INTERNATIONAL STANDARD

ISO 14998

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Petroleum and natural gas industries — Downhole equipment — Completion accessories

Industries du pétrole et du gaz natruel — Équipement de fond de trou — Accessoires de complétion

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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. 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.

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

Introduction

This International Standard has been developed by users/purchasers and suppliers/manufacturers completion accessories intended for use in the petroleum and natural gas industry worldwide. This International Standard is intended to give requirements and information to both parties in the selection, manufacture, testing and use of completion accessories. Further, this International Standard addresses supplier/manufacturer requirements which set the minimum requirements with which suppliers/manufacturers shall comply to claim conformity with this International Standard.

This International Standard has been structured to allow for grades of increased requirements both in quality control and design validation. These variations allow the user/purchaser to select the grade required for a specific application for a chosen accessory.

The three quality grades provide the user/purchaser the choice of requirements to meet a specific preference or application. Quality grade Q3 is the minimum grade of quality offered by this product standard. Quality grade Q2 provides additional inspection and verification steps, and quality grade Q1 is the highest grade provided. Additional quality requirements may be specified by the user/purchaser as supplemental requirements.

Seven standard design validation grades (V0 to V6) provide the user/purchaser the choice of requirements to meet a specific preference or application. Design validation grade V6 is the minimum grade and represents equipment where the validation method has been defined by the supplier/manufacturer. The complexity and severity of the validation testing increases as the grade number decreases.

Users of this International Standard should be aware that requirements above those outlined in this International Standard may be needed for individual applications. This International Standard is not intended to inhibit a supplier/manufacturer from offering, or the user/purchaser from accepting, alternative equipment or engineering solutions. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier/manufacturer should identify any variations from this International Standard.

Petroleum and natural gas industries — Downhole equipment — Completion accessories

1 Scope

This International Standard provides requirements and guidelines for completion accessories, as defined herein for use in the petroleum and natural gas industry. This International Standard provides requirements for the functional specification and technical specifications including: design, design verification and validation, materials, documentation and data control, redress, repair, shipment, and storage. This International Standard covers the pressure containing, load bearing, disconnect/reconnect, tubing movement, and opening a port functionalities of completion accessories.

Products covered under ISO 11960, ISO 10432, ISO 10423, ISO 14310, ISO 16070, ISO 28781, ISO 10407-2, ISO 17824, and ISO 17078-1 are not included. Also not included are other products such as: liner/tubing hangers, down-hole well test tools, inflow control devices, surface controlled sliding sleeves and chokes, down-hole artificial lift equipment, and all functionalities relating to electronics. This International Standard does not cover the connections to the well conduit. Installation of these products is outside the scope of this International Standard.

2 Normative references

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

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3601-1, *Fluid power systems — O-rings — Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 3601-3, *Fluid power systems — O-rings — Part 3: Quality acceptance criteria*

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H2S — containing environments in oil and gas production*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9000 and the following apply.

3.1
anchor
completion accessory designed to disconnect or reconnect the tubing by attaching to a designed receptacle

3.2
assembly
product comprised of more than one component

3.3
blast joint
completion accessory with anti-erosion provision on the OD

3.4
casing
conduit that is an integral lining of a drilled well typically from the surface downward which is not used for a production conduit

3.5
chemical injection mandrel
completion accessory with provision to attach conduit(s) for injection of chemicals

3.6
component
individual part of an assembly

3.7
completion accessory
equipment that forms an integral part of the tubing (3.70) and is not covered by any other ISO downhole equipment standards

Note 1 to entry: See 5.2.

