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Petroleum, petrochemical and natural gas industries — Calculation and reporting production efficiency in the operating phase

Industries du pétrole, de la pétrochimie et du gaz naturel — Calcul et rapport d'efficacité de la production dans la phase d'exploitation

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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).

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

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 expenditure as well as operating expenditure. Revenue loss caused by production loss will affect the profitability of such industry and for a specific plant operatorship.

Production efficiency (PE) is a term often used by operators for historic production availability in the operating phase. PE is a reported measure, and it can be compared with the predicted (or targeted) production availability made during a project development stage. Furthermore, PE is forecasted and tracked during the operating phase to allow tracking of performance. ISO 20815:2018 addresses production assurance activities including analytical methods for predicting production availability, and also includes a production loss categorization.

This document supports this production loss categorization with a harmonized approach for calculating and reporting production loss and production efficiency in the operating phase, including forecasting during this life cycle phase. This will enable precise and consistent feedback of production performance for use in production and operational planning to achieve optimal PE for the operators and associated industry stakeholders. Focus is given to actual produced volume and reference production volume, e.g. production potential that will depend on reservoir and well constraints, plant/process constraints, export/transportation constraints and market constraints. Standardization of PE reporting across the industry will drive consistency and provide better quality PE information and communication for operators and partners.

Petroleum, petrochemical and natural gas industries — Calculation and reporting production efficiency in the operating phase

1 Scope

This document provides requirements and guidance for reporting of production performance data and production loss data in the operating phase by use of production loss categorization. It supplements the principles of ISO 20815:2018, Clause E.3 and Annex G by providing additional details.

This document focusses on installations and asset elements within the upstream business category. Business categories and associated installations and plants/units, systems and equipment classes are used in line with ISO 14224:2016, Annex A.

The production loss categories given in Annex A are given at a high taxonomic level and supplements the reporting of failure and maintenance parameters as defined in ISO 14224:2016, Annex B.

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*

ISO 20815:2018, *Petroleum, petrochemical and natural gas industries — Production assurance and reliability management*

3 Terms, definitions and abbreviated terms

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 Terms and definitions

3.1.1
achieved production potential
production potential (3.1.43) that in retrospect can be verified as the maximum achievable production in a given time period

Note 1 to entry: Achieved production potential is the sum of the achieved production and the estimated *production loss* (3.1.40) occurring in the four production potential elements: *well production potential* (3.1.58), *plant production capacity* (3.1.34), *export capacity* (3.1.12) and *market potential* (3.1.26).

Note 2 to entry: Achieved production potential can vary over time.

3.1.2
asset
item (3.1.21), thing or entity that has potential or actual value to an organization

Note 1 to entry: Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, licenses, intellectual property rights, reputation or agreements.

Note 2 to entry: A grouping of assets referred to as an asset system (see ISO 55000:2014, 3.2.5) could also be considered as an asset.

Note 3 to entry: In this document, 'asset' only refers to the physical assets, which are tangible assets. An organization can also operate assets that are wholly owned or partly owned through joint ventures or other arrangements. Typically, an asset is a facility or an installation, or a group of facilities. The facility corresponds to an installation category in ISO 14224:2016, Table A.1. These installations can be subdivided into plant/units, *systems* (3.1.50), *equipment classes* (3.1.11), subunits, components, etc. as described in ISO 14224:2016, Table 2. In this document, *asset element* (3.1.3) is used to group these as shown in Table A.2.

[SOURCE: ISO 55000:2014, 3.2.1, modified — Notes 2 and 3 to entry have become Notes 1 and 2 to entry, respectively, new Note 3 to entry has been added.]

3.1.3
asset element
underlying *item* (3.1.21) for the *asset* (3.1.2) that is needed for the asset to deliver its product

Note 1 to entry: In this document, which is applicable for upstream business category, the asset elements are wells (including reservoir), subsea installations, production facilities (including process and utilities), and export and import facilities as shown in Table A.2. For other business categories, the asset elements will be different.

Note 2 to entry: The underlying items of the individual asset element will be *systems* (3.1.50) and relevant *equipment classes* (3.1.11) as defined in ISO 14224:2016, and as shown in Table D.1.

3.1.4
availability
ability to be in a state to perform as required

Note 1 to entry: Various availability terms are defined in ISO 14224:2016, ISO 20815:2018 and ISO/TR 12489:2013.

[SOURCE: IEC 60050-192:2015, 192-01-23, modified — Note 1 to entry has been modified, Note 2 to entry has been deleted.]

3.1.5
conventional resources
oil and gas resources where the reservoir rock characteristics and fluid trapping mechanisms permit reservoir fluids to readily flow into the wellbore

Note 1 to entry: This usually includes conventional, reasonably permeable and connected, sandstone and carbonate reservoirs.

3.1.6
corrective maintenance
maintenance (3.1.24) carried out after fault detection to effect restoration

[SOURCE: IEC 60050-192:2015, 192-06-06, modified — Note 1 to entry has been deleted.]

3.1.7
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 B.1 for further information.

[SOURCE: ISO 20815:2018, 3.1.8]

3.1.8
down time
time interval during which an *item* (3.1.21) 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) or production down time (see Figures I.1 and I.2 in ISO 20815:2018). Down time for other operations such as drilling is not addressed in this document but can affect production or prolong the production down time. It is important to distinguish between the equipment down time itself and the down time of the plant to which the equipment belongs; this document focusses on down time of the latter.

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

3.1.9
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.

Note 2 to entry: The term 'downstream' is sometimes used in this document to reflect installations to which products from installations within upstream business category are transported whereas these installations do not necessarily belong to the downstream business category.

[SOURCE: ISO 14224:2016, 3.17, modified — Note 2 to entry has been added.]

3.1.10
enhanced oil recovery
EOR
reservoir process involving the injection of materials not normally present in the reservoir to enhance the overall oil recovery from such reservoir

Note 1 to entry: Also denoted tertiary oil recovery processes; includes chemical, thermal and gas miscible processes, among others.

3.1.11
equipment class
class of similar type of equipment units (e.g. all pumps)

Note 1 to entry: See ISO 14224:2016, Annex A for equipment specific data.

[SOURCE: ISO 14224:2016, 3.18]

3.1.12
export capacity
maximum volume rate that can be exported

Note 1 to entry: The export capacity can be limited by oil or gas or any other product (e.g. produced water and CO_2). Both the capacity of the export systems (e.g. pipeline) and the downstream receiving facilities needs to be considered.

Note 2 to entry: The export capacity is a volume rate applicable for the product exported. Restrictions in the flowrate to storage caused by limitations in the capacity of export pumps, pipeline capacity, etc., will affect export capacity. Limited storage volume resulting in reduced or no production due to insufficient offtake capacity (e.g. shuttle tanker delay) is an event and will not affect the export capacity but it is a *production loss* (3.1.40).

Note 3 to entry: The plant export capacity can vary over time.

3.1.13
failure
loss of ability to perform as required

Note 1 to entry: A failure of an *item* (3.1.21) is an event that results in a fault (i.e. a state) of that item. This is illustrated in the figure in ISO 20815:2018, 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 modified, Notes 2 and 3 to entry have been deleted.]

3.1.14
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]

3.1.15
failure impact
effect of a *failure* (3.1.13) 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' (ISO 14224:2016, 3.9), 'degraded failure' (ISO 14224:2016, 3.11) and 'incipient failure' (ISO 14224:2016, 3.40). Classification of failure impact on taxonomy levels 3 to 5 (see ISO 14224:2016, Figure 3) is shown in ISO 14224:2016, Table 3.

Note 2 to entry: Classification of failure impact on taxonomy levels 4 and 5 (see ISO 14224:2016, Figure 3) is shown in ISO 14224:2016, Table 3. See also ISO 14224:2016, C.1.10.

[SOURCE: ISO 14224:2016, 3.28]

3.1.16
human error
discrepancy between the human action taken or omitted and that intended

Note 1 to entry: See further information in ISO 14224:2016, 3.36.

[SOURCE: IEC 60050-192:2015, 192-03-14, modified — "or required" has been deleted from the definition, example has been deleted, Note 1 to entry has been added.]

3.1.17
improved oil recovery
IOR
process used to improve the overall oil recovery from a reservoir, including but not limited to *enhanced oil recovery* (3.1.10)

Note 1 to entry: IOR includes not only reservoir recovery processes (secondary and tertiary), but also other techniques such as infill drilling and artificial lift.

Note 2 to entry: Secondary recovery processes refer to processes involving the injection of gas and/or water, mostly for maintaining reservoir pressure.

3.1.18
injection efficiency
IE
I_E
ratio of injected volume to the *injection potential* (3.1.19) over a specified period of time

Note 1 to entry: This is a volume-based performance measure similar to *production efficiency* (3.1.39).

Note 2 to entry: Injection availability is a time-based measure.

3.1.19
injection potential
V_{IP}
maximum volume that can be injected in a reservoir within a given time period, considering the capacity of injection systems and injection wells

Note 1 to entry: Injection potential can be related to injection of gas, water, CO_2 or other products.

Note 2 to entry: The maximum volume that can be injected may be taken to mean the 'optimum' volume that is injected to achieve optimal reservoir management. The optimum volume is often the one that maximizes economic recovery from the field. This optimum volume can be less than the maximum volume defined by the physical system capacity of the injection system, wells or reservoir.

3.1.20
integrity
ability of a barrier to function as required when needed

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

Note 2 to entry: There are different definitions of integrity: plant, *asset* (3.1.2), *system* (3.1.50), 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 19900:2019, 3.50) and technical.

[SOURCE: ISO 20815:2018, 3.1.22]

3.1.21
item
subject being considered

Note 1 to entry: The item can be an individual part, component, device, functional unit, equipment, subsystem, or *system* (3.1.50).

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 also ISO 14224:2016, Figure 3.

[SOURCE: IEC 60050-192:2015, 192-01-01, modified — Notes 3, 4 and 5 to entry have been deleted, new Note 3 to entry has been added.]

3.1.22
life cycle phase
discrete stage in the life cycle with a specified purpose

Note 1 to entry: The different life cycle phases 'Explore', 'Appraise', 'Select', 'Define', 'Execute', 'Operate' and 'Abandon' are further described in ISO 15663:2021, 4.5.

Note 2 to entry: This document focusses on the life cycle phase 'Operate' and uses the term 'operating phase' in this respect.

[SOURCE: ISO 15663:2021, 3.1.28, modified — Note 2 to entry has been added.]

3.1.23
lost revenue
total cost of lost or deferred production due to *down time* (3.1.8)

Note 1 to entry: See further information regarding estimation of lost revenue in ISO 15663:2021, Clause C.4, and a more general definition of lost revenue is given in ISO 15663:2021, 3.1.29.

[SOURCE: ISO 20815:2018, 3.1.25, modified — Note 1 to entry has been added.]

3.1.24
maintenance
combination of all technical and management actions intended to retain an *item* (3.1.21) in, or restore it to, a state in which it can perform as required

[SOURCE: IEC 60050-192:2015, 192-06-01, modified — Note 1 to entry has been deleted.]

3.1.25
maintenance impact
effect of the *maintenance* (3.1.24) on the plant or equipment's function(s)

Note 1 to entry: On the equipment level, two classes of impact are defined: critical and non-critical. On plant level, three classes are defined: total, partial or zero impact.

Note 2 to entry: For the calculation of PE data, it can be beneficial to separate the *production loss* (3.1.40) arising from the failure event and from the maintenance impact on production, into two different production loss categories. See further guidance in A.3.2.

[SOURCE: ISO 14224:2016, 3.52, modified — Note 2 to entry has been added.]

3.1.26
market potential
maximum volume rate that can be received by the market

Note 1 to entry: A sales contract can limit the market potential.

Note 2 to entry: The market potential can vary over time.

Note 3 to entry: The market potential reflects market constraints when determining the *structural maximum production potential* (3.1.49). When determining the *structural maximum injection potential* (3.1.48) market potential means the maximum volume that can be delivered by the market.

3.1.27
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, modified — Example has been deleted.]

3.1.28
modification
combination of all technical and administrative actions intended to change an *item* (3.1.21)

Note 1 to entry: Modification is not normally part of *maintenance* (3.1.24) but is frequently performed by maintenance personnel. This is typically the maintenance activity 'Modify' as defined in ISO 14224:2016, Table B.5.

Note 2 to entry: In this document, the use of the term modification is primarily meant to cover major modification activities. See further details in 8.2.2 with respect to how such major modifications are reflected in PE reporting.

[SOURCE: ISO 14224:2016, 3.67, modified — Notes 2 and 3 to entry have been deleted, new Note 2 to entry has been added.]

3.1.29
operative well
well that it is economically warrantable to operate

Note 1 to entry: The individual well potential is part of the *well production potential* (3.1.58) even if the well is temporarily shut down due to equipment failure, well intervention, valve testing, reservoir monitoring, etc. See also Table 4.

Note 2 to entry: Economic warrantability will be defined by the operator. Various economic subject matters will determine this economic margin, e.g. CAPEX, OPEX and revenue factors.

3.1.30
performance objective
indicative level for the desired performance

Note 1 to entry: Objectives are expressed in qualitative or quantitative terms. Objectives are not absolute requirements and may be modified based on cost or technical constraints. See further details in ISO 20815:2018, Annex F.

[SOURCE: ISO 20815:2018, 3.1.41]

3.1.31
performance requirement
required minimum level for the performance of the *system* (3.1.50)

Note 1 to entry: Requirements are normally expressed in quantitative terms, but may also be expressed in qualitative terms.

[SOURCE: ISO 20815:2018, 3.1.42, modified — Note 1 to entry has been modified.]

3.1.32
petrochemical
business category producing the chemicals derived from petroleum and used as feedstock for the manufacture of a variety of plastics and other related products

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

[SOURCE: ISO 14224:2016, 3.75, modified — Example has been deleted.]

3.1.33
planned event
event that is intentional, the start and end time is determined, and the effect of the event in terms of consequences is predictable

Note 1 to entry: See further information in 8.2.

Note 2 to entry: See production loss categories associated with planned events in Table A.1.

3.1.34
plant production capacity
maximum processed volume through the plant that can be achieved in the absence of any failure, interruption or any other event

Note 1 to entry: The plant production capacity is related to the product used for production efficiency calculation (see 7.3). The plant production capacity can be limited by the capacity of systems handling other product streams, e.g. condensate, gas or produced water, or by the capacity of utility systems.

Note 2 to entry: The plant production capacity can vary over time.

Note 3 to entry: The plant represents the *systems* (3.1.50) between the elements well and export as illustrated in Figure 5.

3.1.35
preventive maintenance
maintenance (3.1.24) carried out to mitigate degradation and reduce the probability of *failure* (3.1.13)

Note 1 to entry: See also condition-based maintenance and planned (scheduled) maintenance.

Note 2 to entry: Preventive maintenance can be categorized as shown in ISO 14224:2016, Figure 6.

[SOURCE: IEC 60050-192:2015, 192-06-05 — Note 2 to entry has been added]

3.1.36
primary product
hydrocarbon product that is the main contributor to the production target from an *asset* (3.1.2)

Note 1 to entry: The primary product can be crude oil, condensate or gas. The primary product from an asset (e.g. an individual upstream field or field infrastructure consisting of various installations) will be a result of reservoir characteristics, field development planning and facility design as determined by the production strategy of the field or installation in question.

Note 2 to entry: The primary product can change throughout the operating phase of the asset.

3.1.37
production assurance
activities implemented to achieve and maintain a performance that is at its optimum in terms of the overall economy and at the same time consistent with applicable framework conditions

Note 1 to entry: Production assurance activities relate closely to the integrity management of the installations. See definition of *integrity* (3.1.20).

Note 2 to entry: See further information in ISO 20815:2018 with respect to *production assurance* (3.1.37) for a variety of oil and gas activities.

[SOURCE: ISO 20815:2018, 3.1.45, modified — Note 2 to entry has become Note 1 to entry, new Note 2 to entry has been added.]

3.1.38
production availability
P_A
ratio of production to planned production, or any other reference level, over a specified period of time

Note 1 to entry: This measure is used in conjunction with analysis of delimited systems without compensating elements such as substitution from other producers and downstream buffer storage. Battery limits need to be defined in each case.

Note 2 to entry: See ISO 20815:2018, Clause G.1 and Figure G.1 for further information.

[SOURCE: ISO 20815:2018, 3.1.46, modified — Notes 1, 3, 4 and 5 to entry have been deleted, Note 2 to entry has become Note 1 to entry, new Note 2 to entry has been added.]

3.1.39
production efficiency
PE
P_E
ratio of production to *production potential* (3.1.43) over a specified period of time

Note 1 to entry: PE calculation methodology is described in 5.4.1. There are two methods for PE calculations as described in in 7.2 to 7.4.

Note 2 to entry: PE is normally considered as a historically reported measure, but can also be expressed as a forecast.

Note 3 to entry: With production is meant the actual production for historical reporting or forecast production for PE forecast. The actual production used for calculation of PE is not necessarily the fiscal metered production, see also 6.3.

Note 4 to entry: *Production efficiency* (3.1.39) is a term often used by operators for historic *production availability* (3.1.38) in the operating phase and is a reported measure, but in principle the same measure as predicted production availability that is a modelled measure. See also 3.1.38.

Note 5 to entry: The operator will need to have a production performance system to enable report and calculation of PE data. Such systems can be part of other organization business performance systems and can be related to CMMIS. See further information in Annex A.

3.1.40
production loss
difference between *production potential* (3.1.43) and actual production

Note 1 to entry: Production loss is caused by planned or unplanned activities or events. Annex A defines production the loss categories that shall be used in the upstream business category.

Note 2 to entry: The term production deferment is sometimes used to indicate that the oil/gas constituting the production loss is not totally lost but can be produced at a later stage. Production loss is the term used for PE calculation and reporting since the production loss is actually a loss within the time period considered.

Note 3 to entry: Examples of lost revenue elements as a result of production loss are described in ISO 15663:2021, C.4.1.

3.1.41
production performance
capacity of a *system* (3.1.50) to meet demand for deliveries or performance

Note 1 to entry: *Production availability* (3.1.38), *deliverability* (3.1.7) or other appropriate measures can be used to express production performance.

