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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 — Collecte et échange de données de fiabilité et de maintenance des équipements

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries.*

This third edition cancels and replaces the second edition (ISO 14224:2006), which has been technically revised. The main changes are:

— Clause 3 — several new definitions;

— Clauses 8 and 9 — changes in some figures and tables;

— Annex A — new equipment classes;

— Annex B — associated new and aligned failure modes;

— Annex C — some changes and new subclauses, e.g. C.3.4 and C.7;

— Annex D — new subclause D.5;

— Annex E — new KPIs;

— Annex F — alignment with ISO/TR 12489:2013.

This corrected version of ISO 14224:2016 incorporates various editorial corrections.

Introduction

This International Standard has been prepared based on the previous edition (ISO 14224:2006), experience gained through its use, and know-how and best practices shared through the international development process.

In the petroleum, petrochemical and natural gas industries, great attention is being paid to safety, availability, reliability and maintainability of equipment. The industry annual cost of equipment unavailability is very large, although many plant owners have improved the availability of their operating facilities by addressing this challenge. 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 more important. It is necessary that this information is 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's 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 availability, 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 of optimizing 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.

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. This International Standard also provides a framework and guidelines for establishing performance objectives and requirements for equipment reliability and availability performance.

Annex A contains a summary of equipment that is covered by this International Standard.

This International Standard defines a minimum amount of data that is required to be collected, and it focuses on two main issues:

— data requirements for the categories 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:

a) equipment data, e.g. equipment taxonomy, equipment attributes;

b) failure data, e.g. failure cause, failure consequence;

c) 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:

1) reliability, e.g. failure events and failure mechanisms;

2) availability/efficiency, e.g. equipment availability, system availability, plant production availability;

3) maintenance, e.g. corrective and preventive maintenance, maintenance plan, maintenance supportability;

4) safety and environment, e.g. equipment failures with adverse consequences for safety and/or environment.

This International Standard does not apply to the following:

i. data on (direct) cost issues;

ii. data from laboratory testing and manufacturing (e.g. accelerated lifetime testing), see also 5.2;

iii. complete equipment data sheets (only data seen relevant for assessing the reliability performance are included);

iv. additional on-service data that an operator, on an individual basis, can consider useful for operation and maintenance;

v. 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20815:2008, *Petroleum, petrochemical and natural gas industries — Production assurance and reliability management*

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
active maintenance time
duration of a maintenance action, excluding logistic delay

Note 1 to entry: Technical delays are included in the active maintenance time.

Note 2 to entry: See Figure 4 and Annex C for a more detailed description and interpretation of maintenance times. See also ISO/TR 12489:2013, Figure 5.

Note 3 to entry: A maintenance action can be carried out while the item is performing a required function.

[SOURCE: IEC 60050-192:2015, 192-07-04, modified – Notes 2 and 3 to entry have been added.]

3.2
active repair time
effective time to achieve repair of an item

Note 1 to entry: See also ISO/TR 12489:2013, Figures 5 and 6.

Note 2 to entry: See also definition of “mean active repair time (MART)” in ISO/TR 12489:2013, 3.1.34, that is defined as “expected active repair time”.

3.3
availability
ability to be in a state to perform as required

Note 1 to entry: See Annex C for a more detailed description and interpretation of availability.

Note 2 to entry: Further terms are given in ISO/TR 12489:2013.

[SOURCE: IEC 60050-192:2015, 192-01-23, modified – Notes 1 and 2 to entry have been added.]

3.4
boundary
interface between an item and its surroundings

3.5
common cause failures
failures of multiple items, which would otherwise be considered independent of one another, resulting from a single cause

Note 1 to entry: Common cause failures can also be common mode failures.

Note 2 to entry: The potential for common cause failures reduces the effectiveness of system redundancy.

Note 3 to entry: It is generally accepted that the failures occur simultaneously or within a short time of each other.

Note 4 to entry: 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.

Note 5 to entry: See also ISO/TR 12489:2013, 3.2.14 and 5.4.2.

Note 6 to entry: See also C.1.6

[SOURCE: IEC 60050-192:2015, 192-03-18, modified – Notes 3-6 to entry have been added.]

3.6
common mode failures
failures of different items characterized by the same failure mode

Note 1 to entry: Common mode failures can have different causes.

Note 2 to entry: Common mode failures can also be common cause failures (3.5).