3.8
conduit
casing, tubing or liner, either metallic or non-metallic

3.9
cross-over
(see tubing adapter)

3.10
design validation
process of proving a design by testing to demonstrate conformity of the product to design requirements

[SOURCE: SOURCE: ISO/TS 29001:2010, 3.1.7]

3.11
design verification
process of examining the result of a given design or development activity to determine conformity with specified requirements

[SOURCE: SOURCE: ISO/TS 29001:2010, 3.1.8]

3.12
disconnect load
load at which a completion accessory is designed to disconnect

3.13
drift diameter
minimum ID of a completion accessory, expressed as the OD of the drift bar utilized during assembly inspection, as outlined in 7.4.11

3.14
down-hole well test tools
down-hole tools temporarily set in place for the purpose of evaluating the production potential of the chosen formation

3.15
down-hole artificial lift equipment
equipment integral to the conduit that provides additional energy to the production fluids

3.16
end connection
thread or other mechanism connecting the completion accessory to the conduit

3.17
expansion [travel] joint
completion accessory that facilitates tubing movement

3.18
exposed component
flow-wetted component, internally wetted component, and/or component contacted by well fluid in the annulus

3.19
fill valve
completion accessory with provision to open and/or close a port in the tubing to allow passage of fluids between the ID of the tubing and the annulus, or vice versa

3.20
flow coupling
completion accessory with anti-erosion provision on the ID

3.21
flow-wetted component
component that comes in direct contact with the dynamic movement of well fluids in the flow stream

3.22
free-passage
passing a tool or component over or through another tool or component with un-restricted movement

3.23
gauge OD
maximum specified product OD

3.24
gauge mandrel
completion accessory with provision to attach permanent monitoring devices

3.25
grade
category or rank given to different requirements for quality or design validation

3.26
heat traceable
traceable back to a unique heat and heat treatment of material

3.27
inflow control device
device incorporated into a sand control screen that regulates the flow into the production conduit

3.28
internally wetted component
flow-wetted component and any component out of the flow stream, but contacted by well fluids through a port or other passage to the flow-wetted area

3.29
job lot
batch of material or components that have undergone the same process or series of processes

3.30
job lot traceable
the ability for parts to be identified as originating from a job lot which identifies the included heat(s)

3.31
liner
pipe not extending from the surface and intended to line the walls of a drilled well

3.32
liner [tubing] hanger
mechanical device used for transferring the load of an inner liner [tubing] to the casing below the wellhead

3.33
locator
completion accessory with provision to disconnect or reconnect the tubing to a designed receptacle

3.34
mandrel
component, or components, of a completion accessory that contains the end connections and provides a conduit through the completion accessory

3.35
manufacturing
process and actions performed by an equipment supplier/manufacturer that are necessary to provide finished component(s), assembly(ies), and related documentation, that fulfills the requests of the user/purchaser, and meet the standards of the supplier/manufacturer

Note 1 to entry: Manufacturing begins when the supplier/manufacturer receives the order, and is completed at the moment the component(s), assemblies, and related documentation are surrendered to a transportation provider.

3.36
mill-out extension
completion accessory used below a packer to facilitate removal by milling

3.37
non-conformance
non-fulfillment of a specified requirement

3.38
non-sealing space out joint
completion accessory with provision to accommodate tubing movement used to adjust tubing lengths but without provision to hold pressure

3.39
number of disconnects [reconnects]
number of times a completion accessory can be disconnected [reconnected] and perform its intended function

3.40
number of strokes
maximum number of times a completion accessory can be moved through its stroke length and perform its intended function

3.41
on-off tool
completion accessory with provision to disconnect or reconnect the tubing

3.42
open/close cycle
opening then closing a port

3.43
packer
mechanical device with a packing element, not installed in a designed receptacle, used for blocking fluid (liquid or gas) communication through the annular space between conduits by sealing off the space between them

3.44
perforated sub
completion accessory that contains flow ports for the passage of fluids from the ID of the tubing to the annulus, or vice versa

3.45
performance envelope
graph that illustrates the combined ratings of differential pressure and axial loads

3.46
polished bore receptacle
completion accessory with designed receptacle used to disconnect or reconnect the tubing by accepting a locator, seal assembly, or similar device

3.47
port flow area
area for the passage of fluids from the ID of the tubing to the annulus, or vice versa

3.48
pressure reversal
change in the pressure differential from internal to external of the product, or vice versa

3.49
qualified person
individual with documented abilities gained through training or experience or both as measured against established requirements, such as standards or tests that enable the individual to perform a required function effectively

