability;
  - maintenance, e.g. corrective and preventive maintenance, maintenance supportability;
  - safety and environment, e.g. equipment failures with adverse consequences for safety and/or environment.

- This International Standard does not apply to the following:
  - data on (direct) cost issues;
  - data from laboratory testing and manufacturing (e.g. accelerated lifetime testing);
  - complete equipment data sheets (only data seen relevant for assessing the reliability performance are included);
  - additional on-service data that an operator, on an individual basis, can consider useful for operation and maintenance;
  - methods for analysing and applying RM data (however, principles for how to calculate some basic reliability and maintenance parameters are included in the annexes).

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1:2004, *Rotating electrical machines — Part 1: Rating and performance*

IEC 60076-1:2000, *Power transformers — Part 1: General*

IEC 60076-2:1993, *Power transformers — Part 2: Temperature rise*

IEC 60076-3, *Power transformers — Part 3: Insulation levels, dielectric tests and external clearances in air*

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

IEC 62114, *Electrical insulation systems — Thermal classification*

## 3 Terms and definitions

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

**NOTE** Some derived RM parameters, which can be calculated from collected RM data covered by this International Standard, are contained in Annex C. References to Annex C are given as deemed appropriate.

### 3.1 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

**NOTE** For a more detailed description and interpretation of availability, see Annex C.

### 3.2 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

**NOTE 1** A maintenance action can be carried out while the item is performing a required function.

**NOTE 2** For a more detailed description and interpretation of maintenance times, see Figure 4 and Annex C.



**3.3****boundary**

interface between an item and its surroundings

**3.4****common-cause failure**

failures of different items resulting from the same direct cause, occurring within a relatively short time, where these failures are not consequences of another

NOTE Components that fail due to a shared cause normally fail in the same functional mode. The term common mode is, therefore, sometimes used. It is, however, not considered to be a precise term for communicating the characteristics that describe a common-cause failure.

**3.5****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

NOTE For more specific information, see IEC 60050-191:1990, Figure 191-10.

**3.6****critical failure**

failure of an equipment unit that causes an immediate cessation of the ability to perform a required function

NOTE Includes failures requiring immediate action towards cessation of performing the function, even though actual operation can continue for a short period of time. A critical failure results in an unscheduled repair.

**3.7****degraded failure**

failure that does not cease the fundamental function(s), but compromises one or several functions

NOTE The failure can be gradual, partial or both. The function can be compromised by any combination of reduced, increased or erratic outputs. An immediate repair can normally be delayed but, in time, such failures can develop into a critical failure if corrective actions are not taken.

**3.8****demand**

activation of the function (includes functional, operational and test activation)

NOTE For a more detailed description, see C.2.2.

**3.9****down state**

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

NOTE This state is related to availability performance (see 3.1).

**3.10****down time**

time interval during which an item is in a down state

NOTE The down time includes all the delays between the item failure and the restoration of its service. Down time can be either planned or unplanned (see Table 4).

**3.11****equipment class**

class of similar type of equipment units (e.g. all pumps)

NOTE Annex A describes a variety of equipment classes.

### 3.12

#### **equipment data**

technical, operational and environmental parameters characterizing the design and use of an equipment unit

### 3.13

#### **equipment unit**

specific equipment unit within an equipment class as defined by its boundary (e.g. one pump)

### 3.14

#### **error**

discrepancy between a computed, observed or measured value or condition and the true, specified or theoretically correct value or condition

NOTE 1 An error can be caused by a faulty item, e.g. a computing error made by faulty computer equipment.

NOTE 2 The French term "erreur" can also designate a mistake.

### 3.15

#### **failure**

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

NOTE 1 After the failure, the item has a fault.

NOTE 2 "Failure" is an event, as distinguished from a "fault," which is a state.

NOTE 3 This concept as defined does not apply to items consisting of software only.

NOTE 4 See also Table B.1 and Clauses F.2 and F.3.

### 3.16

#### **failure cause**

#### **root cause**

circumstances associated with design, manufacture, installation, use and maintenance that have led to a failure

NOTE See also B.2.3.

### 3.17

#### **failure data**

data characterizing the occurrence of a failure event

### 3.18

#### **failure impact**

impact of a failure on an equipment's function(s) or on the plant

NOTE On the equipment level, failure impact can be classified in three classes (critical, degraded, incipient); see 3.6, 3.7 and 3.26). Classification of failure impact on taxonomy levels 3 to 5 (see Figure 3) is shown in Table 3.