Note 3 to entry: The potential for common mode failures reduces the effectiveness of system redundancy.

[SOURCE: IEC 60050-192:2015, 192-03-19, modified]

3.7
condition-based maintenance
CBM
preventive maintenance based on the assessment of physical condition

Note 1 to entry: The condition assessment can be by operator observation, conducted according to a schedule, or by condition monitoring of system parameters.

[SOURCE: IEC 60050-192:2015, 192-06-07, modified]

3.8
corrective maintenance
maintenance carried out after fault detection to effect restoration

Note 1 to entry: Corrective maintenance of software invariably involves some modification

Note 2 to entry: See also ISO/TR 12489:2013, Figures 5 and 6, which illustrate terms used for quantifying corrective maintenance.

[SOURCE: IEC 60050-192:2015, 192-06-06, modified – Note 2 to entry has been added.]

3.9
critical failure
failure of an equipment unit that causes an immediate cessation of the ability to perform a required function

Note 1 to entry: 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.

Note 2 to entry: See also definition of “critical dangerous failure” and “critical safe failure” in ISO/TR 12489:2013, 3.2.4 and 3.2.7, respectively.

3.10
cycle
operation and subsequent release/reset

[SOURCE: IEC 60050-444:2002, 444-02-11]

3.11
degraded failure
failure that does not cease the fundamental function(s), but compromises one or several functions

Note 1 to entry: 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.

3.12
demand
activation of the function (includes functional, operational and test activation)

Note 1 to entry: See C.1.3 for a more detailed description.

Note 2 to entry: Annex F.3 gives a list of safety critical equipment which are subject to periodic testing.

Note 3 to entry: See also relevant definitions in ISO/TR 12489:2013: "mean time to demand (MTTD)" is defined in 3.1.38, "failure due to demand" is defined in 3.2.13, and "demand mode of operation safety system" is defined in 3.3.1.

3.13
design life
planned usage time for the total system

Note 1 to entry: It is important not to confuse design life with the 'mean time to failure' (MTTF), which is comprised of several items that might be allowed to fail within the design life of the system as long as repair or replacement is feasible.

[SOURCE: ISO 20815:2008, 3.1.5]

3.14
detection method
method or activity by which a failure is discovered

Note 1 to entry: A categorization of detection methods (e.g. periodic testing or continuous condition monitoring) is shown in Table B.4.

3.15
down state
unavailable state
internally disabled state
internal disabled state
<of an item> state of being unable to perform as required, due to internal fault, or preventive maintenance

Note 1 to entry: Down state relates to unavailability of the item.

Note 2 to entry: The adjectives "down" or "unavailable" designate an item in a down state.

Note 3 to entry: See also Table 4 and Figure 4.

Note 4 to entry: See also ISO/TR 12489:2013, Figures 5 and 6.

[SOURCE: IEC 60050-192:2015, 192-02-20, modified – Notes 3 and 4 to entry have been added.]

3.16
down time
time interval during which an item is in a down state

Note 1 to entry: 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).

Note 2 to entry: Mean downtime is in IEC 60050-192, 192-08-10, defined as the 'expectation of the down time'.

[SOURCE: IEC 60050-192:2015, 192-02-21, modified - Notes 1 and 2 to entry have been added.]

3.17
downstream
business category most commonly used in the petroleum industry to describe post-production processes

EXAMPLE Refining, transportation and marketing of petroleum products

Note 1 to entry: See also A.1.4 for further details.

3.18
equipment class
class of similar type of equipment units (e.g. all pumps)

Note 1 to entry: Annex A contains equipment-specific data for the equipment covered in this International Standard.

3.19
equipment data
technical, operational and environmental parameters characterizing the design and use of an equipment unit

3.20
equipment type
particular feature of the design which is significantly different from the other design(s) within the same equipment class

3.21
equipment unit
specific equipment within an equipment class as defined by its boundary

Note 1 to entry: Equipment unit is given at level 6 of the equipment taxonomy classification with taxonomic levels shown in Figure 3.

3.22
error
discrepancy between a computed, observed or measured value or condition and the true, specified or theoretically correct value or condition

Note 1 to entry: An error within a system can be caused by failure of one or more of its components, or by the activation of a systematic fault.

Note 2 to entry: An error can be caused by a faulty item, e.g. a computing error made by faulty computer equipment.

