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Petroleum, petrochemical and natural gas industries — Production assurance and reliability management

Industries du pétrole, de la pétrochimie et du gaz naturel — Assurance de la production et management de la fiabilité

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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 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document 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 20815:2008), which has been technically revised. The main changes compared to the previous edition are as follows:

— Clause 3: several new terms, definitions and abbreviations;

— Clause 4: new 4.1 and new Figure 2;

— Annexes A, B, C and E: minor changes;

— Annex D: various new text and new figures;

— Annex F: new text in Clause F.3, new Clause F.4, and new figure;

— Annex G and H: some changes in Clauses G.2, G.3, H.1 and H.2;

— Annex I: various changes in Clauses I.7 to I.10, I.18 to I.22, and new Clauses I.23 to I.26.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The petroleum, petrochemical and natural gas industries involve large capital investment costs as well as operational expenditures. The profitability of these industries is dependent upon the reliability, availability and maintainability of the systems and components that are used. Therefore, for optimal production availability in the oil and gas business, a standardized, integrated reliability approach is required.

The concept of production assurance, introduced in this document, enables a common understanding with respect to use of reliability technology in the various life cycle phases and covers the activities implemented to achieve and maintain a performance level that is at its optimum in terms of the overall economy and, at the same time, consistent with applicable regulatory and framework conditions.

Annexes A to I are for information only.

Petroleum, petrochemical and natural gas industries — Production assurance and reliability management

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document describes the concept of production assurance within the systems and operations associated with exploration drilling, exploitation, processing and transport of petroleum, petrochemical and natural gas resources. This document covers upstream (including subsea), midstream and downstream facilities, petrochemical and associated activities. It focuses on production assurance of oil and gas production, processing and associated activities and covers the analysis of reliability and maintenance of the components. This includes a variety of business categories and associated systems/equipment in the oil and gas value chain. Production assurance addresses not only hydrocarbon production, but also associated activities such as drilling, pipeline installation and subsea intervention.

This document provides processes and activities, requirements and guidelines for systematic management, effective planning, execution and use of production assurance and reliability technology. This is to achieve cost-effective solutions over the life cycle of an asset development project structured around the following main elements:

— production assurance management for optimum economy of the facility through all of its life cycle phases, while also considering constraints arising from health, safety, environment, and quality;

— planning, execution and implementation of reliability technology;

— application of reliability and maintenance data;

— reliability-based technology development, design and operational improvement.

The IEC 60300-3 series addresses equipment reliability and maintenance performance in general.

This document designates 12 processes, of which seven are defined as core production assurance processes and addressed in this document. The remaining five processes are denoted as interacting processes and are outside the scope of this document. The interaction of the core production assurance processes with these interacting processes, however, is within the scope of this document as the information flow to and from these latter processes is required to ensure that production assurance requirements can be fulfilled.

The only requirement mandated by this document is the establishment and execution of the production assurance programme (PAP). It is important to reflect the PAP in the overall project management in the project for which it applies.

This document recommends that the listed processes and activities be initiated only if they can be considered to add value.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 14224:2016, *Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
active repair time
effective time to achieve repair of an item

Note 1 to entry: The expectation of the effective time to repair is called MART (mean active repair time).

Note 2 to entry: ISO 14224:2016 distinguishes between the terms mean active repair time (MART), mean time to repair (MTTR), mean time to restoration (MTTRes), and mean overall repairing time (MRT). See ISO 14224:2016, 3.59, 3.63, 3.64 and 3.61 for further details.

Note 3 to entry: The mean active repair time (MART) is defined as "expected active repair time" in ISO/TR 12489:2013, 3.1.34. See also ISO/TR 12489:2013, Figures 5 and 6.

[SOURCE: ISO 14224:2016, 3.2, modified — Notes 1 to 2 to entry have been added.]

3.1.2
availability
ability to be in a state to perform as required

Note 1 to entry: For a binary item, the measure of the availability is the probability to be in up state (i.e. in a state belonging to the up state class), see 3.1.59.

Note 2 to entry: In 3.1.4, the figure shows the system is available at time t_1 and unavailable at time t_2.

Note 3 to entry: See ISO 14224:2016, Annex C for a more detailed description and interpretation of availability.

Note 4 to entry: Technical or operational availability (see ISO 14224:2016, C.2.3.2 and Table E.3) or system availability can be used as derived performance measures. Case specific definition of system availability is needed to reflect the system being addressed.

