INTERNATIONAL STANDARD

ISO 16530-1

First edition
2017-03

Petroleum and natural gas industries — Well integrity —

Part 1: Life cycle governance

Pétrole et industries du gaz naturel — Intégrité du puits —

Partie 1: Gouvernance du cycle de vie

Reference number
ISO 16530-1:2017(E)

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Foreword

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

A list of all parts in the ISO 16530 series can be found on the ISO website.

Introduction

This document has been developed by oil and gas producing operating companies and is intended for use in the petroleum and natural gas industries worldwide. This document is intended to provide guidance to the well operator on managing well integrity throughout the well life cycle. Furthermore, this document addresses the minimum compliance requirements for the well operator in order to claim conformity with this document.

It is necessary that users of this document are aware that requirements over and above those outlined herein may be needed for individual applications.

This document addresses the process of managing well integrity during each of the well life cycle phases, namely: basis of design; design; construction; operation; intervention (including work-over) and abandonment.

The following terminology, in line with ISO/IEC Directives, is used in this document:

a) The term “shall” denotes a minimum requirement in order to conform to this document.

b) The term “should” denotes a recommendation or that which is advised but not required in order to conform to this document.

c) The term “may” is used to indicate a course of action permissible within the limits of this document.

d) The term “can” is used to express possibility or capability.

In addition, the term “consider” is used to indicate a suggestion or to advise.

The phases of a well life cycle have separate and distinct requirements for achieving well integrity management objectives, but all phases have common elements and techniques. Clause 5 discusses these common elements and techniques. Clauses 6 to 11 discuss each individual phase and its requirements. Additionally, each clause highlights the aspects to be considered within the common elements and techniques as applicable to that phase.

Figure 1 summarizes the elements which are common among phases, and the relation between the phases.

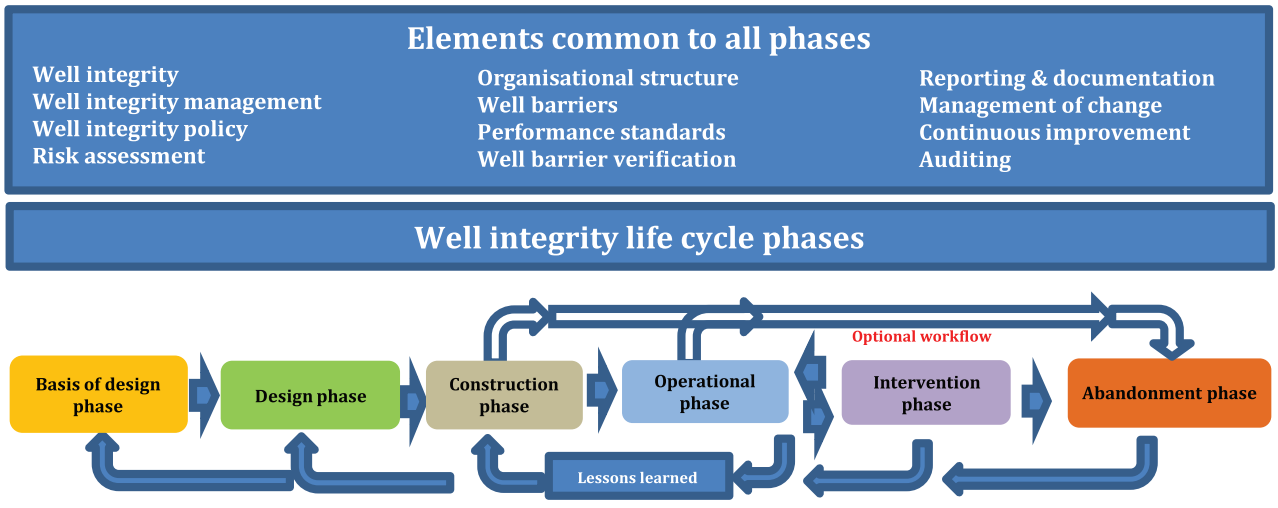

Figure 1 — Elements common to the phases of well integrity management

Petroleum and natural gas industries — Well integrity —

Part 1: Life cycle governance

1 Scope

This document is applicable to all wells that are operated by the petroleum and natural gas industry. This document is applicable to any well, or group of wells, regardless of their age, location (including onshore, subsea and offshore wells) or type (e.g. naturally flowing, artificial lift, injection wells).

This document is intended to assist the petroleum and natural gas industry to effectively manage well integrity during the well life cycle by providing:

— minimum requirements to ensure management of well integrity; and

— recommendations and techniques that well operators can apply in a scalable manner based on a well's specific risk characteristics.

Assuring well integrity comprises two main building blocks: the first is to ensure well integrity during well design and construction, and the second is to manage well integrity throughout the remaining well life thereafter.