Note 3 to entry: In this International Standard, error is also specifically used for software and human errors.

[SOURCE: IEC 60050-192:2015, 192-03-02, modified – Notes 2 and 3 to entry have been added.]

3.23
failure
<of an item> loss of ability to perform as required

Note 1 to entry: A failure of an item is an event that results in a fault of that item: see fault (3.22).

Note 2 to entry: A failure of an item is an event, as distinct from a fault of an item, which is a state [source: ISO/TR 12489:2013].

Note 3 to entry: This concept as defined does not apply to items consisting of software only.

Note 4 to entry: See Table B.1, and also F.2 and F.3.

[SOURCE: IEC 60050-192:2015, 192-03-01, modified – Notes 2 through 4 to entry have been added.]

3.24
failure cause
root cause
set of circumstances that leads to failure

Note 1 to entry: A failure cause can originate during specification, design, manufacture, installation, operation or maintenance of an item.

Note 2 to entry: See also B.2.3 and Table B.3, which define failure causes for all equipment classes.

[SOURCE: IEC 60050-192:2015, 192-03-11, modified – Note 2 to entry has been added.]

3.25
failure data
data characterizing the occurrence of a failure event

Note 1 to entry: See also Table 6.

3.26
failure due to demand
failure occurring on demand

Note 1 to entry: See further details in ISO/TR 12489:2013, 3.2.13.

[SOURCE: ISO/TR 12489:2013, modified – Note 1 to entry has been added.]

3.27
failure frequency
unconditional failure intensity; conditional probability per unit of time that the item fails between t and $t + dt$, provided that it was working at time 0

Note 1 to entry: Another term used for failure frequency is “rate of occurrence”.

Note 2 to entry: See also ISO/TR 12489:2013, 3.1.22 and 3.1.23.

[SOURCE: ISO/TR 12489:2013, modified – Notes 1 and 2 to entry have been added.]

3.28
failure impact
effect of a failure on an equipment’s function(s) or on the plant

Note 1 to entry: On the equipment level, failure impact can be classified in three classes (critical, degraded, incipient); see definitions of “critical failure” (3.9), “degraded failure” (3.11) and “incipient failure” (3.40). Classification of failure impact on taxonomy levels 3 to 5 (see Figure 3) is shown in Table 3.

Note 2 to entry: Classification of failure impact on taxonomy levels 4 and 5 (see Figure 3) is shown in Table 3. See also C.1.10.

3.29
failure mechanism
process that leads to failure

Note 1 to entry: The process can be physical, chemical, logical, or a combination thereof.

Note 2 to entry: See also B.2.2 and Table B.2, which define failure causes for all equipment classes.

[SOURCE: IEC 60050-192:2015, 192-03-12, modified – Note 2 to entry has been added.]

3.30
failure mode
manner in which failure occurs

Note 1 to entry: See also the tables in B.2.6, on the relevant failure modes which defines failure modes to be used for each equipment class

Note 2 to entry: Analysis might require data collection to be established on different taxonomy levels, see Table 3.

[SOURCE: IEC 60050-192:2015, 192-03-17, modified – Notes 1 and 2 to entry have been added.]

3.31
failure on demand
failure likely to be observed when a demand occurs

Note 1 to entry: Failure on demand includes the failures occurred before the demand and the failures due to the demand.

Note 2 to entry: See also C.6 on testing for hidden failures in safety systems.

Note 3 to entry: See also definition on *failure due to demand* (3.26).

Note 4 to entry: See ISO/TR 12489:2013, 3.1.15 for definition of the probability of failure on demand (PFD).

Note 5 to entry: Different failure modes are used to reflect failure on demand (see the tables in B.2.6).

[SOURCE: ISO/TR 12489:2013, modified – Notes 1 through 5 to entry have been added.]

3.32
failure rate
conditional probability per unit of time that the item fails between t and $t + \mathrm{d}t$, provided that it has been working over $[0, t]$

Note 1 to entry: See also definition of failure rate in ISO/TR 12489:2013, 3.1.18.

Note 2 to entry: See also definition of failure rate in IEC 60050-192:2015, 192-05-06 (instantaneous failure rate).

[SOURCE: ISO/TR 12489:2013, modified – Notes 1 and 2 to entry have been added.]