Note 5 to entry: Further terms are given in ISO/TR 12489:2013.

Note 6 to entry: See Figure G.1 for further information.

[SOURCE: IEC 60050-192:2015, 192-01-23, modified — Notes 1 to 6 to entry have been added.]

3.1.3
barrier
functional grouping of safeguards or controls selected to prevent a major accident or limit the consequences

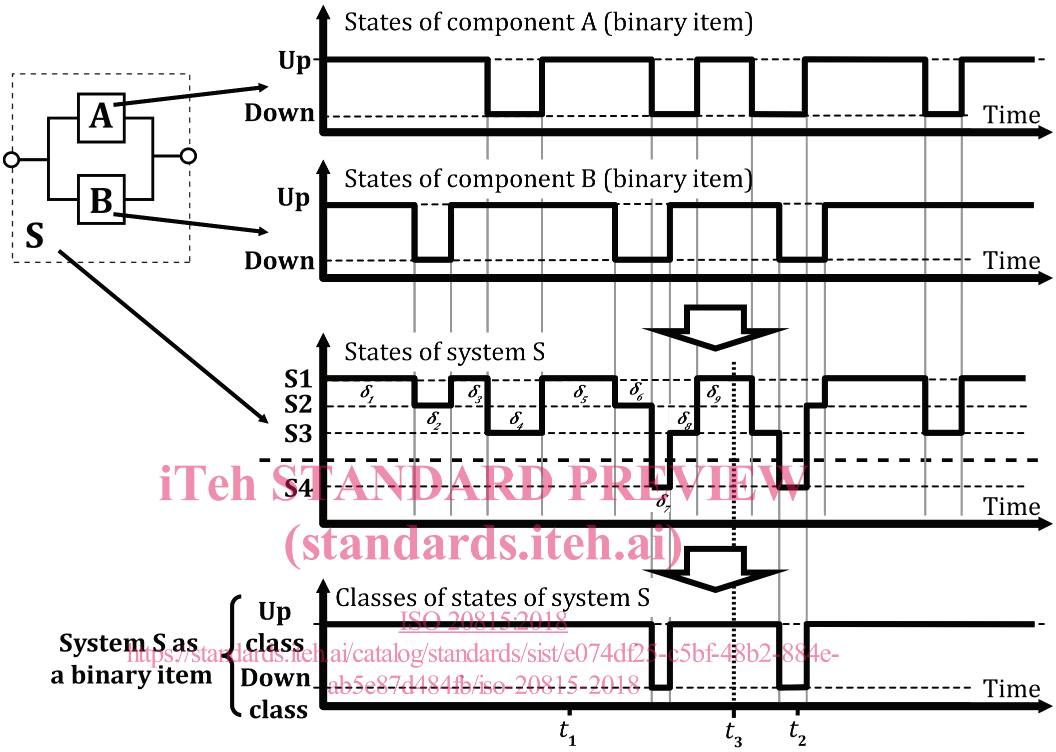
[SOURCE: ISO 17776:2016, 3.1.1]

3.1.4
binary item
item with two classes of states

Note 1 to entry: The two classes can be 'up state' and 'down state'.

EXAMPLE 1 A usual item with an up state (3.1.59) and a down state (3.1.10) is a binary item. Components A and B in the figure below are binary items.

EXAMPLE 2 A system made up of two redundant binary items, A and B, has four states: S_1 (both A and B in up state), S_2 (A in up state and B in down state), S_3 (A in down state and B in up state), S_4 (both A and B in down state). If the system is able to operate as required in states S_1, S_2 and S_3 and not able in state S_4, it is a binary item with the up state class {S_1, S_2, S_3} and the down class {S_4}. This is illustrated in the Figure showing availability behaviour of an 1oo2 system.



3.1.5
common cause failure
failures of multiple items, which would otherwise be considered independent of one another, resulting from a single cause

Note 1 to entry: See also Notes to entry for common cause failures in ISO 14224:2016, 3.5.

[SOURCE: IEC 60050-192:2015, 192-03-18, modified — Note 1 to entry has been added.]

3.1.6
condition monitoring
obtaining information about physical state or operational parameters

Note 1 to entry: Condition monitoring is used to determine when preventive maintenance may be required.

Note 2 to entry: Condition monitoring may be conducted automatically during operation or at planned intervals.