3.50
reconnect temperature
temperature at which the completion accessory can be reconnected and performs its intended function

3.51
redress
replacement of components on a completion accessory

3.52
repair
redress and/or re-manufacture of the completion accessory to restore it to the original functionality

3.53
seal assembly
completion accessory that seals in a designed receptacle

3.54
sealing device
device providing a barrier to the passage of liquid and/or gas across the interface between two components

3.55
sealbore extension
completion accessory with designed receptacle used to disconnect or reconnect the tubing by accepting a locator, seal assembly, or similar device

3.56
shear device
component designed to disconnect one time at a predetermined load

3.57
shear-out safety joint
completion accessory with provision to disconnect the tubing at a pre-determined load through use of a shear device

3.58
sliding sleeve
completion accessory that is activated to open or close communication between the tubing and casing annulus by moving a sleeve

3.59
sour service
completion accessories whose Type 1 components are manufactured from materials that comply with ISO 15156 (all parts)

3.60
standard service
completion accessories whose components may or may not be manufactured from materials that comply with ISO 15156 (all parts)

3.61
stroke
movement from one end of the stroke length to the other end

3.62
stroke distance
cumulative distance determined by the number of rated strokes multiplied by the stroke length

3.63
stroke length
distance between the fully collapsed position and fully expanded position for a completion accessory with provision to accommodate tubing movement

3.64
substantive design change
change to the design, identified by the supplier/manufacturer, that may affect the performance of the product in the intended service condition

3.65
surface controlled down-hole choke
down-hole device used to restrict flow rates through its ID, not intended to seal as a barrier controlled without thru-tubing intervention

3.66
surface controlled sliding sleeve
tubing mounted device that is activated to open or close communication between the tubing and casing annulus by moving a sleeve without thru-tubing intervention

3.67
telescoping swivel sub
completion accessory with provision to rotate and accommodate tubing movement

3.68
temperature cycle range
temperature fluctuation within which the product is designed to operate

Note 1 to entry: The temperature cycle range is applicable anywhere within the product's temperature range.

3.69
temperature range
specified range of temperature at which the product is designed to operate

3.70
tubing
pipe placed within a well to serve as a production or injection conduit

3.71
tubing adapter
completion accessory that connects two different end connections

3.72
tubing seal receptacle
completion accessory with designed receptacle used to disconnect or reconnect the tubing by accepting a locator, seal assembly, or similar device

3.73
tubing size
nominal tubing OD as specified in ISO 11960

3.74
Type 1 component
⟨weld⟩ component that isolates pressure and/or may be loaded in tension as the result of axial loads on the completion accessory during run-in, activation, *in-situ*, or retrieval

3.75
Type 2 component
⟨weld⟩ component that does not meet the criteria of a Type 1 component

3.76
unloader sub
completion accessory with provision to open and/or close a port in the tubing to allow passage of fluids between the ID of the tubing and the annulus, or vice versa

3.77
unloading pressure
maximum differential pressure across a completion accessory at the time of disconnect, or port opening, at which the completion accessory can perform its intended function

3.78
wireline entry guide
completion accessory used at the end of tubing to facilitate re-entry into the tubing

3.79
y-block
completion accessory that connects one tubing string from above to two tubing strings below, or vice versa

4 Symbols and abbreviated terms

AQL	Acceptance quality limit
COC	Certificate of compliance
ID	Inside diameter
MTR	Material test report
NDE	Non-destructive examination
OD	Outside diameter
QC	Quality control

5 Functional specification

5.1 General

The user/purchaser shall prepare a functional specification to order products which conform with this International Standard and specify the following requirements and operating conditions, as applicable, and/or identify the supplier's/manufacturer's specific product. These requirements and operating conditions may be conveyed by means of a dimensional drawing, data sheet or other suitable documentation.