Note 2 to entry: The use of production performance terms should specify whether it represents a predicted or historic production performance.

Note 3 to entry: In this document, *production efficiency* (3.1.39) is used as the measure for production performance.

[SOURCE: ISO 20815:2018, 3.1.47, modified — Note 3 to entry has been added.]

3.1.42
production performance analysis
systematic evaluations and calculations carried out to assess the *production performance* (3.1.41)

Note 1 to entry: Various measures used in production performance analysis to address various parts of the hydrocarbon production chain are shown in Annex B. Production availability analysis is an analysis that normally covers the entire *asset* (3.1.2); see ISO 20815:2018, Clause I.5.

[SOURCE: ISO 20815:2018, 3.1.48, modified — 'of a system' has been removed from the definition, Notes 1 and 2 to entry have been deleted, new Note 1 to entry has been added.]

3.1.43
production potential
V_{PP}
maximum volume that can be produced through wells, plant and export installations, also considering market restrictions, within a given time period

Note 1 to entry: Production potential can vary over time.

Note 2 to entry: Production potential can be expressed as *structural maximum production potential* (3.1.49) or *achieved production potential* (3.1.1).

Note 3 to entry: Production potential is the maximum production potential that is technically feasible and economically acceptable and is the minimum of the four production potential elements: *well production potential* (3.1.58), *plant production capacity* (3.1.34), *export capacity* (3.1.12) and *market potential* (3.1.26). See also Figure 5.

Note 4 to entry: For business categories *midstream* (3.1.27), *downstream* (3.1.9) and *petrochemical* (3.1.32) where there is not a continuous flow from the reservoir to the plant, reservoir and wells might not be relevant for the production potential. However, limitations on import capacity are still to be considered when determining the production potential.

Note 5 to entry: In this document, *production efficiency* (3.1.39) is calculated using 'production potential' instead of the more general 'reference production volume'. See Clause B.2.

3.1.44
reliability
ability of an *item* (3.1.21) to perform a required function under given conditions for a given time interval

[SOURCE: ISO 14224:2016, 3.81 modified — Notes to entry have been deleted.]

3.1.45
reliability management
activities undertaken to achieve reliability related *performance objectives* (3.1.30) and *performance requirements* (3.1.31)

[SOURCE: ISO 20815:2018, 3.1.52 modified — Notes to entry have been deleted.]

3.1.46
safety critical equipment
equipment and *items* (3.1.21) of permanent, temporary and portable equipment playing an important role in safety systems/functions

[SOURCE: ISO 14224:2016, 3.84]

3.1.47
secondary product
hydrocarbon product that is produced from an *asset* (3.1.2) as a result of processing a *primary product* (3.1.36)

Note 1 to entry: The secondary product can be crude oil, condensate or gas. The secondary product from an asset (e.g. an individual upstream field or field infrastructure consisting of various installations) will be a result of reservoir characteristics, field development planning and facility design.

Note 2 to entry: The secondary product can change throughout field life and can become the primary product, depending on the field characteristics.

3.1.48
structural maximum injection potential
SMIP
estimate of the *injection potential* (3.1.19)

Note 1 to entry: SMIP is the maximum injection potential that is technically feasible and economically acceptable, and it is the minimum of the four injection potential elements: well injection potential, plant injection capacity, import capacity and *market potential* (3.1.26). See also Figure 6.

Note 2 to entry: SMIP can vary over time.

Note 3 to entry: SMIP can be adjusted retrospectively when calculating and reporting *injection efficiency* (3.1.18).

3.1.49
structural maximum production potential
SMPP
estimate of the *production potential* (3.1.43)

Note 1 to entry: SMPP is the maximum production potential that is technically feasible and economically acceptable, and it is the minimum of the four production potential elements: *well production potential* (3.1.58), *plant production capacity* (3.1.34), *export capacity* (3.1.12) and *market potential* (3.1.26). See also Figure 5.

Note 2 to entry: SMPP can vary over time.

Note 3 to entry: SMPP can be adjusted retrospectively when calculating and reporting *production efficiency* (3.1.39).

3.1.50
system
set of interrelated *items* (3.1.21) that collectively fulfil a requirement

Note 1 to entry: The hierarchical system structure that applies in this document for the purpose of reporting *production loss* (3.1.40) uses the taxonomic structure in ISO 14224: 2016, Table A.3 for the upstream business category. This table does also include systems and *equipment classes* (3.1.11) applicable for all business categories for 'Safety and control systems', 'Utilities' and 'Auxiliaries' as further described in Table D.1.

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

3.1.51
trip
shutdown of machinery from normal operating condition to full stop

Note 1 to entry: Trip: The shutdown is activated automatically by the control/monitoring system:

— real trip The shutdown is effectuated as a result of a monitored (or calculated) value in the control system exceeding a pre-set limit;

— spurious trip Unexpected shutdown resulting from *failure(s)* (3.1.13) in the control monitoring system or error(s) imposed on the control/monitoring system originating from the environment or people.

Note 2 to entry: See also ISO/TR 12489:2013, 3.4.14.

[SOURCE: ISO 14224:2016, 3.93]

3.1.52
turnaround
revision shutdown
planned event (3.1.33) wherein an entire process unit is taken off stream for revamp or renewal

Note 1 to entry: See also ISO 20815:2018, Table G.1.

[SOURCE: ISO 14224:2016, 3.94]

3.1.53
uncertainty
inability to determine accurately what is or will be the true value of a quantity

Note 1 to entry: Uncertainty can have different meanings. It can be used as a measure of *variability* (3.1.53) within a population, which is a type of uncertainty often referred to as stochastic (or aleatory) uncertainty. Uncertainty can also have a subjective meaning (epistemic uncertainties).

Note 2 to entry: Uncertainty of input data can be relevant for the production efficiency calculations as described in this document.

Note 3 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequences, or likelihood.

[SOURCE: ISO 14224:2016, 3.95 modified — Note 1 to entry has been modified, Notes 2 and 3 to entry have been added.]

3.1.54
unconventional resources
oil and gas resources where the reservoir rock characteristics and fluid trapping mechanisms do not meet the criteria for *conventional resources* (3.1.5)

Note 1 to entry: This includes, but is not limited to, shale oil and gas reservoirs that are commonly produced through multi-fractured horizontal wells.

Note 2 to entry: Coalbed methane (or coal seam gas), 'tight' (low permeability) and/or poorly connected sandstones and carbonate reservoirs may also be considered unconventional resources.

3.1.55
unplanned event
event that is unanticipated, unintentional or uncontrolled

Note 1 to entry: See further information in 8.2.

Note 2 to entry: See production loss categories associated with unplanned events in Table A.1.

Note 3 to entry: Risk management (see ISO 31000:2018) and production assurance activities (see ISO 20815:2018) can have identified such unplanned event and thereby contingency exists to handle this situation.

3.1.56
upstream
business category of the petroleum industry involving exploration and production

EXAMPLE Offshore oil/gas production facility, drilling rig, intervention vessel.

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

[SOURCE: ISO 14224:2016, 3.98]

3.1.57
variability
variations in performance measures for different time periods under defined framework conditions

[SOURCE: ISO 20815:2018, 3.1.62, modified — Note 1 to entry has been deleted.]

3.1.58
well production potential
maximum production rate from the wells

Note 1 to entry: The well production potential is the combined production from individual wells at optimum reservoir conditions. The individual well potential is determined by the reservoir pressure and productivity but can be limited by well design capacity. The well production potential can be limited by flowline capacity, actual process conditions (e.g. inlet separator pressure), etc.

Note 2 to entry: The well production potential is based on measured oil and gas flow rates corrected to export conditions.

Note 3 to entry: The well production potential can vary over time.

Note 4 to entry: The well production potential is not affected if the well is temporarily shut down due to planned and unplanned activities, such as preventive or *corrective maintenance* (3.1.6). See also Table 4.

3.2 Abbreviations

boe barrel of oil equivalent

CHP combined heat and power

CMMIS computerised maintenance management information system

DHSV downhole safety valve

E&P exploration and production

EDP emergency depressurization

ESD emergency shutdown

FLNG floating LNG

FPSO	floating production, storage and offloading
FSU	floating storage unit
GHG	greenhouse gas
GTL	gas to liquids
HSE	health safety and environment
KPI	key performance indicator
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MART	mean active repair time
MTTRes	mean time to restoration
NGL	natural gas liquids
OPEX	operating expenditure
P&A	plug & abandon
PSD	process shutdown
QA	quality assurance
Sm^3oe	standard m^3 of oil equivalent
SPAR	single point anchor reservoir
SPS	subsea production system
SSIV	subsea isolation valve
SURF	subsea, umbilical, riser and flowline
TLP	tension leg platform
toe	ton of oil equivalent

4 Application

4.1 Users of this document

This document is intended for the following users:

— **Operators/owners**: These organizations are the primary users of this document and can use it to calculate and report production loss, and/or analyse related data, and/or recommend actions to improve PE. They can also use it to report and communicate PE data within their organizations, or to other organizations in a partnership or joint venture.

— **Contractors**: These organizations can use this document for similar purposes to that of operators/owners for those activities in the operating phase (e.g. maintenance, modifications and operation support) for which they are responsible.

— **Vendors/manufacturers/suppliers**: These organizations can use this document to support and advise clients/operators on PE improvement efforts.

— **Authorities/regulatory bodies**: These organizations can use this document to apply standardized PE reporting from operators.

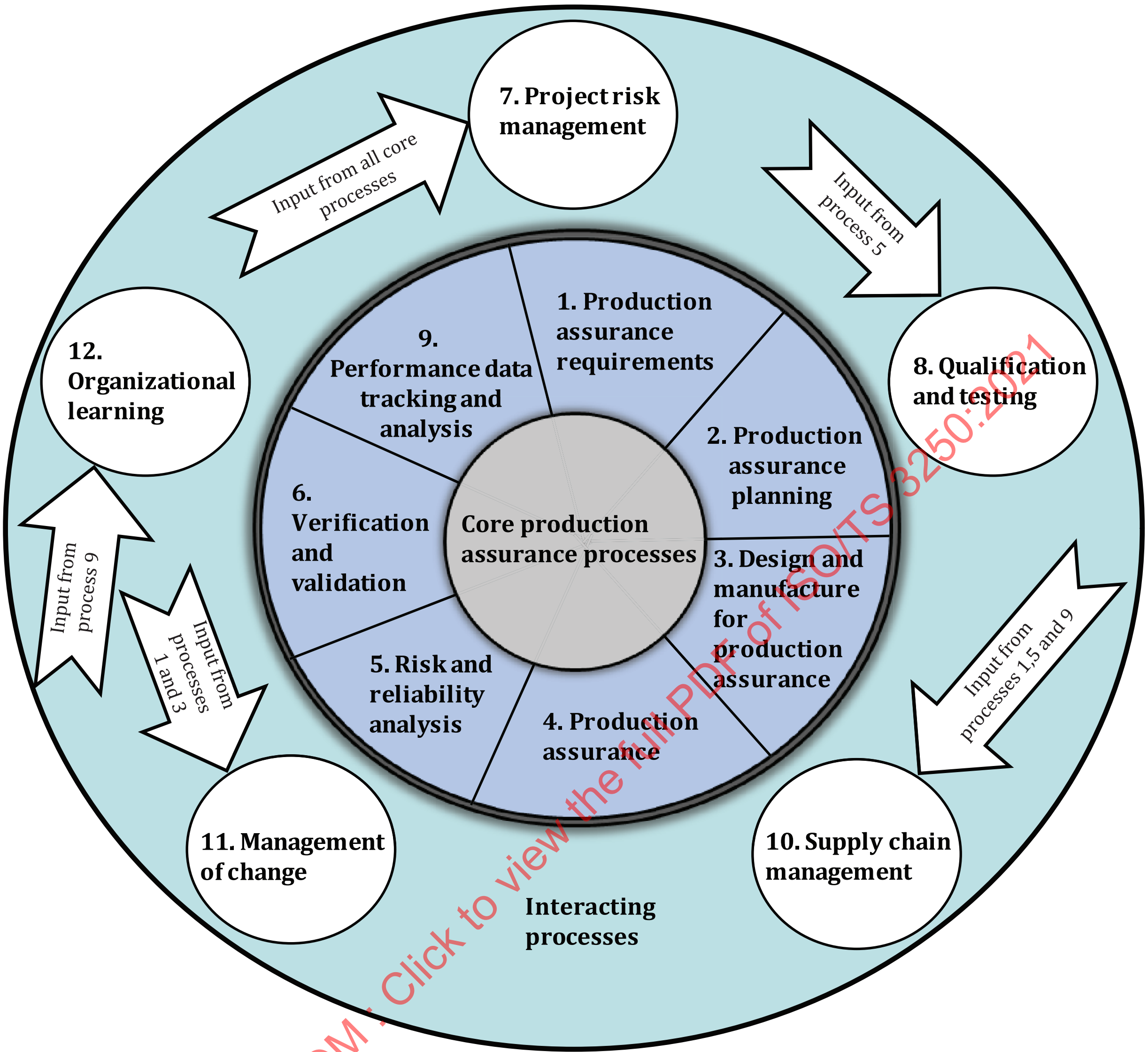
— **Consultants**: They can use this document to conduct production performance analyses, including benchmarking, and to support and advise operators/owners, authorities/regulatory bodies, investors and financial institutions.

4.2 Framework conditions

4.2.1 General

Production assurance is performed to enable cost-effective and safe operations and a variety of production assurance activities can take place during the life cycle phases. ISO 15663:2021, Table 1 defines such life cycle phases for an asset/project, and these phases are also reflected in ISO 20815:2018, Table 2. ISO 20815:2018 provides requirements and recommendations for undertaking such activities across the different life cycle phases including life cycle phase 'Operate'. Figure 1 illustrates processes that are defined as core production assurance processes and that are interacting processes. Calculation and reporting of PE is part of the core production assurance processes covered by ISO 20815:2018, more specifically part of Process 9 – 'Performance data tracking and analysis', as illustrated in Figure 1, and described in more detail in ISO 20815:2018, Clause B.7. Thus, the principles and requirements applicable to production assurance (see 3.1.37) described in ISO 20815:2018 shall also apply to the calculation and reporting of PE in the life cycle phase 'Operate', see also ISO 20815:2018, Table 2.

While process 9 also includes performance data tracking and collection for equipment failures as covered by ISO 14224:2016 with a view to provide feedback of reliability data (ISO 14224:2016, 3.82) into production performance analyses, PE calculation and reporting focuses on the production loss at installation level resulting from failures, maintenance activities and other events. The reporting of the production loss represents a direct relationship to the business performance factors such as lost revenue and OPEX.



NOTE This is a reproduction of ISO 20815:2018, Figure 4.

Figure 1 — Core and interacting production assurance processes

The objectives and use of PE reporting can include:

— basis for establishing PE target (Process 1 – Production assurance requirements);

— comparison of actual PE with performance objectives and performance requirements (production availability targets) (Process 4 – Production assurance);

— identification of the production loss categories (i.e. type of activity or event) that contribute to production loss;

A further analysis of the production loss contributors is necessary to identify cost-effective technical and/or operational mitigating measures. The production loss related to asset elements and the relevant systems and equipment classes are therefore part of the analysis (Process 4).

— benchmarking with other similar production facilities (Process 4);

— contribution to organizational learning (Process 12).

This document also covers to some extent forecasting of PE in the operating phase (see 5.2.1). Production availability predictions performed during field development (i.e. life cycle phases 'Select' and 'Define' as defined in ISO 15663:2021) are covered by ISO 20815:2018. Such predictions will typically use analysis techniques as described in ISO 20815:2018, Clause I.5 and will be based on technical and operational assumptions prior to production start-up.

Conformance to this document implies that an operator has a production performance system in place for calculation and reporting of PE and production loss.

ISO 14224:2016 and ISO 20815:2018 provides requirements and guidance for input data categorization for use in calculation and reporting of PE as described in this document. See further information in Annex A, Annex C and Annex D.

4.2.2 Quality assurance

The operator should have a QA process in place to ensure accurate calculation and reporting of PE (and IE if needed). This QA process should include the necessary and sufficient checks to verify that all data (see Annex A and D) required for such reporting is complete and accurate. The QA activities should be performed at an appropriate time interval (e.g. daily verification of any production loss event recorded and monthly/yearly verification of PE calculation and reporting) or take place as per defined QA review criteria to ensure the following:

a) production loss events are recorded within the main production loss categories;

b) production loss events are correctly allocated and categorized;

c) production loss events lasting across time interval reporting can need special attention;

d) production loss events related to turnaround and modification activities (see 8.3 and 8.4) will need appropriate attention;

e) production volume to be used in the PE calculation at the appropriate PE measurement points is accurately established (see 6.3);

f) regulatory reporting requirements or requirements agreed with external stakeholders are met;

g) production potential remains valid or requires adjustment (including possible retrospective changes);

h) requirements within this document are conformed with.

NOTE The source input data with assumed proper quality are generated from normal business activities and are as such not subject to the above-mentioned PE-specific QA.

4.2.3 HSE considerations

The balance between HSE and PE always requires priority on health, safety and environmental constraints. HSE considerations are therefore important when optimizing PE and to ensure conformance with a minimum set of HSE requirements.

How and when to reflect HSE when allocating the production loss for PE calculation can vary depending on the type of installation and operational framework. It is important to report and monitor such production loss to show conformance with the HSE requirements. This is illustrated by the following examples:

— Some HSE-related production loss categories (e.g. G2) will apply when production shutdown is needed for safety contingency reasons upon a potential accidental event or if an actual accident causes production shutdown.

— An environmental related production loss category (i.e. G4) will apply when unplanned partial or total production shutdown is needed to accommodate environmental permits.

— Various production loss categories (e.g. A5 and D1) can apply if a safety critical equipment (see 3.1.46) has a critical equipment failure and thus unable to maintain safety function and it requires production shutdown.