This document addresses each stage of the well life cycle, as defined by the six phases in a) to f), and describes the deliverables between each phase within a Well Integrity Management system.

a) The "**Basis of Design Phase**" identifies the probable safety and environmental exposure to surface and subsurface hazards and risks that can be encountered during the well life cycle. Once identified, these hazards and risks are assessed such that control methods of design and operation can be developed in subsequent phases of the well life cycle.

b) The "**Design Phase**" identifies the controls that are to be incorporated into the well design, such that appropriate barriers can be established to manage the identified safety and environmental hazards. The design addresses the expected, or forecasted, changes during the well life cycle and ensures that the required barriers in the well's design are based on risk exposure to people and the environment.

c) The "**Construction Phase**" defines the required or recommended elements to be constructed (including rework/repair) and verification tasks to be performed in order to achieve the intended design. It addresses any variations from the design which require a revalidation against the identified hazards and risks.

d) The "**Operational Phase**" defines the requirements or recommendations and methods for managing well integrity during operation.

e) The "**Intervention Phase**" (including work-over) defines the minimum requirements or recommendations for assessing well barriers prior to, and after, any well intervention that involves breaking the established well barrier containment system.

f) The "**Abandonment Phase**" defines the requirements or recommendations for permanently abandoning a well.

The six phases of the well life cycle, as defined in this Scope, and their interrelationships, are illustrated in Figure 1 in the Introduction.

This document is not applicable to well control. Well control refers to activities implemented to prevent or mitigate unintentional release of formation fluids from the well to its surroundings during drilling, completion, intervention and well abandonment operations, and involves dynamic elements, i.e. BOPs, mud pumps, mud systems, etc.

This document is not applicable to wellbore integrity, sometimes referred to as "borehole stability". Wellbore integrity is the capacity of the drilled open hole to maintain its shape and remain intact after having been drilled.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
A-annulus
designation of the annulus between production tubing and production casing

[SOURCE: API RP 90, modified]

3.2
acceptance criteria
specified limits of acceptability applied to process, service, or product characteristics

3.3
as low as reasonably practicable
ALARP
implementation of risk-reducing measures until the cost (including time, capital costs or other resources/assets) of further risk reduction is disproportional to the potential risk reducing effect achieved by implementing any additional measure

Note 1 to entry: See UK HSE.[27]

3.4
ambient pressure
pressure external to the wellhead

Note 1 to entry: In the case of a surface wellhead, the pressure is 0 kPa (0 psig). In the case of a subsea wellhead, it is equal to the hydrostatic pressure of seawater at the depth of the subsea wellhead.

[SOURCE: API RP 90, modified]

3.5
anomaly
condition that differs from what is expected or typical, or which differs from that predicted by a theoretical model

3.6
availability
extent to which the system/structure/equipment is capable of retaining its functional integrity

3.7
B-annulus
designation of an annulus between the production casing and the next outer casing

Note 1 to entry: The letter designation continues in sequence for each outer annulus space encountered between casing strings, up to and including the surface casing and conductor casing strings.

[SOURCE: API RP 90, modified]

3.8
breaking of containment
controlled entry into the containment system of integrity or barrier

3.9
casing liner
casing string with its uppermost point inside a previous casing string and not in the wellhead

3.10
competence
ability of an individual to perform a job properly through a combination of training, demonstrated skills, accumulated experience and personal attributes

3.11
component
mechanical part, including cement, used in the construction of a well

3.12
conductor casing
component that provides structural support for the well, wellhead and completion equipment, and often used for hole stability for initial drilling operations

Note 1 to entry: This casing string is not designed for pressure containment, but upon completion of the well it might have a casing head; therefore, it can be capable of containing low annulus pressures. For subsea and hybrid wells, the low-pressure subsea wellhead is normally installed on this casing string.

[SOURCE: API RP 90, modified]

3.13
consequence
expected effect of an event that occurs

3.14
containment
preventing release of fluid

3.15
deep-set
close to, or at, the cap rock of a reservoir or a depth where it is possible to achieve an overbalance pressure with an hydrostatic column to counter act the maximum anticipated pressure from below

3.16
deviation
departure from a standard

3.17
dispensation
approval to operate with a deviation from a requirement

3.18
extended leak off test
XLOT
application of pressure by superimposing a surface pressure on a fluid column in order to determine the pressure at which a fracture propagates into the exposed formation and also establishes the fracture closure pressure

3.19
failure
loss of ability to perform as required

3.20
failure mode
effect by which a failure is observed on the failed item

3.21
failure modes and effects analysis
FMEA
technique which identifies failure modes and mechanisms, and their effects

3.22
failure mode, effects, and criticality analysis
FMECA
analysis usually performed after an *FMEA* (3.21) which can be based on the probability that the failure mode will result in system failure, or the level of risk associated with the failure mode, or a risk's priority

3.23
fault
abnormal, undesirable state of a system element induced by the presence of an improper command or absence of a proper one, or by a failure

Note 1 to entry: All failures cause faults; not all faults are caused by failure.

Note 2 to entry: System elements can include, for example, an entire subsystem, an assembly, or a component.