### 3.19

#### **failure mechanism**

physical, chemical or other process that leads to a failure

NOTE See also B.2.2.

### 3.20

#### **failure mode**

effect by which a failure is observed on the failed item

NOTE See also B.2.6.

**3.21****failure on demand**

failure occurring immediately when the item is solicited to start (e.g. stand-by emergency equipment)

NOTE See also Clause C.6.

**3.22****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

**3.23****generic reliability data**

reliability data covering families of similar equipment

**3.24****hidden failure**

failure that is not immediately evident to operations and maintenance personnel

NOTE Equipment that fails to perform an “on demand” function falls into this category. It is necessary that such failures be detected to be revealed.

**3.25****idle time**

part of the up time that an item is not operating

**3.26****incipient failure**

imperfection in the state or condition of an item so that a degraded or critical failure might (or might not) eventually be the expected result if corrective actions are not taken

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**3.27****indenture level**

level of subdivision of an item from the point of view of maintenance action

**3.28****item**

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

NOTE In this International Standard, the common term “item” is used on all taxonomy levels 6 to 9 in Figure 3. See also 3.30, which defines a specific item level.

**3.29****logistic delay**

that accumulated time during which maintenance cannot be carried out due to the necessity to acquire maintenance resources, excluding any administrative delay

NOTE Logistic delays can be due to, for example, travelling to unattended installations, pending arrival of spare parts, specialist, test equipment and information, and delays due to unsuitable environmental conditions (e.g. waiting on weather).

**3.30****maintainable item**

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

**3.31****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

### 3.32

#### **maintenance data**

data characterizing the maintenance action planned or done

### 3.33

#### **maintenance impact**

impact of the maintenance on the plant or equipment's function(s)

NOTE On the equipment level, two severity classes are defined: critical and non-critical. On plant level, three classes are defined: total, partial or zero impact.

### 3.34

#### **maintenance record**

part of maintenance documentation that contains all failures, faults and maintenance information relating to an item

NOTE This record can also include maintenance costs, item availability or up time and any other data where relevant.

### 3.35

#### **maintainability**

⟨general⟩ ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources

NOTE For a more detailed definition and interpretation of maintainability, see Annex C.

### 3.36

#### **maintenance man-hours**

accumulated duration of the individual maintenance times used by all maintenance personnel for a given type of maintenance action or over a given time interval

NOTE 1 Maintenance man-hours are expressed in units of hours.  
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NOTE 2 As several people can work at the same time, man-hours are not directly related to other parameters like MTTR or MDT (see definitions in Annex C.5).

### 3.37

#### **modification**

combination of all technical and administrative actions intended to change an item

NOTE Modification is not normally a part of maintenance, but is frequently performed by maintenance personnel.

### 3.38

#### **non-critical failure**

failure of an equipment unit that does not cause an immediate cessation of the ability to perform its required function

NOTE Non-critical failures can be categorized as “degraded” (3.7) or “incipient” (3.26).

### 3.39

#### **operating state**

state when an item is performing a required function

### 3.40

#### **operating time**

time interval during which an item is in operating state

NOTE Operating time includes actual operation of the equipment or the equipment being available for performing its required function on demand. See also Table 4.

**3.41****opportunity maintenance**

maintenance of an item that is deferred or advanced in time when an unplanned opportunity becomes available

**3.42****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

**3.43****redundancy**

existence of more than one means for performing a required function of an item

NOTE For more detailed definitions and interpretations, see C.1.2.

**3.44****reliability**

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

NOTE 1 The term “reliability” is also used as a measure of reliability performance and can also be defined as a probability.

NOTE 2 For more detailed definitions and interpretations, see Annex C.

**3.45****required function**

function or combination of functions of an item that is considered necessary to provide a given service

**3.46****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

**3.47****surveillance period**

interval of time (calendar time) between the start date and end date of RM data collection

NOTE For more detailed definitions and interpretations, see Annex C.

**3.48****tag number**

number that identifies the physical location of equipment

NOTE For more detailed definitions and interpretations, see Annex C.

**3.49****taxonomy**

systematic classification of items into generic groups based on factors possibly common to several of the items

**3.50****up state**

state of an item characterized by the fact it can perform a required function, assuming that the external resources, if required, are provided

NOTE This relates to availability performance.