By use of the PE reporting requirements and guidance in Annex A and Annex D, the contributing factors of production loss can be identified and enable correct improvement measures to be taken that also support the HSE requirements. Table A.1 and Table D.1 provide further information about how production loss categorization documents any HSE related unplanned events and safety systems down time that affects production (or injection), i.e. HSE requirements conformance. Flaring restrictions in PE reporting are provided in 6.7.4. HSE related decision criteria (e.g. regulatory safety requirements and company HSE targets) can thus be explicitly reflected in PE reporting and show prudent operatorship.

These HSE considerations for the purpose of PE calculation and reporting can require support from risk management, risk analysts and technical HSE personnel.

NOTE See ISO 20815:2018, Clauses C.2, F.4, and I.20 for further guidance.

4.2.4 Sustainability and climate change considerations

Production efficiency within petroleum, petrochemical and natural gas industries can be impacted by sustainability and climate change considerations primarily associated with their carbon footprint. When setting PE targets and reporting PE performance, sustainability and climate change should therefore be considered.

The carbon footprint of a product (as defined in ISO Guide 84:2020, 3.1.32) should be reflected within its production performance objectives (e.g. PE targets) and should be addressed through PE calculations and reporting. As an example, GHG emissions (as defined in ISO Guide 84:2020, 3.1.13) are included in production loss category G4 (see Table A.1), as defined in accordance with ISO 20815:2018, which captures production loss due to flaring restrictions (see also 6.7). Mitigations and adaptations related to sustainability and climate change (as outlined in ISO Guide 82:2019 and ISO Guide 84:2020) throughout the lifetime of an installation can also impact PE targets and PE reporting.

NOTE See IOGP report 437 [15] for sustainability reporting guidance.

4.3 Business category

Calculation and reporting of PE is applicable to all business categories and installation categories as shown in Table 1. This table shows installations at taxonomic level 3 (see ISO 14224:2016), although emphasis in this document is on installations within the upstream business category.

Table 2 shows a further subdivision at plant/unit level for upstream (E&P) installations based on Table A.2 in ISO 14224:2016.

Table 1 — Installation category — Level 3

Business category			
Upstream (E&P)	**Midstream**	**Downstream**	**Petrochemical**
Oil/gas production facility (offshore/onshore) Drilling facility (offshore/onshore Maritime vessel Terminal Pipeline FLNG	LNG LPG Gas processing Terminal Storage Shipping Pipeline	Refinery Gas conversion Energy plant Pipeline Terminal Biofuels	Petrochemical complex Terminal Pipeline

NOTE 1 Shipping is defined as any means of transportation (sea, rail, road).

NOTE 2: Gas conversion includes GTL.

NOTE 3 CHP is part of energy plant.

NOTE 4 Drilling facility can be separate or integrated as part of other onshore/offshore installation.

NOTE 5 This table is slightly modified from ISO 14224:2016, Table A.1.

Table 2 — Applicability of this document for upstream (E&P) installations

Installation category	Applicable for PE reporting	Comments
Oil/gas production facility (offshore/onshore)	Yes	This document applies for both conventional and unconventional resources. Aspects of both EOR and IOR are also covered. See 4.5.
Drilling facility (offshore/onshore)	No	PE does not apply for drilling operations as listed in ISO 20815:2018, Table G.2, but drilling facility down time can affect PE.
Maritime vessel	No	PE does not apply for maritime installation and intervention operations as listed in ISO 20815:2018, Table G.3, but maritime vessel down time can affect PE.
Terminal	No	Terminals are normally not considered part of upstream. Events at the terminal can affect PE.
Pipeline	No	PE is not explicitly recorded for pipelines, but pipeline events can affect PE.
FLNG	Yes	FLNG is part of an upstream business category, while LNG is normally part of midstream business category (e.g. onshore LNG facilities). This means that PE reporting for FLNG is covered in this document.

For midstream, downstream and petrochemical business categories, a wide range of measures for production performance (see 3.1.41) is utilized. This document provides some guidance on these business categories, even though focus is on upstream business category. The measures being addressed should consider production loss categories based on activities or events, such as equipment failure and repair, preventive maintenance, process/operational problems, product quality deviation and turnaround and modification.

NOTE See Tables G.4 to G.6 in ISO 20815:2018 for further guidance.

4.4 Overview of PE calculation and reporting work process

Figure 2 shows the PE calculation and reporting work process. The work process supports the objectives of PE reporting as listed in 4.2. For specific work processes, references are made to clauses of this document. For detailed subdivision of production loss on system and equipment class, and failure characteristics ISO 14224:2016 shall be used. The taxonomy classification given in Annex C shall be used. See also Annex D. The organizational learning to minimize production loss shall apply the production assurance and reliability management requirements and guidance given in ISO 20815:2018.

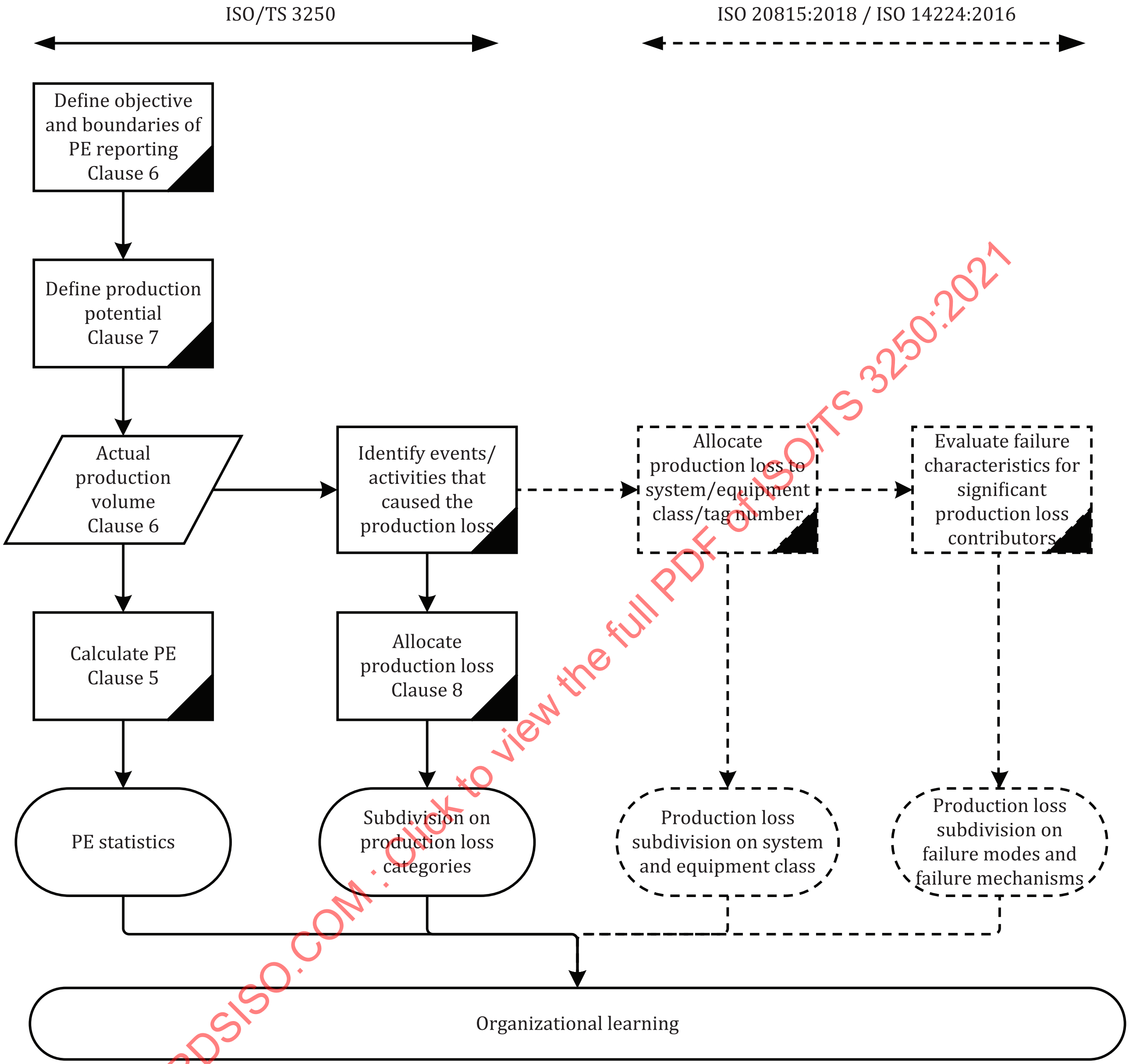


Figure 2 — PE calculation and reporting work process

4.5 Limitations

For the purpose of this document, the following limitations are applicable in PE calculation and reporting in the operating phase:

— This document only covers upstream business category. Production loss categories for midstream, downstream and petrochemical can be found in ISO 20815:2018, Tables G.4 to G.6.

— Injection of CO_2 from external sources in the context of carbon capture and storage is not covered by this document. Only injection of produced CO_2 associated with EOR or injection of well stream derived CO_2 for disposal is covered by this document. This can be measured by using the IE calculation (see 5.5).

— Pre-production losses are not covered in this document, i.e. delayed production start-up due to project schedule delays, well schedule delays and facilities schedule delays (see 8.5).

— The de-centralized configuration of certain production facilities associated with unconventional resources can complicate the allocation of production to individual wells, or a group of wells, as well as make the calculation of PE for the asset more difficult. A good understanding of the whole production system, and of midstream and downstream capacity constraints is therefore needed. The fundamental principles of PE calculation and reporting described in this document are still applicable, but additional guidelines defined by an operator can be necessary to account for the specific asset design.

— The production assurance and reliability management activities undertaken to assess remedial actions to improve PE based on the reported PE in the operating phase are not specifically covered in this document but are addressed in ISO 14224:2016 and ISO 20815:2018. Risk management and analysis activities to assess any HSE issues related to production loss events are not covered in this document; reference is made to relevant documents, such as ISO 31000:2018, ISO 17776:2016, ISO 15544:2000, as well as to ISO 20815:2018, Clause F.4 and Annex I, which list safety related standards. Comparison of production availability predictions during field development with historically reported PE during operating phase is important to gain analytical, operational and organizational learning (see ISO 20815:2018, Clause E.3). PE reporting in accordance with this document will contribute to such comparative assessment but is not addressed in this document.

— Economic considerations related to cost management of production efficiency are not specifically covered in this document but can benefit from use of ISO 19008:2016 and ISO 15663:2021.

4.6 PE data exchange between operators in benchmarking

The PE data exchange can be applied for different business applications, including:

— internal corporate evaluation of PE data amongst the installations within one operator;

— operator exchange of PE data within the license towards other partners (licensees);

— PE benchmarking undertaken between operators monitoring operating performance;

— reporting of PE to authorities.

See also guidance related to PE benchmarking in 7.6.

ISO 14224:2016, Annex E provides general guidance on use of KPI’s and benchmarking that also can apply if PE is used as a KPI.

5 Performance measures

5.1 General

ISO 20815:2018, Clause G.1 lists a number of performance measures that are of relevance for predictions as well as for historical reporting of production availability, i.e. PE. Table B.1 provides a classification of these performance measures as being volume-based and/or time-based.

Production availability as a statistical performance measure with emphasis on prediction is covered in ISO 20815:2018. ISO 20815:2018, Clause G.2 provides guidance for production loss categorization for use in production availability analysis and when reporting PE. This document gives requirements and detailed calculation guidance on aspects specific to such PE periodic reporting for an operator in the operating phase.

5.2 Production efficiency

5.2.1 PE forecasting

Initial PE forecasting for the early (or longer) time period of a new installation or field can be done during its operational preparedness prior to production start-up. PE forecasting can also be done during the operating phase for an existing installation or field. Periodic forecasting of PE during the operating phase, will, as calendar time evolves, be based on increasing operational experience and with further knowledge of actual operating conditions in contrast to the initial PE forecast made prior to production start-up.

PE forecasting is an operator and field specific process to estimate the expected PE over a specified time period. Its purpose varies depending on the time period over which the forecast is prepared, and for which type of installations and part of the value chain it belongs:

— Shorter term forecasts are relevant to export/logistical planning associated with hydrocarbon transportation (e.g. ship transportation by oil shuttle tanker or gas pipeline transportation) and consequence assessments where an event affecting deliverability can occur.

— Longer term forecasts are relevant to providing advice to the market and authorities in relation to expected production. Long-term forecasts are also an input to economic/financial appraisals and life cycle cost analysis (see ISO 20815:2018 and ISO 15663:2021).

PE forecasts differ from production availability predictions using production availability calculations (see ISO 20815:2018, Clause I.5). These differences include the following aspects:

— Production availability predictions done during field development for an installation consider steady state operations and baseline equipment reliability performance for the future operating phase.

— PE forecasts made in the actual operating phase include more known 'installation as is' issues/risks that can occur over time period of the forecast.

— A PE forecast can utilize information on known activities, such as scheduled preventive or corrective maintenance (see ISO 14224:2016, Figure 5). The PE forecast is therefore more accurate on short term basis than a production availability analysis, where such events cannot be accurately scheduled.

— Predictions based on production availability analysis can include production loss resulting from major accidents and rare, long duration events (see ISO 20815:2018, D.3.6 and Annex H). Production loss from such events is normally not included in PE forecasts even though HSE and business continuity management will exist.

5.2.2 PE calculation and reporting

PE calculation and reporting are activities used to assess historic production performance and enable safe and cost-effective future production performance.

PE calculation and reporting are done during the operating phase. Requirements and guidance for recording of production loss, and calculation and periodic reporting of PE are described in this document.

In conjunction with PE calculation and reporting, uncertainty considerations can be needed. The statistical presentation of PE data will depend on operator and installations involved, and variability of PE data can be addressed.

5.2.3 Initial production performance

The initial production performance can be different from what is originally predicted at project sanction. The ratio of actual versus forecasted production volume for the first year of planned production is a typical production performance measure to reflect this (see also ISO 20815:2018, G.2.6). This ratio is a benchmarking KPI and expresses a volumetric fraction of production achievement. It will reveal the project execution ability to meet initial production targets defined during project sanction. This ratio can be affected by a variety of causal factors that are not reflected in the production loss categories in Annex A. Thus, it cannot be compared directly with the volumetric production performance measures (i.e. PE) described in 5.4, but it reflects the production loss category H in ISO 20815:2018, Table G.1. See also 8.5.

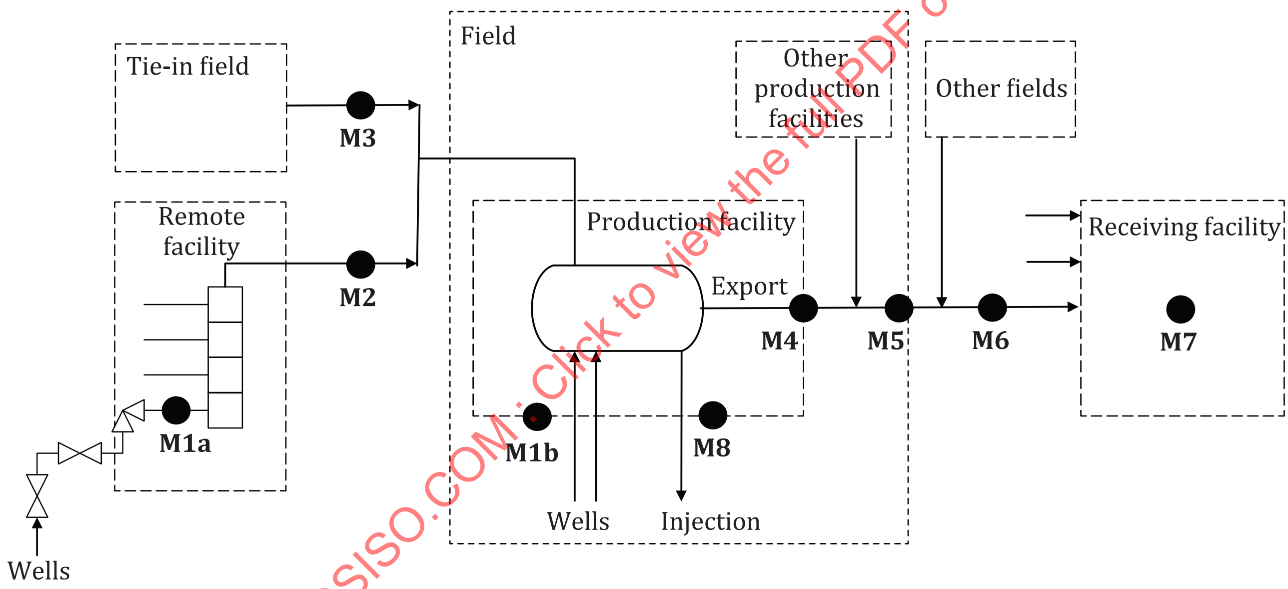
5.3 PE measurement

PE can be measured at various points in the production chain, for instance, for a tie-in, individual plants (e.g. FPSO), infrastructure (e.g. a field with several installations), a hub (e.g. for gas transport) or at corporate level for the operator. PE at a higher taxonomic level can be calculated from PE at lower taxonomic levels.

The exit point where the PE is measured defines in which production loss category the production loss is allocated, e.g. whether a loss is allocated to production loss category D, Process and utilities or production loss category E, Export and import (see Table A.1).

Figure 3 illustrates the possible PE measurement points that can be used in the upstream business category. It follows that while PE can be measured at points that are early or late in the production chain (M1 to M3 and M7), they only reflect performance attributable to relevant production loss categories. PE measurement points M4 to M6 provide a better overview of PE performance. Prioritization of PE measurement points should be based on organizational or asset-specific need.

NOTE Authorities can require specific PE measurement points for reporting.



Key

M1a	individual well (remote facility)
M1b	individual well
M2	group of wells, e.g., at the same location, template, flowline or reservoir segment
M3	tie-in field (not including the host facility)
M4	plant / production facility
M5	field
M6	infrastructure/hub (commingling different fields)
M7	receiving facility
M8	injection

Figure 3 — Possible PE measurement points

5.4 PE calculation methodology

5.4.1 PE calculation formula

The production efficiency (see 3.1.39) used in the operating phase has the following volume-based ratio:

$$\mathrm{PE} = \frac{\text{Production}}{\text{Production potential}}$$

The mathematical expression for production efficiency, $P_E(T_1,T_2)$, over a time interval $[T_1,T_2]$ is given in Formula (1):

$$P_E(T_1, T_2) = \frac{V_P(T_1, T_2)}{V_{PP}(T_1, T_2)} \tag{1}$$

where

$P_E(T_1, T_2)$ is the production efficiency over $[T_1, T_2]$;

$V_P(T_1, T_2)$ is the produced volume over $[T_1, T_2]$;

$V_{PP}(T_1, T_2)$ is the production potential over $[T_1, T_2]$.