Note 3 to entry: Condition monitoring is part of condition-based maintenance. See also ISO 14224:2016, Figure 6.

[SOURCE: IEC 60050-192:2015, 192-06-28, modified — Note 3 to entry has been added.]

3.1.7
corrective maintenance
maintenance carried out after fault detection to effect restoration

Note 1 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 1 to entry has been added.]

3.1.8
deliverability
ratio of deliveries to planned deliveries over a specified period of time, when the effect of compensating elements, such as substitution from other producers and downstream buffer storage, is included

Note 1 to entry: See Figure G.1 for further information.

3.1.9
design life
planned usage time for the total system

Note 1 to entry: 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.

3.1.10
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: This concept is related to a binary item (3.1.4), which can have several down states forming the down state class of the item. All the states in the down state class are considered to be equivalent with regard to the unavailability of the considered item.

Note 2 to entry: See also Notes to entry for down state in ISO 14224:2016, 3.15.

EXAMPLE In the figure in 3.1.4, the down state class of the system S comprises only one state {S_4} and the system S is in down state at time t_2.

[SOURCE: IEC 60050-192:2015, 192-02-20, modified — Notes 1 and 2 have been added.]

3.1.11
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 ISO 14224:2016, Table 4).

Note 2 to entry: Down time can be equipment down time (see Figure 4 and Table 4 in ISO 14224:2016), production down time (see Figures I.1 and I.2) or down time for other operations (e.g. drilling). It is important to distinguish between the equipment down time itself and the down time of the plant to which the equipment belongs.

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

3.1.12
downstream
business category most commonly used in the petroleum industry to describe post-production processes

Note 1 to entry: See ISO 14224:2016, A.1.4 for further details.

[SOURCE: ISO 14224:2016, 3.17]

3.1.13
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 (i.e. a state) of that item (see 3.1.18). This is illustrated in the figure in 3.1.50 for a binary system S comprising two redundant components A and B.

[SOURCE: IEC 60050-192:2015, 192-03-01, modified — Note 1 to entry has been added.]

3.1.14
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 ISO 14224:2016, 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.]

3.1.15
failure data
data characterizing the occurrence of a failure event

Note 1 to entry: See also ISO 14224:2016, Table 6.

[SOURCE: ISO 14224:2016, 3.25]

3.1.16
failure mode
manner in which failure occurs

Note 1 to entry: See also the tables in ISO 14224:2016, B.2.6, on the relevant failure modes, which define failure modes to be used for each equipment class.

[SOURCE: IEC 60050-192:2015, 192-03-17, modified — Note 1 to entry has been added.]

3.1.17
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 $[0, t]$

[SOURCE: ISO/TR 12489:2013, modified — Notes 1 to 4 to entry have been added.]

Note 1 to entry: See ISO 14224:2016, C.3 for further explanation of the failure rate.

Note 2 to entry: This definition applies for the first failure of binary items (3.1.4).

Note 3 to entry: Under the assumptions that the failure rate is constant and that the item is as good as new after repairs the failure rate can be estimated as the number of failures relative to the corresponding accumulated up time divided by this accumulated up time. In this case this is the reciprocal of MTTF (3.1.34). In some cases, time can be replaced by units of use.

Note 4 to entry: The estimation of the failure rate can be based on operating time or calendar time.

3.1.18
fault
<of an item> 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 (ISO 14224:2016, 3.44). The down states of items A, B and S in the figure in 3.1.46 are examples of faults.

Note 2 to entry: An item made of several sub-items (e.g. a system) which continues to perform as required in presence of faults of one or several sub-items is called fault tolerant.

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

[SOURCE: IEC 60050-192:2015, 192-04-01, modified — Note 2 to entry has been added.]

3.1.19
fault tolerance
attribute of an item that makes it able to perform a required function in the presence of certain given sub-item faults

3.1.20
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 Reference[81].

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 Reference[78]).

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.]

3.1.21
instantaneous availability
$A(t)$
probability that an item is in a state to perform as required at a given instant

[SOURCE: IEC 60050-192:2015, 192-08-01]

3.1.22
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 (see DNVGL-ST-F101:2017), well (see ISO 16530-1:2017, 3.73), mechanical, safety (see ISO/TR 12489:2013, 3.1.2), structural (see ISO 19900:—, 3.47) and technical.

3.1.23
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 document, item can also be plant/unit and installation. See ISO 14224:2016, Figure 3.