5.2 Functional type description

The user/purchaser shall specify, as applicable, the following functional type based on the products primary function. Secondary functions and their interactions with the primary functions shall also be identified in detail as required by the operational needs:

- Non-pressure containing, such as:
  - non-sealing space out joint (3.38);
  - perforated sub (3.44);
  - wireline entry guide (3.78).
- Pressure containing, such as:
  - blast joint (3.3);
  - chemical injection mandrel (3.5);
  - cross-over (3.9) or tubing adapter (3.71);
  - flow coupling (3.20);
  - gauge mandrel (3.24);
  - mill-out extension (3.36);
  - sealbore extension (3.55);
  - y-block (3.79).
- Disconnect or reconnect, such as:
  - anchor (3.1);

- locator (3.33);
- on-off tool (3.41);
- polished bore receptacle (3.46);
- seal assembly (3.53);
- shear-out safety joint (3.57);
- tubing seal receptacle (3.72).

— Tubing movement, such as:

- expansion joint (3.17);
- telescoping swivel sub (3.67);
- travel joint (3.17).

— Open a port in the conduit; such as:

- fill valve (3.19);
- sliding sleeve (3.58);
- unloader sub (3.76).

NOTE This is a representative sample of completion accessories and is not meant to be all inclusive of products covered in this International Standard. Completion accessories may have multiple functionalities, they have been listed here only as examples of products that have the listed functionality.

5.3 Well parameters

The user/purchaser shall specify, as applicable, the following well parameters:

— dimensions, material, grade of the casing and tubing;

— end connections;

— well angle from the vertical;

— deviations and restrictions product must pass through;

— configuration of tubing (single or multiple strings) and other lines (electrical/hydraulic) that must pass through or by-pass the completion accessory;

— relationship of the completion accessory with other well devices/tubing/casing by means of a well schematic drawing, if applicable;

— expected minimum and maximum values of production/injection pressures, pressure differentials, temperatures, changes in temperatures, and flow rates;

— any other relevant well parameter(s).

5.4 Operational parameters

The user/purchaser shall specify, as applicable, any of the following operational parameters:

— installation method, including conveyance method;

— activation method and number of times activated or manipulated;

— setting depth;

— retrieving method;

— anticipated loading conditions, including combined loading (pressure, tension/compression) and torque, applied to the completion accessory prior to and during activation, during use, and during retrieving;

— expected activation temperature and anticipated temperature cycle during well operations and completion processes;

— size, type and configuration of devices to be run through or over the completion accessory;

— any other relevant operational parameters.

5.5 Environmental compatibility

5.5.1 General

If the user/purchaser has access to the corrosion property data of the operating environment based on historical data and/or research, they shall state to the manufacturer which material(s) has the ability to perform as required within the corrosion environment per the requirements of 5.5.3 as applicable. Otherwise, material compatibility shall be specified according to 5.5.2.

5.5.2 Well environment

The user/purchaser shall identify the density, chemical/physical composition, and the condition of the fluid and/or its components, including solid (sand production, scale, etc.), liquid and/or gaseous, to which the completion accessory is exposed during its expected life cycle.

5.5.3 Material designation

If the user/purchaser chooses to specify materials, the following designations may be used:

— standard service (3.60);

— sour service (3.59).

Material selection may be made for a group of components using the following designations:

— flow-wetted components (3.21);

— internally wetted components (3.28);

— exposed components (3.18);

— any other components.

5.6 Compatibility with related well equipment

The user/purchaser shall identify, as applicable, the following:

— top and bottom tubular connection(s), the material and dimensions of the connections to the conduit(s);

— internal receptacle profile(s), bore dimensions(s), outside diameter, inside diameter and the respective locations;

— size, type and configuration of other products and conduits to be used in connection with this product.

5.7 Design validation

The user/purchaser shall specify the required design validation grade. This International Standard provides seven design validation grades (V6 to V0), as defined in 6.5 and the annexes. The selected design validation grade applies to all applicable validation testing per Annex A through Annex D.

5.8 Quality control

The user/purchaser shall specify the required quality grade. This International Standard provides three grades (Q3, Q2 and Q1) of quality control, as defined in 7.4.