Similar to calculation of production availability (see Clause B.2), PE is calculated over a period of time, e.g. daily, monthly or yearly. PE shall be calculated as a volume-based measure over the defined time period in order to capture changes of the production potential during this time period. Averaging PE values calculated for short time periods to find PE for a longer time period, e.g. averaging monthly PE to find PE for a year, will lead to incorrect results. See examples in Clause E.3.

Clause 6 provides for guidance on produced volume. Clause 7 provides guidance on production potential.

As stated in ISO 20815:2018, G.2.7, time-based performance measures have limitations with respect to partial shutdowns and should not be applied at plant or installation level. See also Clause B.2.

5.4.2 PE boundary conditions and reporting period

The physical boundaries of the installation or production facilities for which PE is calculated and reported shall be defined in order to correctly allocate production loss (see Clause 8). Battery limits for production loss categories and for asset elements are described in Annex A and Annex D, respectively. It shall be clarified whether downstream storage, linepack and substitution are considered. If such downstream compensating measures are included within the boundaries, the PE will reflect the deliverability of the facilities (see ISO 20815:2018, Figure G.1).

The start and end of the time period for PE reporting shall be defined. PE can be reported for daily, monthly or yearly time periods.

5.5 Injection efficiency calculation formula

Calculation and reporting of injection efficiency should follow the same principles as for production as a volume-based performance measure.

The injection efficiency (see 3.1.18) that should be used in the operating phase has the following volume-based ratio:

$$\text{IE} = \frac{\text{Injection}}{\text{Injection potential}}$$

It follows that the mathematical expression for injection efficiency as a volume-based performance measure is given in Formula (2):

$$I_E(T_1, T_2) = \frac{V_I(T_1, T_2)}{V_{IP}(T_1, T_2)} \tag{2}$$

where

$I_E(T_1, T_2)$ is the injection efficiency over $[T_1, T_2]$;

$V_I(T_1, T_2)$ is the injected volume over $[T_1, T_2]$;

$V_{IP}(T_1, T_2)$ is the injection potential over $[T_1, T_2]$.

The effect of loss of injection on production and subsequently on PE is covered in 8.7.

In the oil and gas industry time-based performance measures for injection are sometimes used and can apply for gas, water, CO_2, etc. ISO 20815:2018, G.2.7 provides calculation formula for time-based performance measures (see also Table B.1).

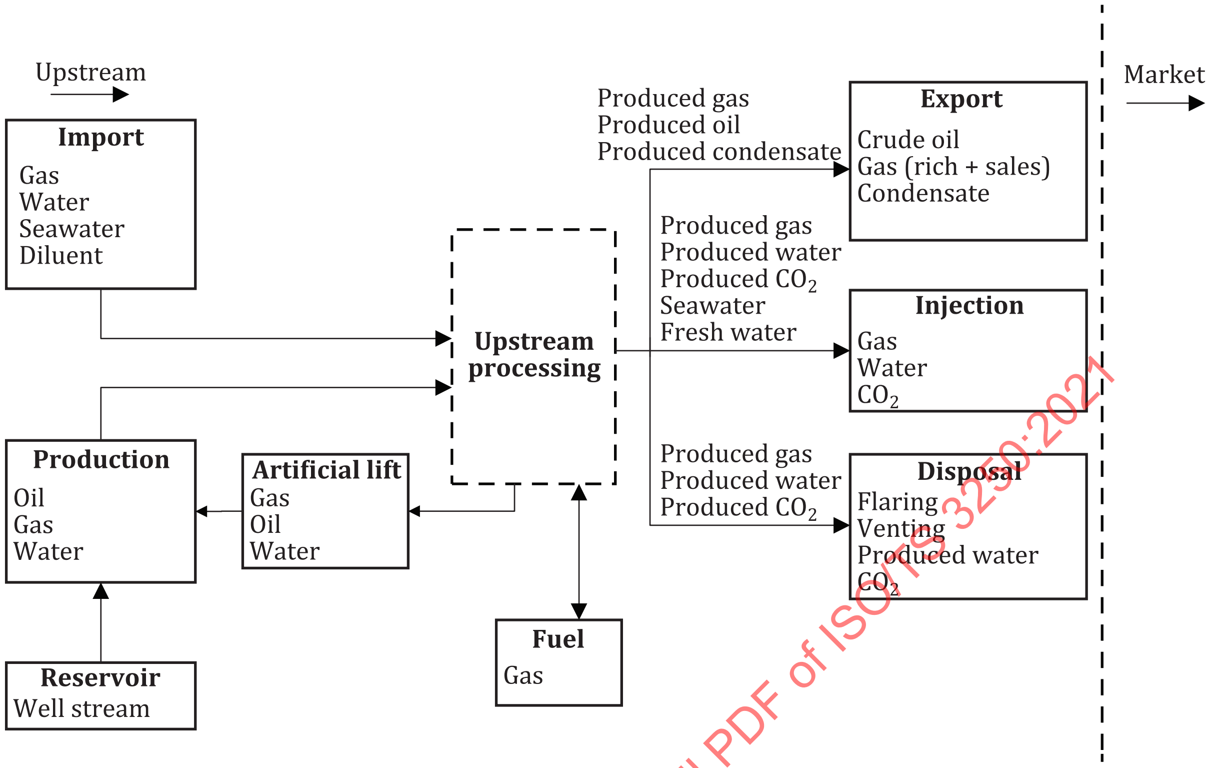
6 Production

6.1 General

This clause contains requirements and guidance on the hydrocarbon production, produced volume and which product or medium to be measured, in relation to calculation and reporting of PE. It also provides guidance on the material balance and whether or not to include the different product flows in the produced volume.

6.2 Material balance

Figure 4 depicts material balance for hydrocarbon production at a typical upstream production facility. PE may be measured on the oil or gas streams at the PE measurement points shown in Figure 3. ISO 14224:2016, Figure A.1 provides typical connections and flow between upstream, midstream, downstream and petrochemical business categories.



Midstream – The following products are normally part of midstream but can be part of upstream in case of FLNG: LNG, LPG and NGL.

Figure 4 — Products and material balance — hydrocarbon production

Figure 4 covers some EOR elements, e.g. CO_2 injection. With EOR, there can be additional flows, which affect the material balance, and which shall be taken into account when calculating PE. IOR is reflected in Figure 4 when gas lift is the artificial lift method and when water and/or gas injection is used for reservoir pressure support.

6.3 Export – measured product

The measured product is normally one or all the exported products. The measured product will vary depending on the characteristics of the production facilities. Measured products can include all the export streams shown in Figure 4. However, it is more normal to select one main product (i.e. the primary product) for PE calculation and reporting.

The product that is selected as the primary product (see 3.1.36) and as the secondary product (see 3.1.47) shall be stated and clarified. Since secondary products do not necessarily contribute to production targets, they may be excluded from PE calculations. An increase in PE of the secondary product can also have a negative impact on the PE of the primary product, e.g. an increase of gas production (secondary product) can result in gas coning and therefore reducing production of crude oil (primary product).

The following methods can be used:

a) calculate and report PE for the primary product (e.g. oil or gas);

b) calculate and report PE on the primary and secondary products separately;

c) calculate and report PE on the combined oil and gas production based on oil equivalents.

In many cases, the PE calculated by any of the three methods will yield the same results. The methods will yield different results for the calculated PE in cases where there is a possibility to switch between sources (reservoirs), with different ratio between the primary or secondary products, where intermediate storage is available for one of the products, or a secondary product is disposed of (e.g. flaring of gas).

The measured volumes of the primary and secondary products as input to the PE calculation do not necessarily equal the fiscal metered volumes of the same products.

NOTE Fiscal metering is usually prescribed by national regulations. An example of functional and technical requirements for fiscal, custody transfer and allocation metering systems are described in NORSOK I-106:2014.

6.4 Conversion factors for oil equivalents

Conversion factors are of importance when exchanging PE numbers between operators, as they are important assumptions in the calculation of this volumetric performance measure. Conversion factors used for the calculation of oil equivalents shall be documented since such conversion factors can vary between operators and fields.

Oil equivalents are measured as mass (toe) or volume (boe or Sm^3oe). The conversion of gas to oil equivalents is based on the heating value of gas and the heating value of oil. The composition of the gas and the composition of the oil varies from field to field and from region to region throughout the world. On a single field, the composition of oil and gas can also vary over time. No standardized conversion factors exist but company standards or national authorities can define such factors. The possible differences in conversion factors should be taken into account when comparing PE from different installations/facilities.

NOTE See Annex M in IOGP report 437 [15] for conversion factors for energy content and volume.

6.5 Injection

Injection volumes are not considered part of production and are not included as part of production in PE calculations.

6.6 Disposal – general

Non-hydrocarbon product streams that are normally disposed of (e.g. produced water) are not considered part of production. If an event prevents the disposal of the product and this results in a production loss of the primary product (e.g. oil), the production loss is attributable to a suitable production loss category (see Clause 8 and Annex A).

6.7 Disposal – flaring or venting of large volumes

6.7.1 Production facilities with a gas export route (to sales)

Most production facilities have a flare system for process safety purposes. Unplanned events, e.g. equipment failures, spurious trips, real trips or fluctuations in plant processing conditions, can lead to a certain level of flared gas. If the gas is normally exported (as a saleable product) and is part of production in PE calculations (see methods described in 7.2 to 7.4), then the gas shall be considered part of production. Any gas routed to the flare shall then be classified as a production loss, attributable to suitable production loss category (see Clause 8).

If flaring restrictions require shutdown of oil and gas production, any lost oil and gas production shall be documented as production loss.

6.7.2 Production facilities with a gas injection route only

For production facilities with gas injection only, the gas is not considered part of production and should not be included as part of production in PE calculations. If gas destined for injection purposes (reservoir management purposes) is directed up the flare due to a planned or unplanned event that prevents the ability to inject this gas, then this flared gas should not be reported as a production loss (see also 6.5).

6.7.3 Production facilities with no gas export route or other gas disposal routes

Production facilities with no gas export route, or no other gas disposal routes (e.g. gas injection), have to flare associated gas continuously during production. In this case, there are two options for PE reporting in conjunction with planned and unplanned events:

a) The associated gas is not considered part of the production volume (as it cannot be sold), and it follows that flared volumes are not considered (they are neglected, and not considered part of production volume or production loss).

b) The associated gas is considered part of the production potential, and the flared volumes are considered part of production volume (they are not considered as production loss).

Option a) is the recommended option.

6.7.4 Flaring restrictions

Restrictions imposed by authorities on flaring volume can result in the need to shut down or reduce hydrocarbon production to avoid exceeding the flaring limits. This is reported in production loss category G4 (see Table A.1). The flaring restrictions can vary between countries with respect to time frame of flaring permits (e.g. monthly or yearly) and operational conditions. Such flaring restrictions will also minimize GHG emissions (see also ISO Guide 84:2020).

NOTE See also IOGP report 437 [15] for sustainability reporting guidance.

6.8 Disposal – venting of small volumes

Venting of large hydrocarbon volumes can be treated in the same way as flaring with respect to calculation and reporting of PE. Venting of small volumes is neither treated as a production loss nor as part of the production potential. Small volume for venting can come from sources such as:

— venting from well;

— venting from relief valves;

— venting from tanks;

— shuttle tankers volatile organic compounds.

Although venting of small hydrocarbon volumes is not included in PE calculation, monitoring of venting volumes is an element of environmental management with the aim to minimize GHG emissions (see also ISO Guide 84:2020).

6.9 Fuel

Fuel (normally gas) required for the operation of the installations is often extracted from the hydrocarbon production. Fuel gas is in many cases the cheapest and most convenient energy source accessible and the consumption of fuel gas is a prerequisite for operation. Even in the case that there is gas export from the installation and the fuel gas could have been sold, the fuel gas should not be regarded as a production loss. Fuel gas should therefore neither be included in the production nor in the production potential.

6.10 Import

Imported products can be gas, diluent or other substances (e.g. water). Import can affect production directly (e.g. diluent to achieve a product quality specification) or indirectly (e.g. imported gas used for gas injection).

Diluent can be used to blend with heavy crude hydrocarbons for various purposes that include increasing lifting capabilities for the heavy crude in the well, aid the separation process and improve product specifications for commercial purposes. The volume of diluent in the blend should be excluded from PE calculations. Actual production and production potential should only include hydrocarbons from the reservoir(s) that are produced through the production facility to which the PE calculation relates. Discrepancies due to shrinkage and/or flash off that occur as a result of blending should be taken into account when considering the contributing streams to production of hydrocarbons for the production facility.

In case an event prevents the import, the associated production loss shall be allocated to a suitable production loss category.

6.11 Artificial lift

Gas used for artificial lift in well(s) flows in a closed loop. Gas used for artificial lift shall not be included when measuring production.

7 Production potential

7.1 General

The PE calculation highly depends on the production potential volume that is used in the calculation. This clause contains guidance on two different methods to determine the production potential, which in turn will have an effect on the calculated PE.

7.2 Methods for determination of production potential

While the production can be measured accurately at the production facility, determination of the production potential is more challenging. With reference to Formula (1), two methods can be used for determining the production potential and therefore PE:

— Method A: Let $V_{PP}(T_1,T_2)$ be the structural maximum production potential.

— Method B: Let $V_{PP}(T_1,T_2)$ be the achieved production potential.

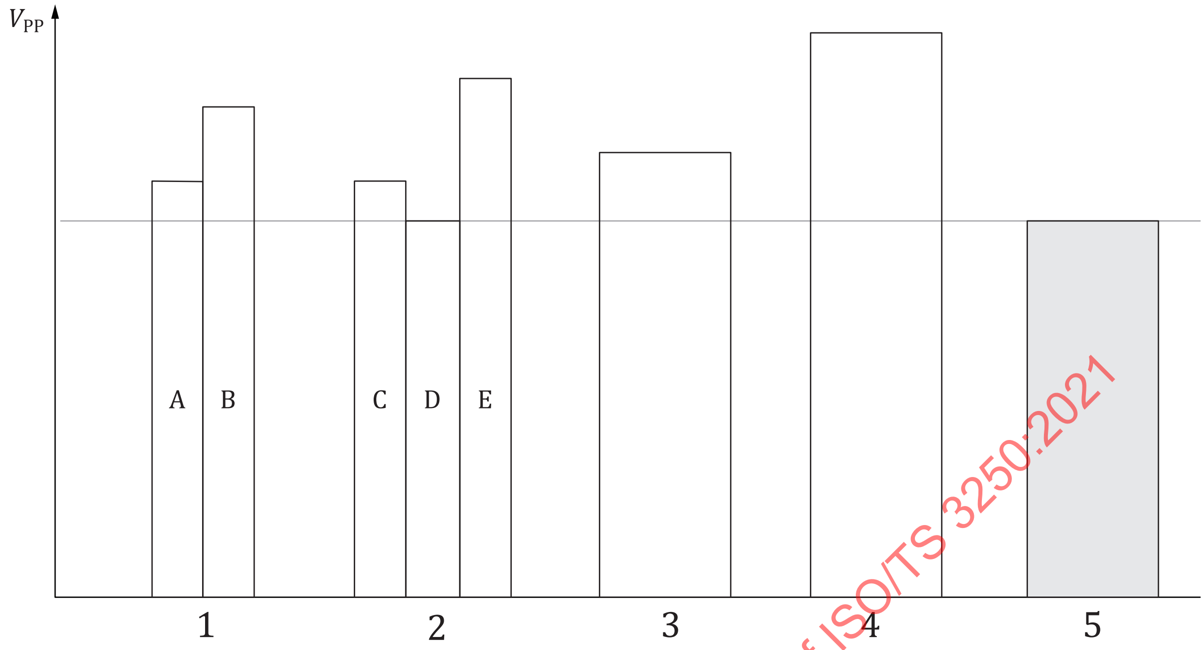
Production potential is a time-variate parameter (see 7.6).

The operator shall state which method is used when communicating PE data externally, e.g. towards partners in a license, or in case of PE benchmarking.

See calculation examples in Annex E.

7.3 Structural maximum production potential (Method A)

If Method A is used, an estimate for the SMPP is set prior to the time period for which PE reporting applies. The SMPP is the minimum of the four production potential elements as shown in Figure 5 where, as an example, the gas processing capacity of the plant is the minimum of the four production potential elements and therefore determines the value of SMPP.



Key

V_{PP} production potential
1 well production potential
2 plant production capacity
3 export capacity
4 market potential
5 SMPP

A reservoir
B well
C oil
D gas
E water

Figure 5 — Determining structural maximum production potential

The four production potential elements are further described below, along with important considerations for determining their values.

1) Well production potential (see 3.1.58):

— a well shall not be included in the well production potential, until it is available for production and a rate measured or modelled (see also 3.1.29);

— flowing well rates can decline in each time period according to a reduction based on well test rate trend;

— the individual well potential of a well that is shut in can decline depending on overall reservoir segment or sand unit offtake, and voidage replacement ratio;

— when artificial lift is applied, the well production potential shall be expressed as inclusive of the effects from the installed artificial lift;

— an individual well potential shall be included as part of well production potential, until the well is unable to flow – either naturally or with artificial lift, where installed.

2) Plant production capacity (see 3.1.34):

— the plant production capacity represents the production capacity of the systems between the elements well and export;

— oil, gas or water as elements/systems can limit the plant production capacity;

— the plant production capacity can also be limited by utility systems.

3) Export capacity (see 3.1.12).

4) Market potential (see 3.1.26).

NOTE See ISO 20815:2018, G.2.2 to G.2.4 for guidance related to well production potential, plant production capacity and market potential.