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

3.1.24
logistic delay
delay, excluding administrative delay, incurred for the provision of resources needed for a maintenance action to proceed or continue

Note 1 to entry: Logistic delays can be due to, for example, travelling to unattended installations, pending arrival of spare parts, specialists, test equipment and information, and delays due to unsuitable environmental conditions (e.g. waiting on weather).

Note 2 to entry: See also ISO/TR 12489:2013, Figure 5.

[SOURCE: IEC 60050-192:2015, 192-07-13, modified — Notes 1 and 2 to entry have been added.]

3.1.25
lost revenue
total cost of lost or deferred production due to down time

3.1.26
maintainability
<of an item> ability to be retained in, or restored to a state to perform as required, under given conditions of use and maintenance

Note 1 to entry: Given conditions would include aspects that affect maintainability, such as: location for maintenance, accessibility, maintenance procedures and maintenance resources.

Note 2 to entry: Maintainability can be quantified using appropriate measures. See IEC 60050-192:2015, 192-07-Maintainability and maintenance support: measures.

Note 3 to entry: See Figure G.1 for further information.

[SOURCE: IEC 60050-192:2015, 192-01-27, modified — Note 3 to entry has been added.]

3.1.27
maintainable item
item that constitutes a part or an assembly of parts that is normally the lowest level in the equipment hierarchy during maintenance

[SOURCE: ISO 14224:2016, 3.48]

3.1.28
maintenance
combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

[SOURCE: IEC 60050-192:2015, 192-06-01]

3.1.29
maintenance data
data characterizing the maintenance action planned or done

Note 1 to entry: See also ISO 14224:2016, Table 8.

[SOURCE: ISO 14224:2016, 3.51]

3.1.30
maintenance management
all activities of the management that determine the maintenance requirements, objectives, strategies, and responsibilities, and implementation of them by such means as maintenance planning, maintenance control and the improvement of maintenance activities and economics

[SOURCE: EN 13306:2017, 2.2]

3.1.31
maintenance supportability
supportability
<of an item> ability to be supported to sustain the required availability with a defined operational profile and given logistic and maintenance resources

Note 1 to entry: Supportability of an item results from the inherent maintainability (3.1.26), combined with factors external to the item that affect the relative ease of providing the required maintenance and logistic support.

Note 2 to entry: See ISO 14224:2016, Annex C for further details regarding the interpretation of maintainability.

[SOURCE: IEC 60050-192:2015, 192-01-31, modified — Note 2 to entry has been added.]

3.1.32
major accident
hazardous event that results in multiple fatalities or severe injuries; or extensive damage to structure, installation or plant; or large-scale impact on the environment

Note 1 to entry: Examples of large-scale impact on the environment are persistent and severe environmental damage that can lead to loss of commercial or recreational use, loss of natural resources over a wide area or severe environmental damage that will require extensive measures to restore beneficial uses of the environment.

Note 2 to entry: In ISO 17776:2016, a major accident is the realization of a major accident hazard.

[SOURCE: ISO 17776:2016, 3.1.12]

3.1.33
mean availability
average availability
$A(t_1, t_2)$
average value of the instantaneous availability over a given time interval $[t_1, t_2]$

[SOURCE: IEC 60050-192:2015, 192-08-01, modified — Note 1 to entry has been added.]

Note 1 to entry: The average availability is the ratio between the accumulated time spent in up state and the length of the considered period of observation. For example, in 3.1.4 the figure shows the average availability of the system over the interval $[0, t_3]$ is equal to $(\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 + \delta_6 + \delta_8 + \delta_9)/t_3$, i.e. $1 - \delta_7/t_3$ where δ_7/t_3 is the average unavailability of the system. This formula is similar to the formula obtained for production availability calculations when only two levels, 100 % and 0 %, are considered.

3.1.34
mean time to failure
MTTF
expected time before the item fails

Note 1 to entry: See further details in ISO/TR 12489:2013, 3.1.29.

Note 2 to entry: IEC 60050-192:2015 defines MTTF as ”expectation of the operating time to failure”.

Note 3 to entry: See also ISO 14224:2016, Annex C.

[SOURCE: ISO/TR 12489:2013, 3.1.29, modified — Notes 1 through 3 to entry have been added.]

3.1.35
midstream
business category involving the processing, storage and transportation sectors of the petroleum industry

Note 1 to entry: See ISO 14224:2016, A.1.4 for further details.