3.33
fault
inability to perform as required, due to an internal state

Note 1 to entry: A fault of an item results from a failure, either of the item itself, or from a deficiency in an earlier stage of the life cycle, such as specification, design, manufacture or maintenance. See *latent fault* (3.44).

Note 2 to entry: A fault is often a result of a failure of the item itself but the state can exist without a failure (see ISO 20815:2008, 3.1.14).

Note 3 to entry: See also ISO/TR 12489:2013, 3.2.2.

[SOURCE: IEC 60050-192:2015, 192-04-01, modified – Notes 2 and 3 to entry have been added.]

3.34
generic reliability data
reliability data covering families of similar equipment

Note 1 to entry: See Annex D.5 and Table D.5.

3.35
hidden failure
failure that is not immediately evident to operations and maintenance personnel

Note 1 to entry: Equipment failures that occurred at an earlier point of time, but were first observed at demand, fall into this category. Such failures are first revealed when the relevant functionality is tested (activated).

Note 2 to entry: See definition with notes to entry in ISO/TR 12489:2013, 3.2.11.

Note 3 to entry: See also *latent fault* (3.44).

3.36
human error
discrepancy between the human action taken or omitted and that intended

EXAMPLE Performing an incorrect action; omitting a required action.

Note 1 to entry: Discrepancy with intention is considered essential in determining human error (see [303]).

Note 2 to entry: The term "human error" is often attributed in hindsight to a human decision, action or inaction considered to be an initiator or contributory cause of a negative outcome such as loss or harm.

Note 3 to entry: In human reliability assessment human error is defined as any member of a set of human actions or activities that exceeds some limit of acceptability, this being an out of tolerance action or failure to act where the limits of performance are defined by the system (see [298]).

Note 4 to entry: See also IEC 62508:2010 for further details.

Note 5 to entry: See also ISO/TR 12489:2013, 5.5.2.

[SOURCE: IEC 60050-192:2015, 192-03-14, modified – Notes 1 through 5 to entry have been added.]

3.37
human fatigue
loss of physiological and psychological function as a result of extended wakefulness, heavy work, excessive stimulation, illness or stress

Note 1 to entry: Human fatigue can be related to some of the failure causes in Table B.3, e.g. operating error.

[SOURCE: Moore-Ede M.:2009, modified – Note 1 to entry has been added.]

3.38
idle state
non-operating up state during non-required time

Note 1 to entry: The adjective "idle" designates an item in an idle state.

Note 2 to entry: In some applications, an item in an idle state has some functioning subsystems, and is therefore considered to be operating.

Note 3 to entry: The non-operating time comprises the idle time, the stand-by time and the externally disabled time

[SOURCE: IEC 60050-192:2015, 192-02-14, modified – Note 3 to entry has been added.]

3.39
idle time
time interval for which the item is in an idle state

[SOURCE: IEC 60050-192:2015, 192-02-15]

3.40
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

Note 1 to entry: The recording of incipient failure requires some criteria for when a fault of this nature requires registration as opposed to a state/condition where no corrective actions are required.

3.41
indenture level
level of subdivision of an item from the point of view of maintenance action

3.42
integrity
ability of a barrier to function as required when needed

Note 1 to entry: See 3.1.2 in ISO/TR 12489:2013 for definition of safety integrity.

Note 2 to entry: There are different definitions of integrity: plant, asset, system, pipeline, well (see ISO 16530-1:—, 2.73), mechanical, safety (see ISO/TR 12489:2013, 3.1.2), structural and technical.

3.43
item
subject being considered

Note 1 to entry: The item can be an individual part, component, device, functional unit, equipment, subsystem, or system.

Note 2 to entry: The item may consist of hardware, software, people or any combination thereof.

Note 3 to entry: 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.

[SOURCE: IEC 60050-192:2015, 192-01-01, modified – Note 3 to entry has been added.]

3.44
latent fault
undetected fault
<of an item> fault that has not become apparent

Note 1 to entry: A latent fault can eventually be revealed by preventive maintenance or by a system failure.

[SOURCE: IEC 60050-192:2015, 192-04-08, modified]

3.45
life cycle
series of identifiable stages through which an item goes, from its conception to disposal

Note 1 to entry: See 5.2 for the purpose of data collection.

Note 2 to entry: See also ISO 20815:2008, Table 2 for the purpose of production assurance.

[SOURCE: IEC 60050-192:2015, 192-01-09, modified – Notes 1-2 to entry have been added.]