3.24
flow-wetted
<surface> coming into direct contact with the dynamic movement of well fluids in the flow stream

[SOURCE: API Spec 11D1]

3.25
fluid
substance that has no fixed shape and yields easily to external pressure

Note 1 to entry: A fluid can be either a gas or a liquid.

3.26
formation integrity test
FIT
application of pressure by superimposing a surface pressure on a fluid column in order to determine ability of a subsurface zone to withstand a certain pressure

3.27
formation strength
pressure that the formation can withstand

3.28
functionality
operational requirements of the system/structure/equipment in order to establish and maintain integrity

3.29
hazard
source of potential harm or a situation with a potential to cause loss (any negative consequence)

3.30
hybrid well
well drilled with a subsea wellhead and completed with a surface casing head, a surface tubing head, a surface tubing hanger and a surface tree

Note 1 to entry: A hybrid well can have either one (single-bore production riser) casing string or two (dual-bore production riser) casing strings brought up from the subsea wellhead and tied back to the surface equipment. These wells are typically located on floating production platforms, e.g. tension-leg platforms (TLPs).

[SOURCE: API RP 90, modified]

3.31
impairment
state of diminished ability to perform a function, without having yet failed

3.32
imposed annulus pressure
annulus pressure that is imposed for purposes such as gas lift, water injection, thermal insulation, etc.

[SOURCE: API RP 90, modified]

3.33
inflow testing
leak test of well barrier element by creating a differential pressure and observing for pressure change on the low pressure side

Note 1 to entry: See also 5.9.3.3.

3.34
intervention
operation to enter the well which requires breaking containment of an existing well barrier

3.35
leak
unintended and undesired movement of fluids

3.36
leak off test
LOT
application of pressure by superimposing a surface pressure on a fluid column in order to determine the pressure at which the exposed formation accepts whole fluid

[SOURCE: API RP 59, modified]

3.37
major accident
incident such as an explosion, fire, loss of well control, release of oil, gas or dangerous substances causing, or with significant potential to cause, damage to facilities, serious personal injury or widespread persistent degradation of the environment

3.38
major accident hazard
MAH
hazard with a potential for causing a *major accident* (3.37)

3.39
maximum allowable annulus surface pressure
MAASP
p_{MAASP}
greatest pressure that an annulus can contain, as measured at the wellhead, without compromising the integrity of any element of that annulus, including any exposed open-hole formations

3.40
monitoring
observation of the operating parameters of a well, via instrumentation, on a predefined frequency to ensure that they remain within their operating limits

Note 1 to entry: Examples of well operating parameters include pressures, temperatures, flow rates.

3.41
operated well
well for which the well operator has control and management of operations

3.42
operating limits
set of established criteria, or limits, beyond which a device or process should not be operated

3.43
outflow
fluids that flow out of one place to another, typically out of a well

3.44
performance standard
statement, which can be expressed in qualitative or quantitative terms, of the performance required of a system or item of equipment in order for it to satisfactorily fulfil its purpose

3.45
pressure test
application of pressure to a piece of equipment or a system to verify the pressure containment capability for the equipment or system

3.46
primary well barrier
first set of well barrier elements that prevent flow from a source of inflow

3.47
production casing
innermost string of casing in the well

[SOURCE: API RP 90, modified]

3.48
production riser
casing strings rising from the seafloor to the wellhead (fixed platforms) or casing strings attached to the subsea wellhead rising from seafloor to a surface wellhead (hybrid wells)

3.49
production string
completion string
string consisting primarily of production tubing, but also including additional components such as the surface-controlled subsurface safety valve (SCSSV), gas-lift mandrels, chemical injection and instrument ports, landing nipples, and packer or packer seal assemblies

Note 1 to entry: The production string is run inside the production casing and is used to conduct production fluids to the surface.

[SOURCE: API RP 90, modified]

3.50
production tubing
tubing that is run inside the production casing and used to convey produced fluids from the hydrocarbon-bearing formation to the surface

Note 1 to entry: Tubing can also be used for injection. In some hybrid wells, for example, tubing is used as a conduit for gas for artificial lift below a mudline pack-off tubing hanger to isolate the gas-lift pressure from the production riser.

[SOURCE: API RP 90, modified]

3.51
reliability
ability of an item to perform a required function under given conditions for a given time interval

3.52
residual risk
risk that remains after controls have been implemented

3.53
risk
combination of the consequences of an event and the associated likelihood of its occurrence

3.54
risk assessment
overall process of risk identification, risk analysis and risk evaluation

[SOURCE: ISO Guide 73:2009, 3.4.1]

3.55
risk register
tool to record, follow up and close out actions related to relevant assessed risks

Note 1 to entry: Each entry in the risk register typically includes a description of the risk, a description of the action(s), the responsible party, the due date, and status of the action.

3.56
safety-critical element
SCE
part of a facility, including computer programs, whose purpose is to prevent or limit the consequences of a major accident, or whose failure could cause or contribute substantially to a major accident

Note 1 to entry: Safety critical elements include measures for prevention, detection, control and mitigation (including personnel protection) of hazards.

[SOURCE: EU Directive 2013/30/EU, modified]