[SOURCE: ISO 14224:2016, 3.65]

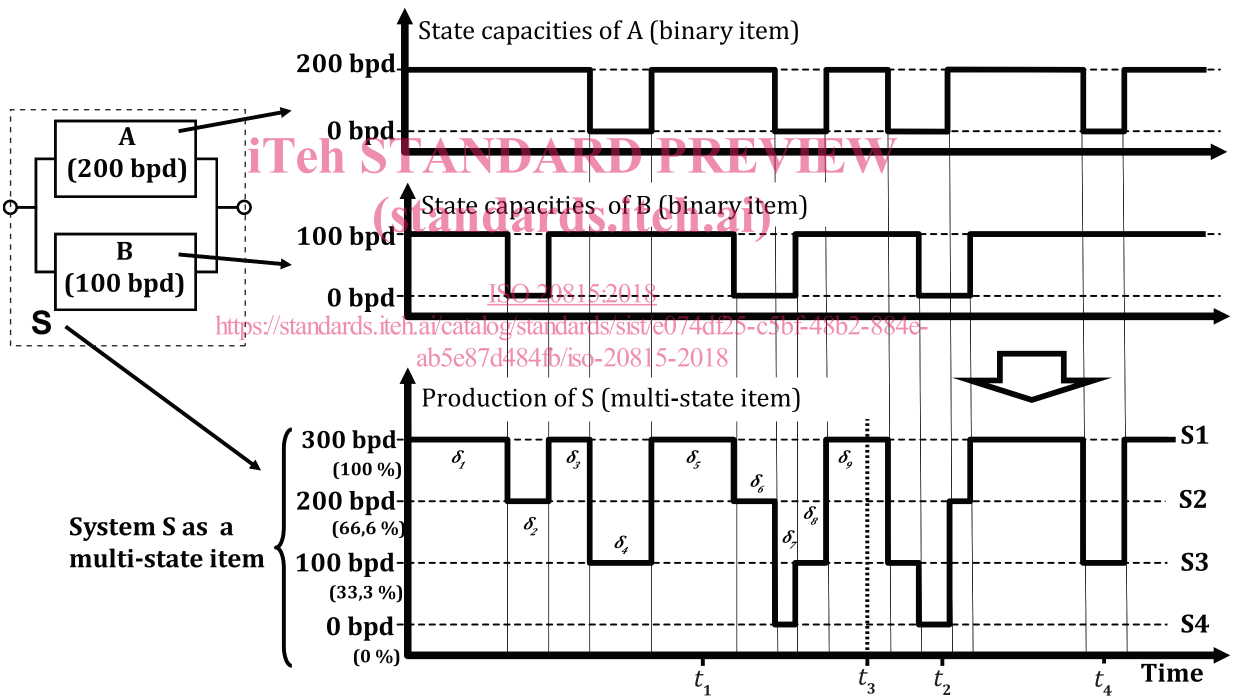
3.1.36
modification
combination of all technical and administrative actions intended to change an item

[SOURCE: ISO 14224:2016, 3.67]

3.1.37
multi-state item
item with more than two classes of states

Note 1 to entry: This is an extension of the binary items beyond the concepts of up and down states. This can characterize single items with degraded states or systems made up of several components.

EXAMPLE An oil production system comprising two wells, A and B, that can be considered as binary items (see 3.1.3) has four states: S_1 (both A and B in up state), S_2 (A in up state and B in down state), S_3 (A in down state and B in up state), S_4 (both A and B in down state). If, when they are in up state, A produces 200 bpd (barrels per day) and B produces 100 bpd, then the system has four classes of production 300 bpd, {S_1},200 bpd, {S_2}, 100 bpd, {S_3} and 0 bpd, {S_4}. With regards to oil production, it is a multi-state item. This is illustrated in the figure showing production availability behaviour of a multi-state system.



3.1.38
observation period
time period during which production performance and reliability data are recorded

3.1.39
operating state
<of an item> state of performing as required

Note 1 to entry: See also ISO 14224:2016, Table 4.

Note 2 to entry: In some applications, an item in an idle state is considered to be operating.

Note 3 to entry: The state capacities of a multi-state item characterize various levels of operation and consequently, the definition of the operating state of a multi-state item depends on the situation, for example, if:

— no other requirement is given, any state with a capacity greater than zero is an operating state;

— a minimum capacity is required, it provides the limit to split the states between up and down classes;