The potential or capacity of these four elements is established with respect to the measured product (see 6.3). If PE is measured on oil equivalents, the potential/capacity of both oil and gas is defined for each of the four production potential elements. Associated gas or any other stream shall be individually considered to identify limitations to the potential. SMPP is determined as the minimum potential/capacity of the oil and gas for the four elements and then converted to oil equivalents. The process of calculating SMPP in oil equivalents should be replicated at any point in time where any of the gas/oil/condensate ratios change.

The four production potential elements have a potential or capacity that will vary over time, e.g. as reservoir pressure declines, well stream composition changes, plant capacities change, or contracted sales volumes change. This should be reflected in the forecast SMPP as a variation over time. The SMPP should be constant over a set time period of a minimum of 24 hours.

The SMPP should be reviewed at least annually (see also 7.6). The SMPP forecast should be updated at least annually (see also 7.6).

7.4 Achieved production potential (Method B)

If Method B is used, the actual production is measured, whereas the production loss is estimated to find the achieved production potential. Production loss is assigned after a set time period of production, often being 24 hours or more. The achieved production potential should match the maximum production that could have been achieved in case no production loss occurred. If possible, the production potential should be determined by comparing production rates to a recent production period without restrictions or loss. In the case of a continuous loss for a long-term period, relevant well and field network modelling can be used to determine the production potential and the production loss. Adjusting the potential in case of long-term production down time is described in 7.6.

Even in the case that Method B is applied, an estimate of SMPP can have been determined for other purposes, e.g. for PE forecasting. In this case, PE can be calculated using both Method A and Method B for comparison.

7.5 Differences between Method A and Method B

Method A and Method B will in most instances result in a similar calculated PE, but differences will exist.

For Method A, the SMPP is a forecast that is based on inputs, which in some cases are uncertain and might not be correct on the actual production day. Such uncertainties and inaccuracies can be related to the following:

— uncertainty in reservoir simulations;

— incorrect assumptions on capacities;

— unpredictable nominations of production volumes related to a sales contract;

— flush production (increased flow from a well after a shutdown period);

— intermittent producing wells (those which do not have the capacity for continuous production but require shut-in periods to allow pressure build-up).

7.6 Adjusting the production potential

Adjusting the production potential is mostly relevant when SMPP is used in Method A but can also be applied to achieved production potential. The production potential shall be reviewed at regular intervals (at least annually) or in case of an event, and shall be adjusted as necessary.

There can be occurrences where either the estimated production potential no longer reflects the production potential that can be realistically achieved, or production exceeds the estimated production potential on a regular basis. Such occurrences can be the result of a change of circumstances or uncertain (possibly incorrect) assumptions used during the previous or initial estimation of the production potential. If the situation is assessed to be temporary, the production potential does not need to be adjusted. If the situation is assessed to be permanent or of some duration, adjustment of the production potential should be considered.

In a situation where the well production potential cannot be achieved due to incorrect assumptions (e.g. new well coming onstream, incorrect well decline analysis, increased water-cut or early gas-breakthrough), the production potential can be updated at any point. This can also be done retrospectively in the case of Method A. In Method B no production loss will be assigned for not meeting an incorrect production potential.

If the circumstance arises where actual production exceeds the production potential, no 'negative' production loss should be assigned when using Method B, and the SMPP should always be updated when using Method A (see also Figure E.1). There shall be no circumstance where the PE exceeding 100 % is reported.

NOTE Actual production can exceed the production potential, for example in the case of flush production after an extended shutdown, or when introducing new equipment where the impact is uncertain.

Table 4 and Table 5 include guidance with respect to any need for adjustment of production potential in case of various planned or unplanned events. In some cases, the events in Table 4 and Table 5 apply to Method A only, because the production potential is automatically adjusted with Method B.

Economic viability can influence the well production potential, e.g. see events 2, 4 and 9 described in Table 4. Volumes can be removed from the SMPP if there is no economical viable solution available to re-establish a certain production potential or a production potential is established from a new development target, e.g. a new well, facility upgrade. For benchmarking purposes internally or between operators, the allowed timeline for establishing economic viability shall be aligned to ensure appropriate comparison between producing fields. If it is not aligned, a correction should be put in place prior to benchmarking taking place.

Table 4 — Well events affecting well production potential

No	Event	Well production potential	Production loss category
1	Reservoir uncertainties	Reservoir simulations are associated with uncertainty. The production potential can be adjusted based on updated reservoir simulations or based on achieved production.	In the case of deviations between estimated well production potential and actual production, production loss should be allocated to production loss category A1. The reported production loss depends on whether compensation is possible by increasing production from other wells.
Operators may add more detailed guidance.			

Table 4 *(continued)*

No	Event	Well production potential	Production loss category
2	Downhole well equipment failure with severe failure consequences	In the case that it is not economically viable to repair the well by downhole well intervention, the well production potential should be adjusted by removing the individual well potential of the damaged well from the production potential. If a well intervention is planned for to restore the well, the well production potential (and the production potential) should not be adjusted.	Production loss should be allocated to production loss category A5 from when the well is unable to produce due to the failure until the time the well production potential is adjusted. If the well equipment failure is repaired by well intervention the production loss should be allocated to production loss categories A5 and A6.
3	Delayed start-up of a well in an existing field	The well should be included in the well production potential from the time when the well is ready to flow and available for production, i.e. an operative well (see 3.1.29).	Production loss category H2 in ISO 20815:2018, Table G.1 does not apply, but might be addressed in benchmarking.
4	Well shutdown due to low pressure or flow, or high water cut	The individual well potential should be removed from the well production potential.	Not applicable.
5	Well is only able to flow for short time periods before depleting (Intermittent producing well)	In case Method A is used, the well is normally not included in the well production potential. SMPP should be adjusted retrospectively to avoid PE above 100 % when the well is flowing. In case Method B is used, the well should be included in the achieved production potential when flowing.	Not applicable.
6	Flush production	In case Method A is used, SMPP should be adjusted retrospectively to avoid PE above 100 %.	Not applicable.
7	Planned reservoir intervention (well operations) for increasing (or maintaining) well potential	The production potential should be adjusted from the time when this well potential is made available.	Production loss caused by the intervention should be allocated to production loss category A2. Intervention can also imply production loss on adjacent wells (e.g. caused by shutdown during heavy lifts). Such loss should also be allocated to production loss category A2 (see also Table A.1).
8	Permanent P&A of a well	The individual well potential should be set to zero and excluded in the well production potential from the time when well is no longer available for production.	Not applicable.
9	Reduced well production potentials caused by injection equipment failures	The well production potential (and production potential) shall not be adjusted.	Production loss caused by critical failures or operational problems with injection equipment shall be allocated to the appropriate production loss category.
Operators may add more detailed guidance.			

Table 5 — Other events affecting production potential

No	Event	Production potential	Production loss category
1	Delayed start-up due to project schedule of facilities schedules delays	Assuming that PE reporting starts when the facility comes on stream, the production potential should be adjusted to zero. See also guidance in 7.7.	Production loss category H1 or H3 in ISO 20815:2018, Table G.1 do not apply, but might be addressed in benchmarking.
2	Modifications affecting capacity	The production potential should be adjusted to reflect the new capacity after the modification is completed (see also 8.4). This is not covered as part of corrective maintenance that will normally not affect production potential.	Production loss resulting from the actual modification should be allocated to production loss category F2.
3	Post-modification impact (after modifications)	The production potential should not be adjusted (see also 8.3).	Post-modification production loss should be allocated to the initiating event, i.e. production loss categories A9, B5, or D5. The time when this will no longer apply shall be defined by the operator, and from this time, other production loss categories related to the type of event will apply.
4	Plant production capacity variations	Plant production capacities can vary temporarily, e.g. as seasonal variations caused by changes in ambient temperature. In that case the production potential should be adjusted. Plant production capacity can also change permanently, e.g. as changes in well stream composition make handling of produced water or gas a limiting factor. In that case the production potential shall adjusted.	If SMPP is not adjusted, the appropriate production loss category for production loss caused by temporary capacity limitations can be D4.
5	Production critical failure	Production potential should not be adjusted, unless the equipment is permanently taken out of service.	Production loss should be allocated to the appropriate production loss category.
6	Loss of export route, changes in capacity of downstream installations	Permanent downstream limitations should result in adjustment of production potential.	Temporary limitations should be recorded as a production loss in of the production loss category E.
7	Market limitations	Permanent limitations should result in adjustment of production potential.	Temporary limitations should be recorded as a production loss in production loss categories G6 or G8.
Operators may add more detailed guidance.			

In the case of a change of circumstances or an event resulting in a permanently reduced production potential (SMPP if Method A), this production potential should be adjusted only if there is no economic justification (e.g. supported by life cycle costing of competing options using ISO 15663:2021) to implement a plan within a pre-determined timeline to re-establish the production potential.

7.7 Schedule delays

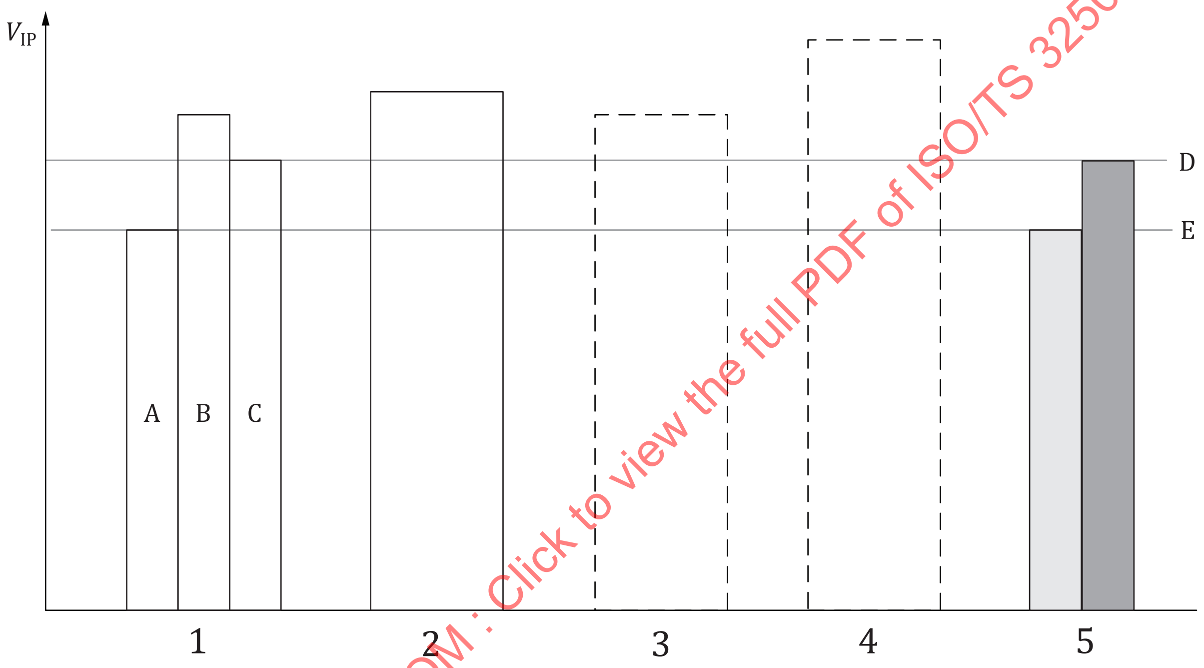
Schedule delays can occur for any activity that can affect production potential, such as field development, drilling or modifications.

In the case that there are delays (or advances) of the planned schedule, the production potential will be affected. In the case that Method B is applied, there is no need to adjust the achieved production potential. In the case that Method A is applied, the SMPP can be adjusted based on criteria defined by the operator. Such criteria can include the reason for the delay, the effect on the production potential in terms of time or production volume.

7.8 Injection potential

If a separate performance measure is to be calculated and reported for injection operations, similar calculation methods as the volume-based PE measure is often used, i.e. calculation of injection efficiency (see 5.5). In that case, the injection potential can be determined similarly to the production potential by Method A or Method B. If Method A is selected, the injection potential, structural maximum injection potential, can be established as the optimum injection volume over a time period, rather than the maximum that is possible given the capacity constraints of the injection systems and injection wells.

Figure 6 illustrates SMIP determined by capacities and constraints (far right column) and SMIP determined by the optimum injection volume (second column from right).



Key

V_{IP} injection potential

1 well injection potential

2 plant injection capacity

3 import capacity

4 market potential

5 SMIP

A optimum injection volume

B reservoir

C well

D SMIP limited by well

E SMIP limited by optimum injection volume

Figure 6 — Determining structural maximum injection potential

Injection potential elements 'import capacity' and 'market potential' can be relevant in cases where the injection medium, e.g. gas, is imported from another field. If a time-based performance measure is used for injection, no injection potential needs to be defined. A time-based performance measurement for injection will typically be expressed as availability, demand availability or on-stream availability, as given in ISO 20815:2018, Annex G. Table B.1 also provides these performance measurement terms.

The need for conversion factors (see 6.4 concerning PE calculation) is not applicable for the determination of injection potential and injection efficiency.

8 Production loss categories

8.1 General

The production loss categories for installations in upstream business category follow the principles in ISO 20815:2018, G.3 and further requirements and guidance is given in this document. Production loss categories shall be allocated for the different parts of the asset. The following asset elements for upstream business category apply:

— wells;

— subsea installations;

— production facilities;

— export and import facilities.

This clause provides requirements and additional guidance to ensure standardized PE loss categorization, and further details are given in Annex A.

8.2 Planned and unplanned events

Production loss categories distinguish between planned events (see 3.1.33) and unplanned events (see 3.1.55). The following cases illustrate which production loss category to use:

— An activity starts as a planned event but is subsequently extended in duration. Only if there is a specific change in the nature of the work is a separate event/classification introduced for the activity. For instance, a routine maintenance activity on a gas compressor uncovers major structural damage once the inspection is underway. The production loss resulting from the planned routine maintenance activity is categorized as a planned event, i.e. production loss category D3, Preventive maintenance, whereas the production loss resulting from the extended time required to repair the uncovered structural damage is categorized as D2, Active corrective maintenance.

— A failure of a redundant component in a subsea control module does not result in a production loss. A subsea intervention is planned to replace the subsea control module as a precautionary measure. The production loss resulting from the subsea intervention is categorized as B2, Unplanned subsea intervention, because an equipment failure, which is an unplanned event, initiated the subsea intervention.

— A critical failure of a subsea control module results in a production loss. A subsea intervention is planned to replace the subsea control module. The production loss resulting until subsea intervention starts is categorized as B1, *Subsea equipment failure.* The production loss during subsea intervention until well is available for production is categorized as B2, Unplanned subsea intervention.

8.3 Turnaround

Turnaround (see 3.1.52) is a planned event with full production shutdown due to integrity management or regulatory requirements. Production loss caused by turnaround shall be reported in production loss category F1.

A turnaround that extends in time beyond the planned duration will cause additional production loss and shall also be reported in production loss category F1. Production loss category F1 should also be subdivided in planned and extended turnaround, respectively, as indicated in Table A.1.

8.4 Modification

Modification (see 3.1.28) is a planned event and any production loss as part of PE calculation and reporting can be handled by one of the following two options:

a) ISO 20815:2018, Table G.1 has a production loss category F2, Modification, implying that shutdown of a plant for modification, e.g. tie-in or major module installation, represents a production loss for the existing producing asset and should be documented accordingly.

b) Because modifications are part of the business plan, normally with the objective of increasing the production potential as a result of the modification, the production potential can be adjusted (down) during the actual modification. The modification itself is not considered to represent a production loss.

In conjunction with PE data exchange or benchmarking, the option used shall be stated.

A modification that extends in time beyond the planned duration will cause additional production loss and shall also be reported in production loss category F2. Production loss category F2 should also be subdivided in planned and extended modification, respectively, as shown in Table A.1.

Whether production loss occurring after a modification should be allocated to post-modification impact (i.e. in production loss categories A9, B5 or D5) or to other production loss categories (e.g. equipment failure or process/operational problems) can be determined either with a time-limit after the modification subject to the operator's decision, or based on a failure investigation of the production loss event, e.g. root cause analysis (see IEC 62740:2015), to decide whether the event originated from the modification or not.

8.5 Pre-production

Production loss can occur as a result of production start-up delays, i.e. events covered by the pre-production (see production loss category H in ISO 20815:2018, Table G.1). Such events are not relevant for PE calculation and reporting, since PE reporting starts after production start-up. This production loss category is sometimes used by project management during project execution using other KPIs as described in ISO 20815:2018, G.2.6. Such methods typically used in benchmarking will not be comparable with PE as calculated by Method A or Method B (see 7.2), as the assumptions and conditions for estimation are different.

8.6 Flaring and venting of gas

In most cases with flaring and venting of gas, the associated production loss is not due to equipment failure in the flare system. The flaring and venting are normally caused by events in other systems (e.g. compressor failures or process/operational problems). The production loss should be allocated to the appropriate production loss category (e.g. D1 or D3) that initiated the event. Only specific issues in the flare/vent system preventing production (or injection) should be allocated to the flare/vent system (see also 6.7 and 6.8).

8.7 Injection

Loss of injection of gas, water or CO_2 can affect oil production negatively and shutdown of injection can be reported as cause of production loss. The direct impact of lost injection volumes on production volumes is often complex and difficult to establish and will typically be a time-variate relationship. Such injection volume loss should therefore be separately reported along with a clear description of whether the PE has been affected due to such loss of injection. Performance measures for injection are described in 5.5.

A good understanding of the dependencies and interactions between the reservoir, well design and production facility during the time period for when injection is needed, is important for assessing injection efficiency. Since this subject matter is field specific, no more guidance is given but an operator can establish guidance as needed.

In the case that other materials are injected for EOR purposes, this shall be treated similarly as gas or water injection.

8.8 Accounting period

In the case that the SMPP or achieved production potential is limited by the market potential (see 7.3) by a sales contract that specifies a produced volume to be delivered within an accounting period, there is a possibility that the production loss resulting from a production shutdown can be recovered within the accounting period by utilization of the available (full) well production potential and plant capacity. In such a case, the produced volume equals the production potential in the time period. Thus, there is no production loss to be allocated to a production loss category, and the PE is not reduced because of the shutdown. See example in Clause E.5.