**3.51****up time**

time interval during which an item is in an up state

## 4 Abbreviated terms

NOTE Specific abbreviations used for equipment types (e.g. BOP) and units (e.g. kW) are not included in the list below, but covered within each chapter where they are used.

CAPEX	capital expenditure	MUT	mean up time
CDF	cumulative distribution function	MDT	mean down time
CM	condition monitoring	NDT	nondestructive testing
CMMIS	computerized maintenance-management information system	OPEX	operational expenditure
DHSV	downhole safety value	PM	preventive maintenance
ESD	emergency shutdown	P&ID	process and instrument diagram
FTA	fault-tree analysis	PSD	process shutdown
FMECA	failure mode, effect and criticality analysis	PSV	process safety valve
HIPPS	high-integrity process-protection system	QRA	quantitative risk assessment
KPI	key performance indicators	RA	reliability and availability
LCC	life cycle cost	RAM(S)	reliability, availability, maintainability (and safety)
LEL	lower explosion limit	RBI	risk-based inspection
MEG	monoethylene glycol	RCM	reliability-centred maintenance
MI	maintainable item	RM	reliability and maintenance
MTBF	mean time between failures	SIL	safety integrity level
MTTF	mean time to failure	SSIV	subsea isolation valve
MTTR	mean time to repair	TEG	triethylene glycol
MTTM	mean time to maintain	TTF	time to failure
		TTR	time to repair
		WO	work order

## 5 Application

### 5.1 Equipment coverage

This International Standard is applicable to equipment types used in the petroleum, natural gas and petrochemical industry, including but not limited to equipment categories such as process equipment and piping, safety equipment, subsea equipment, pipeline systems, loading/unloading equipment, downhole well equipment and drilling equipment. The equipment may be permanently installed at the facilities or used in conjunction with installation, maintenance or modification phases.

Annex A contains examples of how this International Standard should be used for specific equipment types. The users are expected to define taxonomies for additional equipment classes as needed based on the principles given by this International Standard.

Some principles for RM data collection at equipment level can be applied for monitoring and analysing performance at plant and system levels constituted by various equipment types. However, facility- and plant-performance monitoring also requires other types of data not covered by this International Standard.

## 5.2 Time periods

This International Standard is applicable to data collected during the operational life cycle of equipment, including installation, start-up, operation, maintenance and modification. Laboratory testing, manufacturing and fabrication phases are excluded from the scope of this International Standard. It is, however, emphasized that analysis of relevant historic RM data shall be used in the dimensioning of such testing prior to operation. Technology qualification and development require, and benefit from, past reliability knowledge to reveal potential improvement areas (see 8.3).

## 5.3 Users of this International Standard

This International Standard is intended for users such as the following.

- a) Installation/plant/facility: Operating facility, e.g. maintenance and engineering personnel logging equipment failures or recording maintenance events into facility information management systems.
- b) Owner/operator/company: Reliability staff or others creating (generic) equipment reliability databases for equipment located in company facilities; reliability engineers requiring data or maintenance engineers preparing maintenance plans. This International Standard provides a format for analysing any RM data element as appropriate associated with an analysis (as described in Annex D); e.g. root-cause analysis, analysis of historic performance, prediction of future performance, use in a design process, etc.
- c) Industry: Groups or companies exchanging equipment RM data or joint industry reliability database project co-operation. Improved communication of equipment reliability performance requires the principles in this International Standard to be adhered to (as a "reliability language").
- d) Manufacturers/designers: Use of RM data to improve equipment designs and learn from past experience.
- e) Authorities/regulatory bodies: A format for communicating any RM data on an individual-event basis or as otherwise required from the operating company. This International Standard is, for example, vital for authorities addressing safety equipment reliability.
- f) Consultant/contractor: A format and quality standard for data collection projects and analyses of safety, reliability or maintenance aspects commonly performed by contractors/consultants for the asset owners (e.g. oil companies).

While others, such as developers of computer-maintenance-management software, can find this International Standard to be useful, the primary users are expected to be owners and/or operators who should find the data to be collected readily available within operating facilities.

## 5.4 Limitations

Through analysis of data, RM parameters can be determined for use in design, operation and maintenance. This International Standard does not provide detailed descriptions of methods for analysing data. However, it does give recommendations for defining and calculating some of the vital RM parameters (Annex C) and reviews the purposes and benefits of some analytical methodologies for which data can be used. Such analytical methodologies and application areas can be found in other International Standards, and relevant