It is still recommended to assess events with such production impact and down time as part of production assurance and organizational learning. Any equipment failures shall be recorded in CMMIS, even if no production loss occurred.

Annex A
(normative)

Production loss categorization

A.1 General

This annex provides requirements for production loss categorization with focus on the installations within the upstream business category. The production loss categories follow the same principles as in ISO 20815:2018, Clauses E.3 and G3. Table A.1 is introduced to ensure improved production loss reporting and ensure standardized PE reporting in the operating phase.

Some supplementary guidance is given in Table A.3, also including explanations of some differences between Table A.1 and ISO 20815:2018, Table G.1.

The relationship between the production loss categorization of activity or event and the use of the system/section classification from ISO 14224:2016, Table A.3 is indicated in Table A.2 and further described in Table D.1.

ISO 14224:2016, Annex B provides requirements for how critical and non-critical equipment failures (causing equipment down time) shall be described by failure modes, failure mechanisms and failure causes. If such failures affect production (i.e. production critical failures), the production loss shall be allocated to appropriate systems and equipment classes as explained in Table D.1. A principal difference is that the production down time reflects a volume-based production loss, as opposed to equipment down time that reflects a time-based unavailable function. Useful illustrations of such a relationship can be found in ISO 20815:2018, Figures I.1 and I.2.

A.2 Production loss categories

Reporting of PE data in accordance with the principles of this document shall be implemented in the operator production performance system, thereby enabling a standardized format for information sharing internally and externally. The business value of PE data is in the knowledge of historic (or predicted) production loss contributors as defined by the production loss categories being used to minimize such revenue loss and OPEX. The production loss categorization shall be in accordance with Table A.1. When allocating a production loss to a specific production loss category, further subdivision may be used depending on company governance and needs for production assurance to meet business objectives.

Another requirement for the operator is the allocation of the reported production loss for the asset elements versus the system and equipment class that contributed to such production loss. See Clause A.3 and Table D.1 for further details. Table D.1 shall be evaluated for use when establishing the production loss system needed for PE calculation and reporting, and likewise if reporting injection efficiency.

Table A.1 lists production loss categories for reporting of PE data. Table A.1 also shows injection loss categories for use if also reporting IE data.

All production loss categories in Table A.1 apply when reporting PE data, irrespectively of whether Method A or Method B is used for PE calculation. The only exception is production loss category A1 that only applies for Method A.

Production loss categorization with respect to planned/unplanned event or activity shall be in accordance with Table A.1. However, Table D.1 provides additional requirements and guidance for an operator production performance system that can be beneficial to identify production loss contributors and enable optimal production efficiency.

The same approach as described above for production loss categorization applies if injection loss categorization is needed for analysing IE data.

Table A.1 — Production loss categories

Production loss category	Type of activity or event	Planned or unplanned	Injection loss category
A: Wells			
A1	Reservoir uncertainty	Unplanned	X
A2	Reservoir intervention	Planned	X
A3	Reservoir intervention	Unplanned	X
A4	Well testing [a]	Planned	X
A5+A6 combined [b]	Downhole well equipment or X-mas tree failure and intervention	Unplanned	X
A5	Downhole well equipment or X-mas tree failure	Unplanned	X
A6	Unplanned downhole well equipment or X-mas tree intervention	Unplanned	X
A7	Planned activities on well equipment	Planned	X
A8	Flow assurance	Unplanned	X
A9	Post-modification impact	Unplanned	X
A10	Reservoir storage limit	Planned or un-planned	X
A11	Reservoir containment problems	Unplanned	X
B: Subsea			
B1+B2 combined [b]	Subsea equipment failure and intervention	Unplanned	X
B1	Subsea equipment failure	Unplanned	X
B2	Unplanned subsea intervention	Unplanned	X
B3	Planned subsea intervention or activities	Planned	X
B4	Flow assurance	Unplanned	X
B5	Post-modification impact	Unplanned	X
D: Process and utilities [c]			
D1+D2 combined [b]	Equipment failure and repair	Unplanned	X
D1	Equipment failure	Unplanned	X
D2	Active corrective maintenance	Unplanned	X
D3	Preventive maintenance	Planned	X
D4	Process / operational problems	Unplanned	X
D5	Post-modification impact	Unplanned	X
E: Export and import			
E1	Storage limits	Unplanned	N/A
E2+E3 combined [b]	Unavailable tanker or loading operations	Unplanned	N/A
E2	Unavailable loading operations	Unplanned	N/A
E3	Shuttle tanker delay	Unplanned	N/A
E4	Export/import pipeline	Planned or unplanned	X
E5	Infrastructure dependencies	Planned or unplanned	X
E6	Flow assurance	Planned or unplanned	X

Table A.1 *(continued)*

Production loss category	Type of activity or event	Planned or unplanned	Injection loss category
E7	Utilities import	Planned or unplanned	X
F: Turnaround and modifications			
F1	Turnaround [d]	Planned or unplanned	X
F1.1	Turnaround	Planned	X
F1.2	Extended turnaround	Unplanned	X
F2	Modification [d]	Planned or unplanned	X
F2.1	Modification	Planned	X
F2.2	Extended modification	Unplanned	X
G: Other			
G1	Bad weather	Unplanned	X
G2	Safety and environmental	Unplanned	X
G3	Labour conflict	Unplanned	X
G4	Environmental permits/limits	Unplanned	X
G5	Security	Unplanned	X
G6	Authority restrictions	Planned or unplanned	X
G7	Product quality deviations	Unplanned	X
G8	Commercial	Planned or unplanned	X
G9	Other	Planned or unplanned	X

NOTE 1 The production loss categories are similar to those given in ISO 20815:2018, Table G.1 except for the differences explained in Table A.3. In addition, the effect of schedule delays on production as described in 7.7 are not covered in this document.

NOTE 2 All injection loss categories apply when reporting IE data, irrespectively of whether Method A or Method B is used for IE calculation. The only exception is injection loss category A1 that only applies for Method A.

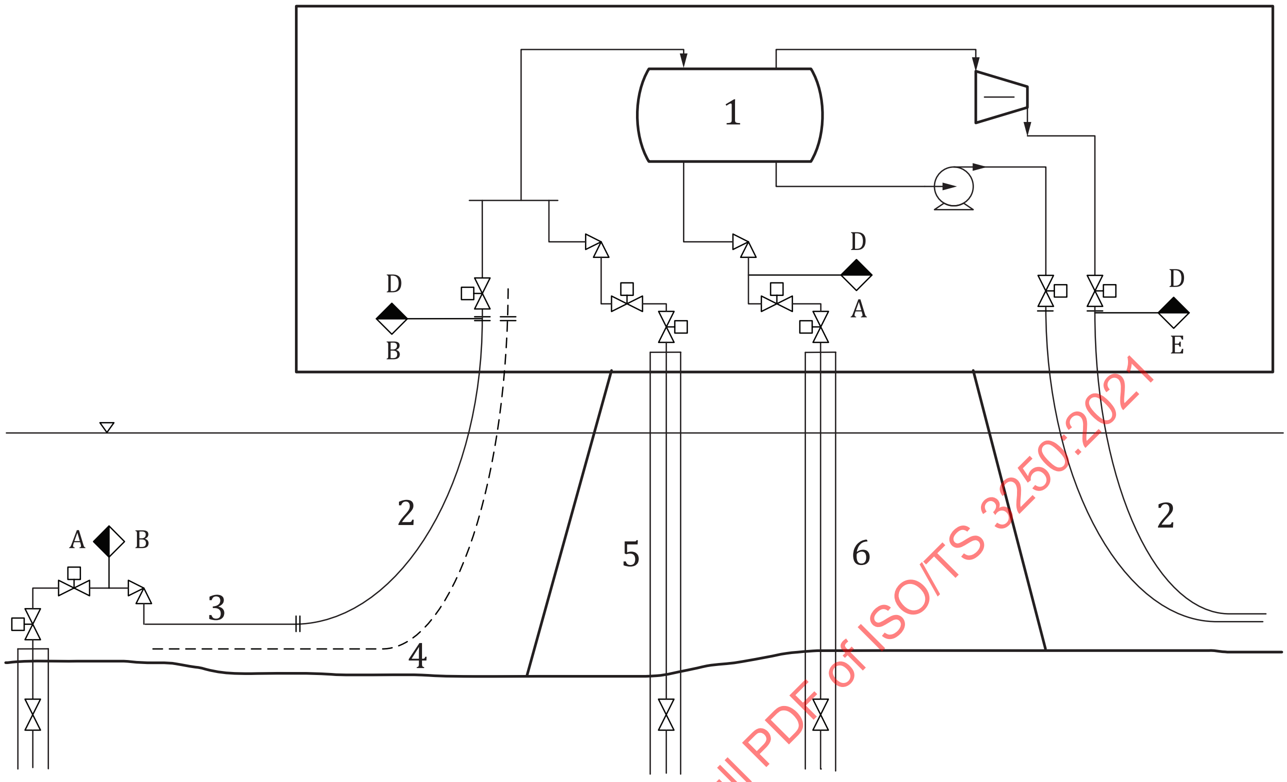
[a] Well testing is a more general term and is used instead of well production testing as used in ISO 20815:2018, Table G.1, since well testing is applicable for both production wells and injection wells.

[b] The underlying production loss categories can be combined (e.g. A5+A6), unless the subdivision (e.g. A5 and A6 separately) is desired by the operator.

[c] Production loss category D combines categories C and D from ISO 20815:2018, Table G.1 to keep the labelled production loss categories A to G as defined therein.

[d] Production loss categories F1 and F2 can be subdivided as indicated in the table.

Figure A.1 is an illustration of some of the battery limits of the different production loss categories. Similar battery limits will apply if injection loss categories are used but will depend on the asset characteristics and field infrastructure.



Key

1	process	A	wells
2	riser	B	subsea
3	flowline	D	process and utilities
4	umbilical	E	export and import
5	production		
6	injection		battery limits

Figure A.1 — Battery limits for production loss categories

Production loss resulting from events related to import (see Figure 4) are not directly allocated to any of the activities or events in Table A.1, and different company practices can exist. Such events should be allocated to production loss category E. In this document, the production loss category E is therefore named as 'Export and import'.

Additional production loss categories for unplanned extended time period for turnarounds and modifications are further explained in Table A.3.

A.3 Production loss categorization – supplementary guidance

A.3.1 General

Production loss is allocated to a production loss category as shown in Table A.1. In order to conform with this document, it is required to provide a more detailed allocation of the production loss to the asset element where the production loss occurred and the system and equipment that caused the production loss.

A unique production loss event record number shall be given for each production loss event. It is recommended to specify failure and maintenance event record number(s) or referencing to such in CMMIS.

The failure impact (see 3.1.15) and maintenance impact (see 3.1.25) on production, is not necessarily fully known when production loss reporting takes place. ISO 14224:2016, Table 6 specifies ‘failure impact on plant operations’ as data to be recorded for each failure event and references ISO 14224:2016, Table C.2 for consequence classification. Failure investigation, for example with root cause analysis (see ISO 14224:2016, Table D.2), can be needed in some severe cases to identify which equipment class(es) did cause the production loss.

The following asset elements, systems and equipment classes form the basis for Table D.1:

— asset elements (see 3.1.3): They represent value chain elements within the installations that form the hydrocarbon production chain for which PE reporting applies, but they can also include associated infrastructure outside installations belonging to upstream business category that affects PE;

— system: see ISO 14224:2016, Table A.3;

— equipment class: see ISO 14224:2016, Table A.4.

Table A.2 shows the relationship between the production loss categories in Table A.1, the asset elements, and the systems as shown in ISO 14224:2016, Table A.3. Some of the asset elements will contain a few associated systems, whilst the asset element ‘Production facilities (including process and utilities)’ contains many systems and these are thus not listed as they depend on installation. See further details in Table A.3 and Table D.1.

In this document, all risers are covered in the asset element ‘subsea installations’, but an operator may categorize some production/injection risers in the asset element ‘wells’. The import/export risers are classified as part of the asset element ‘subsea installations’. However, production loss associated with import/export risers are covered in production loss category E. See Table D.1 for further information.

It is important to distinguish between the production loss categorization requirements shown in Table A.1 and the equipment failure data and maintenance data requirements shown in ISO 14224:2016. The latter requires documentation that is not necessarily needed for PE reporting. The organizational responsibility for these information systems can vary amongst operators but failure and maintenance data shall always be covered by a CMMIS system.

Table A.2 — Relationship between production loss categories, asset elements and associated systems

Asset element	Production loss category					
	A: Wells	**B: Subsea**	**D: Process and utilities**	**E: Export and import**	**F: Turnaround and modifications**	**G: Other**
Wells	S20, S21, S22, S24				X	X
Subsea installations		S20, S24, S26, S27		S20, S24	X	X
Production facilities			Many		X	X
Export and import facilities				S4, S5, S6, S30, S31, S80	X	X

NOTE 1 The same principles apply for the relationship between injection loss categories, asset elements and associated systems when calculating and reporting injection efficiency.

NOTE 2 Production loss category ‘wells’ includes production loss related to downhole and subsea/surface well related equipment as explained in Table A.1 and Table A.3.

NOTE 3 ‘Subsea installations’ will not necessarily be an asset element for the asset for which PE reporting applies.

A.3.2 Production loss categories – supplementary guidance

The production loss categorization shall be in accordance with Table A.1. Table A.3 provides additional requirements and guidance for an operator production performance system. For a production loss activity or event normally only one of the production loss categories applies. The battery limits for the production loss categories A-E are given in this subclause and in Table A.3.

NOTE Table A.1 as compared with ISO 20815:2018 has renamed some of the production loss categories and some production loss categories have been combined. Furthermore, ISO 20815:2018, Table G.1 provides other comments that have not been reproduced verbatim in Table A.3. However, explanations have been added in Table A.3 (see footnotes) and Table D.1 to describe the differences between these tables.

Some additional guidance for the use for PE calculation and reporting is provided below and further details are given in Table A.3:

a) Production loss category A

— Battery limits: The battery limits for production loss category A is up to and including the production wing valve or injection wing valve, as further described in footnote a in Table A.3. This is common practice amongst operators and implies that some different production loss categorization will appear as shown in footnotes e and f in Table A.3. Implicitly, also production loss category A9 will cover, e.g. well related post-modification effects.

b) Production loss category B

— Battery limits: The battery limits for production loss category B are from the subsea X-mas tree choke valve to the riser/umbilical topside/onshore termination at the offshore or onshore tie-in facility. It covers subsea located process and utility functions, and also some topsides located items as further described in footnote i in Table A.3.

c) Production loss category D

— Battery limits: The battery limits for production loss category D are from the topside/onshore manifold (including dry X-mas tree choke valve) or import/production riser hang off (if subsea wells) to export system interface. It covers process and utility functions located topside or onshore.

d) Production loss category E

— Battery limits: The battery limits for production loss category E cover main export activities of tanker offtake or pipelines.

— Concerning production loss in the export facilities located subsea (i.e. export riser and SSIV), this should be included in production loss category E4. Import and export risers are covered by production loss category E, whilst production and injection risers are covered by production loss category B.

e) General principles

— Separation of down times: Even though combination is possible by the operator, it is recommended to separate production loss in the time period ‘from fault detected until the active repair starts’ and ‘active repair time until equipment is restored and made available for production’ as shown in Table A.3. This enables better recording of active repair time (MART) versus time to restoration (MTTRes) (see ISO/TR 12489:2013, Figure 5). This is reflected in the production loss categories A5/A6, B1/B2 and D1/D2.

— Human error impact on production loss: Human error related failure causes, e.g. operating error, can be collated and covered to focus on such matters (see ISO 14224:2016, Table B.3). Human error can influence all production loss categories but production loss category D4 can be used. Further guidance is given in ISO/TR 12489:2013 regarding human factors.

— Other: No physical battery limits apply for turnaround and modifications (e.g. tie-in or major module installation), but they will cause full or partial production shutdown (see also 8.3 and 8.4).

An operator may subdivide some of the production loss categories, if this is considered to add value for analysing the reported PE data.

Table A.3 — Production loss categorization with respect to planned/unplanned event or activity

Production loss category	Type of activity or event	Planned or unplanned	Comments related to production loss categorization
A: Wells			[a]
A1	Reservoir uncertainty	Unplanned	Production loss due to reservoir uncertainties (e.g. production or injection less than anticipated). See ISO 20815:2018, Table G.1 for further information.
A2	Reservoir intervention	Planned	[b] Reservoir intervention includes planned well interventions such as logging, fracturing and re-perforating not involving retrieval of well completion string. See ISO 20815:2018, Table G.1 for further information.
A3	Reservoir intervention	Unplanned	[c]
A4	Well testing	Planned	[d] The infrastructure of the field installations will influence how PE is affected by well testing. See ISO 20815:2018, Table G.1 for further information.
A5+A6 combined	Downhole well equipment or X-mas tree failure and intervention	Unplanned	[e]
A5	Downhole well equipment or X-mas tree failure	Unplanned	Production loss in the time period from fault detected until the active repair (i.e. well intervention) starts. See ISO 20815:2018, Table G.1 for more information.
A6	Unplanned downhole well equipment or X-mas tree intervention	Unplanned	[f] Production loss arising from when the active repair starts until the faulty equipment (i.e. downhole well equipment or surface/subsea X-mas tree) is restored, and the well then made available for production/injection. Prolonged down time in an operative well (see 3.1.29) due to well intervention shall be reported as production loss, as the operative well is part of the well production potential (see 3.1.58).
A7	Planned activities on well equipment	Planned	[g]
A8	Flow assurance	Unplanned	[h]
A9	Post-modification impact	Unplanned	Reduction or shutdown in well production (or injection) caused by a modification project (after run-in), e.g. side-tracking or re-completion.
A10	Reservoir storage limits	Planned or unplanned	This applies in the case that injection needs to be shut down when reservoir storage limits are reached, e.g. caused by maximum allowable reservoir pressure. Reservoir storage limits can apply for reporting production efficiency or when reporting injection efficiency.
A11	Reservoir containment problems	Unplanned	This applies only if reporting injection efficiency and when injection containment is lost. Injection containment can be injection outside the planned target reservoir, e.g. intra-reservoir communication or into overburden formation. This production loss category also applies when reporting production efficiency.
B: Subsea			[i] [j]
B1+ B2 combined	Subsea equipment failure and intervention	Unplanned	[k]
B1	Subsea equipment failure	Unplanned	Production loss in the time period from fault detected until the active repair (i.e. subsea intervention) starts. See ISO 20815:2018, Table G.1 for more information.

Table A.3 *(continued)*

Production loss category	Type of activity or event	Planned or unplanned	Comments related to production loss categorization
B2	Unplanned subsea intervention	Unplanned	Production loss arising from when the active repair starts until the faulty equipment (i.e. subsea equipment) is restored and made available for subsea production/injection. If subsea well intervention (i.e. entry into the well) is needed, then production loss category A6 can be needed.
B3	Planned subsea intervention or activities	Planned	Preventive maintenance (i.e. periodic testing) of safety critical equipment such as subsea valves, subsea HIPPS and SSIV (see ISO 14224:2016, A.2.6.8), subsea processing equipment (e.g. subsea pumps or subsea compressor) and inspection pigging. Production loss during minor modification for the existing subsea installations (e.g. equipment upgrades). This production loss category can be subdivided as needed.
B4	Flow assurance	Unplanned	Flow assurance problems, e.g. hydrates, scaling, wax and asphaltenes.
B5	Post-modification impact	Unplanned	Reduction or shutdown in subsea production caused by a modification project (after run-in), e.g. new subsea template/subsea manifold tie-ins.
D: Process and utilities			[l]
D1+D2 combined	Equipment failure and repair	Unplanned	[m]
D1	Equipment failure	Unplanned	[n]
D2	Active corrective maintenance	Unplanned	[o]
D3	Preventive maintenance	Planned	[p] Preventive maintenance covers activities as shown in ISO 14224:2016, Figure 6 (see ISO 14224:2016, Annex F for information regarding safety critical equipment).
D4	Process / Operational problems	Unplanned	[q r]
D5	Post-modification impact	Unplanned	[s] Reduction or shutdown in production caused by a modification project (after run-in), e.g. pipeline tie-ins and compressor upgrade.
E: Export and import			[t]
E1	Storage limits	Unplanned	Unplanned production shutdowns caused by full storage, e.g. on offshore platform, FPSO or dedicated FSU.
E2+E3 combined	Unavailable tanker or loading operations	Unplanned	[u] Failure of equipment under the control of the production facility or shuttle tanker loading delays. This does not include third-party export infrastructure, covered by production loss category E5.
E2	Unavailable loading operations	Planned or unplanned	[v] Planned shutdowns is indicated in ISO 20815:2018, Table G.1 and can be part of production loss category E2 if, e.g. FSU has preventive maintenance that causes reduced PE on the production facility.
E3	Shuttle tanker delay	Unplanned	Shuttle tanker being unable to receive cargo due to tanker technical reasons, weather, e.g. sea state operational limitations or delayed arrival (see also ISO 20815:2018, Clauses I.25 and I.26).
E4	Export/import pipeline	Planned or Unplanned	[w] Planned and unplanned events can be separated. Shutdowns in pipeline transportation system caused by unplanned or planned events. Planned periodic testing of subsea pipeline isolation valves, SSIV located in the export pipelines or valves at onshore isolation station (see ISO 14224:2016, A.2.6.7 and A.2.6.8).

Table A.3 *(continued)*

Production loss category	Type of activity or event	Planned or unplanned	Comments related to production loss categorization
E5	Infrastructure dependencies	Planned or Unplanned	x Infrastructure dependencies affecting production/injection can arise from activities or events at installations within upstream, midstream (e.g. LNG plant), downstream (e.g. refinery) or petrochemical (e.g. methanol plant) business categories. This infrastructure can vary much between field facilities (see ISO 20815:2018, Table G.1, and ISO 14224:2016, Figure A.1 and Tables A.1 and A.2). Planned and unplanned events can be separated. Production loss categories for facilities within midstream, downstream or petrochemical business categories are not covered in this document, but can be found in ISO 20815:2018, Tables G.4 to G.6.
E6	Flow assurance	Planned or Unplanned	Planned (e.g. pigging) and unplanned (e.g. hydrate plug removal) events can be separated.
E7	Utilities import	Planned or Unplanned	y This production loss category covers external power supply from submarine power cables (see ISO 14224:2016, Table A.4). Restricted utility import caused by failures of equipment located within the production facility is covered by production loss categories B or D. Planned and unplanned events can be separated.
F: Turnaround and modifications			No physical battery limits apply for turnaround and modifications (e.g. tie-in or major module installation), but it will cause full or partial production shutdown (see also 8.3-8.4).
F1	Turnaround	Planned or Unplanned	As defined in ISO 14224:2016, 3.94, turnaround is a major maintenance activity, as planned for by the operator. It is recommended to subdivide turnaround into (planned) turnaround and extended (unplanned) turnaround.
F1.1	Turnaround	Planned	Equipment repair (with possible upgrade) due to major equipment failures may be recorded here instead of in other equipment failure related production loss categories, if the repair is done simultaneously as part of a planned turnaround.
F1.2	Extended turnaround	Unplanned	As per ISO 20815:2018, Table G.1, unplanned extension of turnaround should also be documented as production loss, i.e. extended turnaround as compared with original forecast.
F2	Modification	Planned or Unplanned	Modification that will require full (or partial) production shutdown, as described in 8.4 and in ISO 20815:2018, Table G.1. The modification is a major activity, as planned for by the operator. It is recommended to subdivide modification into (planned) modification and (unplanned) extended modification for the production facility for which production loss reporting applies.
F2.1	Modification	Planned	Equipment repair (with possible upgrade) due to major equipment failures may be documented here instead of in other equipment failure related production loss categories, if the repair is done simultaneously as part of a planned modification. The production loss arising from such equipment restoration may be considered as a planned event, even though the equipment failure itself was unplanned.
F2.2	Extended modification	Unplanned	As per ISO 20815:2018, Table G.1, unplanned extension of modification should also be documented as production loss, i.e. extended modification as compared with original forecast.
G: Other			No physical battery limits apply for the production loss category 'Other'. Production shutdown due other events originating at the production facility itself or due to external factors. Some guidance below is reproduced from ISO 20815:2018, Table G.1.
G1	Bad weather	Unplanned	Production impact due to weather. Weather problems that affect tankers are covered in production loss category E3. Precautionary planned production shutdown caused by adverse weather will also be covered, unless subdivision of planned weather contingency and unplanned bad weather impact may be applied by the operator. See also ISO Guide 84:2020 with respect to precautionary adaptation and consequences of extreme weather risk.
G2	Safety and environmental	Unplanned	Safety or environmental related events or shutdown required due to safety contingency (e.g. ship collision risk) or accidental spill of oil, chemicals or synthetic materials, where there has been or can be a significant effect of pollution on the environment.

Table A.3 *(continued)*

Production loss category	Type of activity or event	Planned or unplanned	Comments related to production loss categorization
G3	Labour conflict	Unplanned	
G4	Environmental permits/limits	Unplanned	Reduced production to accommodate environmental discharge permits / discharge limits (e.g. flaring, produced water disposal, oil in water limits, chemical discharge limits).
G5	Security	Unplanned	Terrorism, riots, etc.
G6	Authority restrictions	Planned or Unplanned	Restrictions by country regulatory bodies, national quotas, OPEC, etc. The restrictions can be planned or unplanned depending on whether restrictions are temporary or permanent.
G7	Product quality deviations	Unplanned	Out of product specification (below and above specification).
G8	Commercial	Planned or Unplanned	Production loss caused by production constraints due to commercial aspects of the business.
G9	Other	Planned or Unplanned	[z]

[a] The bracket 'downhole and subsea/surface' as used in ISO 20815: 2018, Table G.1 has been removed. The battery limits for production loss category A include the reservoir, downhole well completion and surface or subsea X-mas tree (up to and including the production wing valve or injection wing valve). The subsea X-mas tree is part of the battery limits used in this document, what differs from ISO 20815:2018, Table G.1. Only production loss in operative well (see 3.1.29) is covered, because a non-operative well is not part of the well production potential (see 3.1.58).

See Table A.107 (Downhole well completion), Table A.90 (Subsea wellhead and X-mas trees), Table A.115 (Surface wellhead and X-mas trees) and A.2.9 concerning various well interventions in dry or subsea completed wells in ISO 14224:2016.

[b] The phrase 'planned reservoir interventions' is used in ISO 20815:2018, Table G.1.

[c] The phrase 'unplanned reservoir interventions' is used in ISO 20815:2018, Table G.1

[d] The phrase 'well production testing' is used in ISO 20815:2018, Table G.1.

[e] ISO 20815:2018 uses production loss category A5 'downhole well equipment failure' and production loss category A6 'unplanned downhole well intervention'. Such production loss categories can be combined by an operator as shown in this example. It is recommended to keep these separately to better measure mean active repair time (MART) versus mean time to restoration (MTTRes) (see ISO/TR 12489:2013, Figure 5 and ISO 14224:2016, 3.59 and 3.64).

This production loss category will also cover surface/subsea wellhead and X-mas tree since the X-mas tree is part of the well barrier. This means that production loss due to topsides or onshore X-mas trees critical failure can also be documented in A5/A6. Thus, production loss categories B1/B2 and C1/C2 as shown in ISO 20815:2018, Table G.1 are combined here as indicated, given equipment is within the battery limits as per footnote a above.

[f] The phrase 'unplanned downhole well intervention' as used in ISO 20815:2018, Table G.1 has been adjusted in this document, since X-mas tree is within the wells battery limits used in this document.

[g] The phrase 'planned downhole well intervention or activities' as used in ISO 20815:2018, Table G.1 has been adjusted in this document, since X-mas tree is within the well's battery limits used in this document. A more general phrase is used, as this production loss category covers preventive maintenance (see ISO 14224:2016, Figure 6) of well equipment, e.g. periodic testing of safety critical equipment such as X-mas tree valves and DHSV.

[h] The phrase 'flow assurance (unplanned)' as used in ISO 20815:2018, Table G.1 has been adjusted by putting '(unplanned)' in a separate column in this document. It still covers production loss due to flow problems in the well, e.g. hydrates, scaling, wax and asphaltenes.

[i] The phrase 'subsea installations' as used in ISO 20815:2018, Table G.1 has been adjusted to 'Subsea' in this document. The battery limits for production loss category B include the subsea installations from subsea X-mas tree choke valve to the riser/umbilical topside/onshore termination at the offshore or onshore tie-in facility. This implies that subsea well intervention requiring subsea X-mas tree retrieval is not included, as this is covered in production loss category A. However, subsea production control and subsea processing utilities located topsides/onshore are covered. Topsides power distribution related to subsea electrical power distribution is also covered.

[j] The production/injection from/to the subsea wells is covered in production loss category B. The production loss in the export facilities located subsea (i.e. export riser and SSIV) should be included in production loss category E4. See Table A.87 (subsea production control), Table A.99 (subsea electrical power distribution) and A.2.6 in ISO 14224:2016.

[k] ISO 20815:2018 uses production loss category B1 'subsea equipment failure' and production loss category B2 'unplanned subsea intervention'. Such production loss categories can be combined by an operator as shown in this example. It is recommended to keep these separately, to better measure mean active repair time (MART) versus mean time to restoration (MTTRes) (see ISO/TR 12489:2013, Figure 5 and ISO 14224:2016, 3.59 and 3.64).

[l] This production loss category is entitled 'process and utilities' and is a combination of the production loss categories 'production facilities' and 'process and utilities' as used in ISO 20815:2018, Table G.1. The battery limits for this production loss category include all process and utility functions located topsides or onshore for the installation. If a surface X-mas tree, then it covers from the X-mas tree choke valve, as the X-mas tree itself is part of production loss category A. Subsea processing is covered in production loss category B. See ISO 14224:2016, Table A.4, which covers many equipment classes belonging to process, safety and control, utility and auxiliary systems.

[m] The phrase 'equipment failure and repair' covers 'production facilities equipment failure (C1)', 'unplanned production facilities maintenance (C2)' and 'equipment failure and repair (D1)' as used in ISO 20815:2018, Table G.1 (see footnote l above). Such production loss categories can be combined by an operator as shown in this example. It is recommended to keep these separately, as production loss categories D1 and D2. This will better differentiate how production loss is affected by mean active repair time (MART) versus mean time to restoration (MTTRes) (see ISO/TR 12489:2013, Figure 5 and ISO 14224:2016, 3.59 and 3.64).

Table A.3 *(continued)*

Production loss category	Type of activity or event	Planned or unplanned	Comments related to production loss categorization

n The phrase 'equipment failure' differs from the phrases used for production loss categories C1 and D1 in ISO 20815:2018, Table G.1. It covers production loss in the time period from fault detected until the active repair starts (see also ISO 20815:2018, Table G.1).

o The phrase 'active corrective maintenance' differs from the phrase used for production loss categories C2 and D1 in ISO 20815:2018, Table G.1. It is in line with ISO 14224:2016, Figure 6, noting that production loss covers such loss arising from when the active repair starts until the faulty equipment is restored and made available for operation. Thus, this is equivalent to production loss categories A6 and B2.

p The term 'preventive maintenance' (see ISO 14224:2016, 3.78) covers 'planned production facility maintenance' (production loss category C3) or 'preventive maintenance' (production loss category D2) used in ISO 20815:2018, Table G.1.

q Process upsets in the process and utility systems (see ISO 20815:2018, Table G.1 for further information). It includes both production loss categories D3 and C4, e.g. both separation problems, real trips due to narrow alarm thresholds for sensors; and issues created by hydrate, scale, wax, asphaltene, sand, etc. deposits in the process and utility systems' equipment.

r Human error related failure causes, e.g. operating error, can be collated and covered in production loss category D4 to focus such matters (see ISO 14224:2016, Table B.3). However, human error can influence all production loss categories.

s Combines production loss categories C5 and D4 from ISO 20815:2018, Table G.1.

t The phrase 'export facilities' as used in ISO 20815:2018, Table G.1 has been adjusted to 'export and import' in this document. The battery limits for production loss category E includes export systems related to tanker offloading or pipelines. If any SSIV for functional safety purposes is used, this can likewise be covered in production loss category E. Import risers can be included as well. See A.2.6.3 (risers) and A.2.6.7 (subsea pipelines) in ISO 14224:2016.

u These production loss categories can be combined but it is recommended to separate between on-situ installations and ship transport as in ISO 20815:2018, Table G.1.

v If this was labelled 'equipment failure' then also repair needed to be added. 'Equipment failure' covers what is entitled 'loading operations' (Production loss category E2) in ISO 20815:2018, Table G.1, which includes offloading equipment failures.

w The phrase 'export pipeline' as used in ISO 20815:2018, Table G.1 has been adjusted to 'export/import pipeline' in this document. Export riser is covered here, e.g. into intrafield pipelines, export pipelines and export lines to offshore loading systems (see ISO 14224:2016, A.2.6.7). It also covers subsea or onshore pipelines to onshore terminal. Import riser and import pipeline from other fields can also be included but production riser/injection riser and flowline from/to subsea wells are covered in production loss category B.

x The phrase 'downstream restrictions' is used in ISO 20815:2018, Table G.1.

y Utility import is added as new production loss category as this is not used in ISO 20815:2018, Table G.1. It covers external power supply from submarine power cables (see ISO 14224:2016, Table A.4).

z Other production loss which cannot be covered by the other production loss categories.

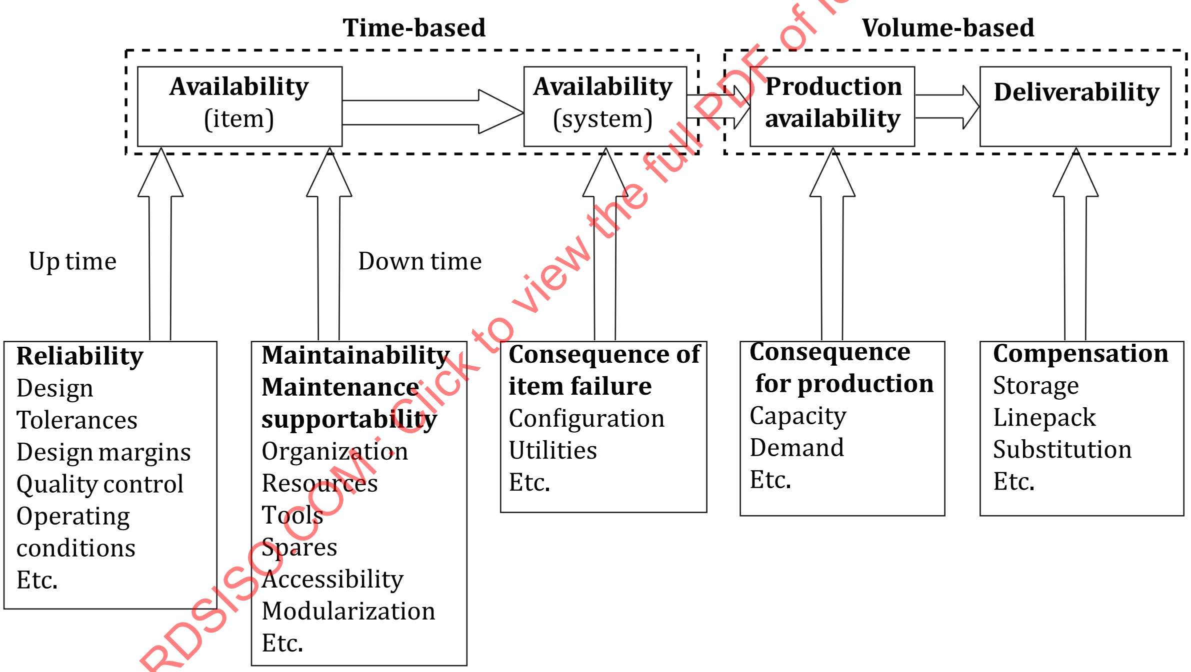
Annex B
(informative)

Performance measures for production availability

B.1 General

ISO 20815:2018, Clause G.1 lists a number of performance measures that can be relevant for production availability predictions in the planning phase or for reporting in the operating phase and used as key performance indicators for an operator or in benchmarking. Some of the measures are time-based and some are volume-based as shown in Figure B.1.

Production availability can be calculated referring to the entire plant or a section of it, as can be seen from many of the performance measures listed in Table B.1. PE reporting covers the entire production chain. Likewise, injection availability can also be calculated as reflected in Table B.1.



NOTE This is a reproduction of ISO 20815:2018, Figure G.1.

Figure B.1 — Illustration of the relationship between some time-based and volume-based production assurance terms

Table B.1 — Performance measures

Reference to ISO 20815:2018, G.1		Performance measure	Vol-ume-based	Time-based
a)		Production availability of oil for storage or for export, measured at the exit of the process facility	x	
b)	1	Production availability of water injection Water injection availability	x	
	2	Availability of water injection		x
c)	1	Production availability of gas injection Gas injection availability	x	
	2	Availability of gas injection		x
	3	Production availability of CO_2 injection CO_2 injection availability	x	
	4	Availability of CO_2 injection		x
d)		Availability of utility systems	x	x
e)		Production availability of gas for export, measured at the exit of the process facility Gas export availability	x	
f)		Production availability of gas for export according to contractual requirements (e.g. variable contractual nomination) and evaluation of penalties due to failure to fulfil contractual requirements	x	x
g)		Deliverability of gas export, measured at the delivery point and including the effect of compensating measures	x	
h)		Production availability of the subsea installation in isolation without considering downstream elements	x	
i)		Loading availability; measured offshore or onshore	x	x
j)		On-stream availability; fraction of time the flow out of the system exceeds zero		x
k)		Demand availability; fraction of time the flow out of the system satisfies demand		x
l)		Availability of the process facilities in isolation		x

Depending on the objective of the analysis, the performance measures in Table B.1 can be established annually based on the production profile or for only a specific production period, e.g. the production-plateau period, first year or maximum-water-production period. The performance measures can be analysed by various production performance analyses as further described in ISO 20815:2018.

B.2 Production availability calculation formula

The mathematical expression for production availability (see 3.1.38), $P_A(T_1,T_2)$, over a time interval $[T_1,T_2]$ as defined in ISO 20815:2018, G.2.1 is given in Formula (B.1):

$$P_A(T_1, T_2) = \frac{V_P(T_1, T_2)}{V_R(T_1, T_2)} \tag{B.1}$$

where

$P_A(T_1, T_2)$ is the production availability over $[T_1, T_2]$;

$V_P(T_1, T_2)$ is the produced volume over $[T_1, T_2]$;

$V_R(T_1, T_2)$ is the reference production volume over $[T_1, T_2]$.

See also guidance on models for production availability calculations in ISO 20815:2018, Clause I.5.

Annex C
(normative)

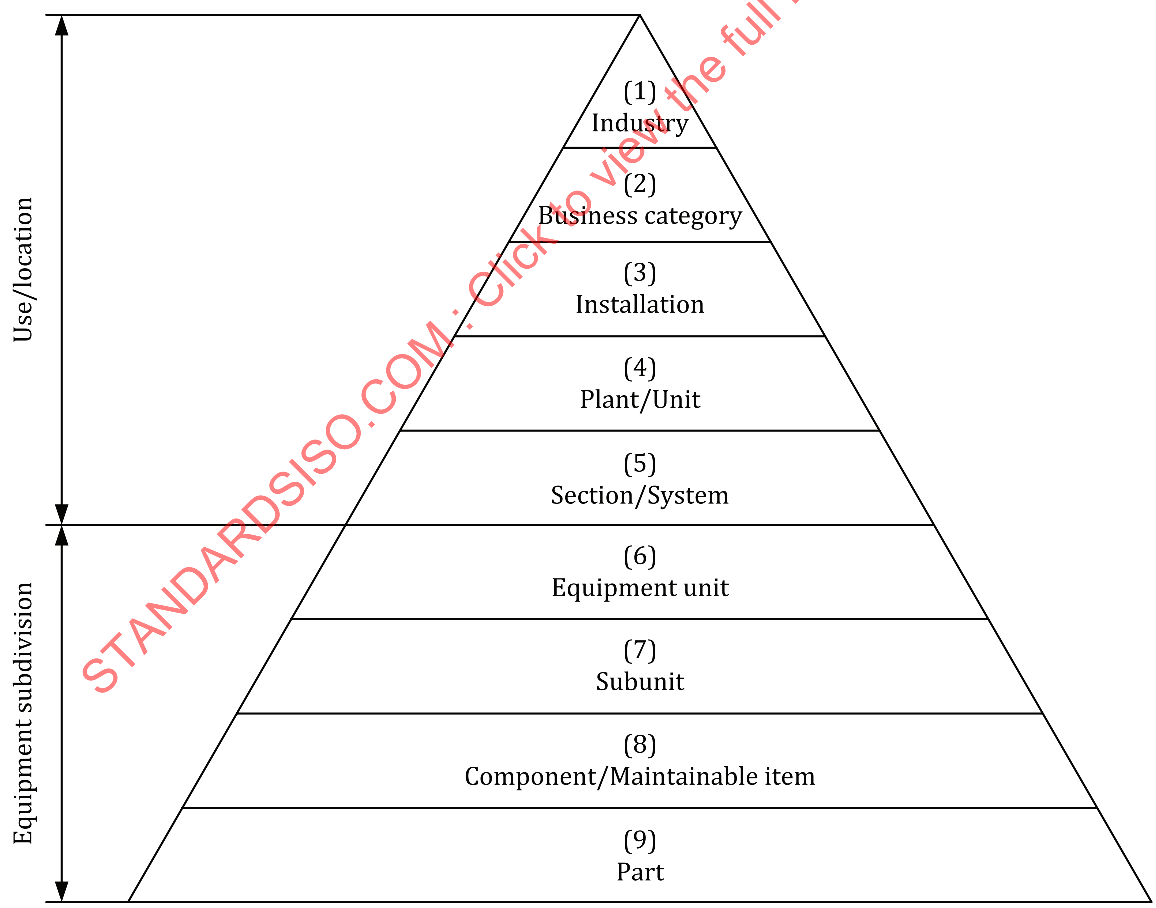
Taxonomy classification

C.1 General

This annex provides a framework regarding taxonomy as defined in ISO 14224:2016 that shall apply also when reporting what systems and equipment units are contributing to a production or injection loss. Further requirements and guidance regarding how production loss for an asset element is allocated versus systems and equipment classes are shown in Annex D.

C.2 Taxonomy classification

ISO 14224:2016 has a taxonomy classification system used for production assurance and reliability management, as shown in Figure C.1. ISO 14224:2016, Table A.3 provides a list of 27 systems that covers upstream business categories, and 31 other systems (i.e. safety and control systems, utilities and auxiliaries) applicable for all business categories have been reflected in Table D.1.



NOTE This is a reproduction of ISO 14224:2016, Figure 3.

Figure C.1 — Taxonomy classification with taxonomic levels

Annex D
(informative)

Production loss subdivision with respect to system and equipment class

D.1 General

This annex applies if the operator requires production loss allocation towards the systems and equipment classes that caused the production loss, as explained in Clause A.2. Such information is valuable and necessary to minimize production loss and understand what systems and equipment units are contributing to a production or injection loss.

In this document, all risers are covered in the asset element 'subsea installations', but an operator may categorize some production/injection risers in the asset element 'wells'. The import/export risers are classified as part of the asset element 'subsea installations'. However, production loss associated with import/export risers are covered in production loss category E. See Table D.1.

The same approach can be used for injection loss subdivision with respect to systems and equipment classes.

D.2 Production loss related to asset elements – systems and equipment classes

Table D.1 provides a relationship between the part of the asset (i.e. the asset element) where the production loss occurred and the systems and underlying equipment classes that caused this production loss. Table D.1 can be evaluated for use when establishing the production loss system needed for PE calculation and reporting. As explained in Clause A.2, Table D.1 applies if such classification is needed. For a real production loss (or injection loss) activity or event, only a subset of these systems or equipment classes will apply.

Table D.1 — Production loss categorization – Asset element versus system and equipment class

Asset element [a]	System [b]	Notes related to system	Associated ISO 14224:2016 system numbers [c]	Associated ISO 14224:2016 equipment classes [d]
Wells		Asset element battery limits: The asset element 'wells' includes the production/injection items in the operative well but does not cover the associated system or equipment used to undertake the actual well interventions or drilling.		See Table A.107 (downhole well completion), Table A.90 (subsea wellhead and X-mas trees), Table A.115 (surface wellhead and X-mas trees) and A.2.9 concerning various well interventions in dry or subsea completed wells in ISO 14224:2016.
	Reservoir	NOTE 1 In the description of 'wells' in ISO 20815:2018, Table G.1 (Production loss category A), 'reservoir' is included within 'wells'.		Reservoir is not equipment and does thus not appear in ISO 14224:2016.
	Well completion	NOTE 2 Downhole well completion can be further subdivided, with respect to the well location, e.g. subsea, offshore or onshore. It can also be subdivided with respect to equipment classes (see ISO 14224:2016, Table A.4, footnote [q] for equipment classes).	S22	WE, SS, ESP

Table D.1 *(continued)*

Asset element [a]	System [b]	Notes related to system	Associated ISO 14224:2016 system numbers [c]	Associated ISO 14224:2016 equipment classes [d]
	Subsea/Surface wellhead and X-mas tree	NOTE 3 Subsea or surface wellhead and X-mas trees for either a producing or injection well (see ISO 14224:2016, Table A.3 for more information). This can be separated into S24.1 and S21.1 to show whether production loss appearing from a subsea or surface well in case installation has both types of well completions. Explanation 1 [e]: The phrase 'well production/injection' (S21) is used in ISO 14224:2016 for dry completed wells. SURF (S24) is used in ISO 14224:2016 for subsea completed wells. These can be combined but are typically given separate system numbers by an operator and can thus be separated as stated in NOTE 3.	S20, S21 or S24	XD or XT
	Subsea wellhead and X-mas tree	NOTE 4 The phrase ‘subsea wellhead and X-mas tree’ is used for subsea completed wells. NOTE 5 Other subsea equipment, including downstream subsea choke, is covered in asset element B (see below).	S24.1	XT
	Surface wellhead and X-mas tree	NOTE 6 The phrase ‘surface wellhead and X-mas tree’ is used for dry completed wells. The surface X-mas tree is part of S21 as per ISO 14224:2016, Table A.3, footnote c. NOTE 7 Other surface equipment downstream of the dry X-mas tree choke (e.g. piping as covered in ISO 14224:2016, A.2.3.5) is covered in asset element ‘production facilities’ (see below).	S21.1	XD, PI
Subsea installations		Asset element battery limits: The asset element ‘subsea installations’ includes the subsea installations from subsea X-mas tree choke valve to the riser/umbilical topside/onshore termination at the offshore or onshore tie-in facility. Subsea production control and subsea processing utilities located topsides/onshore, and topsides power distribution related to subsea electrical power distribution are also covered. NOTE 8 The well intervention and subsea intervention equipment used in conjunction with downhole and subsea well related systems is not part of the production chain, but failure in such can affect production loss, and is covered in other time loss reporting as described in ISO 20815:2018, Tables G.2 and G.3.		See Table A.87 (subsea production control) and Table A.99 (subsea electrical power distribution) and A.2.6 for other information in ISO 14224:2016.
	SURF – Subsea, umbilical, riser and flowline	NOTE 9 SURF includes subsea installations from subsea X-mas tree choke valve to riser/umbilical topside/onshore termination at the offshore or onshore tie-in facility. SPS is part of SURF, but the subsea X-mas tree is part of asset element ‘wells’ (see above). The surface ESD valve on top of riser is not part of SURF.	S24	CS, TM, FL, MA, PR, VA
	SURF – Subsea wellhead and X-mas tree	NOTE 10 The subsea choke is an item in the subsea X-mas tree (see ISO 14224:2016, Table A.3 for more information). If S24 is subdivided, then the subsea choke may be assigned S24.2 by the operator as the rest of the subsea X-mas tree is part of asset element ‘wells’ (and denoted S24.1), but S24 is used since part of SPS system supplier delivery.	S24.2	XT

Table D.1 *(continued)*

Asset element [a]	System [b]	Notes related to system	Associated ISO 14224:2016 system numbers [c]	Associated ISO 14224:2016 equipment classes [d]
	SURF – Subsea controls	NOTE 11 Subsea located production controls equipment. It also covers dynamic and static umbilicals, and topsides located subsea controls equipment.	S24.3	CS
	SURF – Subsea template	NOTE 12 The subsea template is part of system S24.	S24.4	TM
	SURF – Subsea flowline and manifold	NOTE 13 Flowline and manifold are part of S24 and can be subdivided.	S24.5	FL, MA
	Well riser - SURF - Riser and well topside	NOTE 14 The type of riser will depend on plant/unit (e.g. offshore platform, FPSO or TLP) for dry wells or tie-backs of subsea well completed wells of the oil/gas production facility, or for an FLNG riser. Systems S20 and S24 can be combined or separated as shown below (i.e. S20.1 and S24.5), and further subdivision may be done by the operator, depending on installations. In this document, all risers are covered in asset element 'subsea installations', but an operator may categorize some production/injection risers in asset element 'wells'.	S20 or S24	DT, PR
	SURF - Riser	NOTE 15 Production riser (or injection riser) system for well flow between topsides fixed/floating installation and subsea completed wells. Other risers not connected to subsea wells (e.g. export or import risers) are not covered (see NOTE 16 and NOTE 17).	S24.5	PR
	Riser and well topside	NOTE 16 Production riser (or injection riser) system for dry completed wells on a SPAR or TLP with subsea wellhead. The surface X-mas tree on top of such riser is covered in S21 (see S21.1 above). Production (or injection) risers for fixed installations are also covered.	S20.1	DT, PR
	Export/Import riser - SURF - Other risers	NOTE 17 Export riser system including export lines to storage plant/unit or to offshore loading systems (see ISO 14224:2016, A.2.6.3 and A.2.6.7). In this document, export risers are covered in asset element 'subsea installations', and import risers are also covered in asset element 'subsea installations'. Explanation 2 [e]: Export riser system covers 'riser and well topside' (S20) and 'SURF' (S24). This can be combined as shown here or separated.	S20.2 or S24.6	PR
	Subsea processing	NOTE 18 Relevant if the subsea production system contains subsea processing functions.	S26	SC, SH, SV, SP
	Subsea processing utilities	NOTE 19 This covers various utility functions for subsea processing, located topsides or subsea. It also covers electrical power distribution for subsea processing equipment (e.g. dynamic and static power cables, and topsides located subsea power distribution equipment) (see ISO 14224:2016, A.2.6.5).	S27	EP + FC, PT, SG
Production facilities		Asset element battery limits: The asset element 'production facilities' includes all process, safety and control, utility and auxiliary system located topsides or onshore for the installation. If a surface X-mas tree, then it covers from the X-mas tree choke valve.	[f]	See ISO 14224:2016, Table A.4, which covers several applicable equipment classes belonging to process, safety and control, utility and auxiliary systems. Such equipment class codes are not shown in this table but some examples are given for illustration.
	Process - General	NOTE 20 See ISO 14224:2016, Table A.3.	See below	

Table D.1 *(continued)*

Asset element [a]	System [b]	Notes related to system	Associated ISO 14224:2016 system numbers [c]	Associated ISO 14224:2016 equipment classes [d]
	Oil process / treatment	NOTE 21 See ISO 14224:2016, Table A.3 for more information. S1 can be subdivided.	S1	
	Gas process / treatment	NOTE 22 See ISO 14224:2016, Table A.3 for more information. S2 can be subdivided, as shown below.	S2	
	Gas recompression	NOTE 23 Topsides located gas recompressors.	S2.1	
	Gas treatment	NOTE 24 Gas treatment includes dehydration and sweetening.	S2.2	
	Gas conditioning	NOTE 25 Gas conditioning includes hydrocarbon dewpoint control.	S2.3	
	Gas re-injection and gas lift	NOTE 26 Topsides located gas injection equipment.	S2.4	
	Water injection	NOTE 27 The topsides or onshore part of water injection.	S3	
	Oil / condensate export	NOTE 28 Exported product into crude storage (S6), into shuttle tankers or into export pipeline.	S4	
	Gas export	NOTE 29 Gas export includes topsides/onshore located gas export compressor. Fiscal metering is a separate system (see S92).	S5	
	Storage	NOTE 30 Export hydrocarbon storage, e.g. oil and condensate. The offshore and onshore loading systems are covered in S89.	S6	
	LNG process	NOTE 31 If FLNG, then systems S35-S38 apply (see ISO 14224:2016, Table A.3).	S35-S38	
	LNG utilities	NOTE 32 If FLNG, then S39 applies (see ISO 14224:2016, Table A.3).	S39	
	Upstream utilities	NOTE 33 See ISO 14224:2016, Table A.3. See also other utility systems below that apply for upstream business category only, and other utility systems below that also apply for all business categories.	See below	
	Oily water treatment		S7	
	Closed drains	NOTE 34 Open drains system belongs to safety and control systems (see ISO 14224:2016, Table A.3). See S78.	S8	OC
	Methanol	NOTE 35 Methanol storage and distribution is covered.	S9	
	Fuel gas		S10	
	Fresh water		S11	
	Offshore systems	NOTE 36 These systems are relevant for offshore systems but not for onshore upstream facilities.	See below	
	Ballast water		S12	
	Seawater		S13	
	Position keeping		S14	DP
	Ice management	NOTE 37 Ice management applies for Arctic operations as described in ISO 35104:2018.	S15	
	Safety and control systems	NOTE 38 See also ISO/TR 12489:2013, Annex A.	See below	
	Emergency / process shutdown (ESD, EDP & PSD)	NOTE 39 See ISO 14224:2016, Table A.3 for more information. These systems (S67, S68 and S69) can be separated. They include ESD leading to blowdown.	S67- S69	
	Fire and gas	NOTE 40 See ISO 14224:2016, Table A.3 for more information. These systems (S70, S71 and S72) can be separated.	S70-S72	