6 Technical specification

6.1 General

The supplier/manufacturer shall prepare a technical specification which conforms to the requirements defined in the functional specification. If the technical specification does not fully meet the functional requirements, the supplier/manufacturer shall identify the differences to the user/purchaser. The supplier/manufacturer shall also provide to the user/purchaser the product data sheet defined in 7.2.3.

6.2 Technical characteristics

The following criteria shall be met:

— the product shall perform in accordance with the functional specification during installation, activation, operation, and retrieval;

— where applicable, the product shall not compromise well intervention operations.

6.3 Design requirements

6.3.1 General

Products conforming to this International Standard shall be manufactured to drawings and specifications that are substantially the same as those of the same size, type, and model of product that was validated.

6.3.2 Design documentation

Design of products manufactured to this International Standard shall include documentation of those designs. This documentation shall include, as applicable design requirements, assumptions, analysis methods, comparison with previous designs or operating history of similar products, calculations, manufacturing drawings and specifications, design reviews and/or, physical testing results (such as design validation testing). The supplier/manufacturer shall identify each component as either a Type 1 (3.74) or Type 2 (3.75).

6.3.3 Materials

6.3.3.1 General

Materials (both metallic and non-metallic), and/or the service, shall be stated by the supplier/manufacturer and shall be suitable for the class of service and the environment specified in the functional specification. The manufacturer shall have documented specifications for all materials and all materials used shall comply with the manufacturer's documented specifications.

The user/purchaser may specify materials for the specific use and corrosion environment in the functional specification. Should the manufacturer propose to use another material, the manufacturer shall state that this material has performance characteristics suitable for all parameters specified in the well and production/ injection parameters.

Material substitutions from those materials used in the validation tested completion accessory products are allowed without validation testing as long as they meet the requirements of 6.6 and 6.7. The manufacturer's selection criteria for these substitutions shall be documented and the substituted material shall conform to the design, functional and technical requirements of this International Standard.

Material substitutions require approval by a qualified person and the supporting documentation incorporated into the design file.

6.3.3.2 Metals

6.3.3.2.1 Specifications

The manufacturer's specifications shall define:

a) chemical-composition limits;

b) heat treatment conditions;

c) mechanical-property limits:

   1) tensile strength;

   2) yield strength;

   3) elongation;

   4) hardness.

6.3.3.2.2 Mechanical property verification

When required by the quality grade, the mechanical properties for Type 1 metal components shall be verified by tests conducted on a material sample produced from the same heat of material. The material sample shall experience the same heat treatment process as the component it qualifies. Material subsequently heat-treated from the same heat of material shall be hardness-tested after processing to confirm compliance with the hardness requirements of the manufacturer's specifications. The hardness results shall verify through documented correlation that the mechanical properties of the material tested meet the properties specified. The heat treatment process parameters shall be defined in a heat treatment procedure. Hardness testing is the only mechanical-property test required after stress relieving. Material test reports provided by the material supplier or the manufacturer are acceptable documentation when validated.

6.3.3.3 Non-metals

The manufacturer's documented specifications for non-metallic compounds shall include handling, storage and labelling requirements, including the cure date, batch number, compound identification and shelf life appropriate to each compound and shall define those characteristics critical to the performance of the material, such as:

a) compound type;

b) mechanical properties, as a minimum:

   1) tensile strength (at break);

   2) elongation (at break);

   3) tensile modulus (at 50 % or 100 %, as applicable).

c) compression set;

d) durometer hardness.

6.3.4 Performance rating

The supplier/manufacturer shall state the performance ratings for the following: pressure, temperature, axial loads, disconnect, reconnect, tubing movement, as applicable for the products. For completion accessories validated to grades V4 through V0, a rated performance envelope is also required.

An example envelope is illustrated in Figure 1. The area within the boundaries defines the rated performance envelope. The lines forming the boundary of the envelope are defined as the maximum operational limits for the products. Metal mechanical properties within the temperature range shall be considered when determining performance ratings.

Rated performance envelopes shall meet the following criteria.

— The rated performance envelope shall represent the supplier's/manufacturer's maximum ratings.

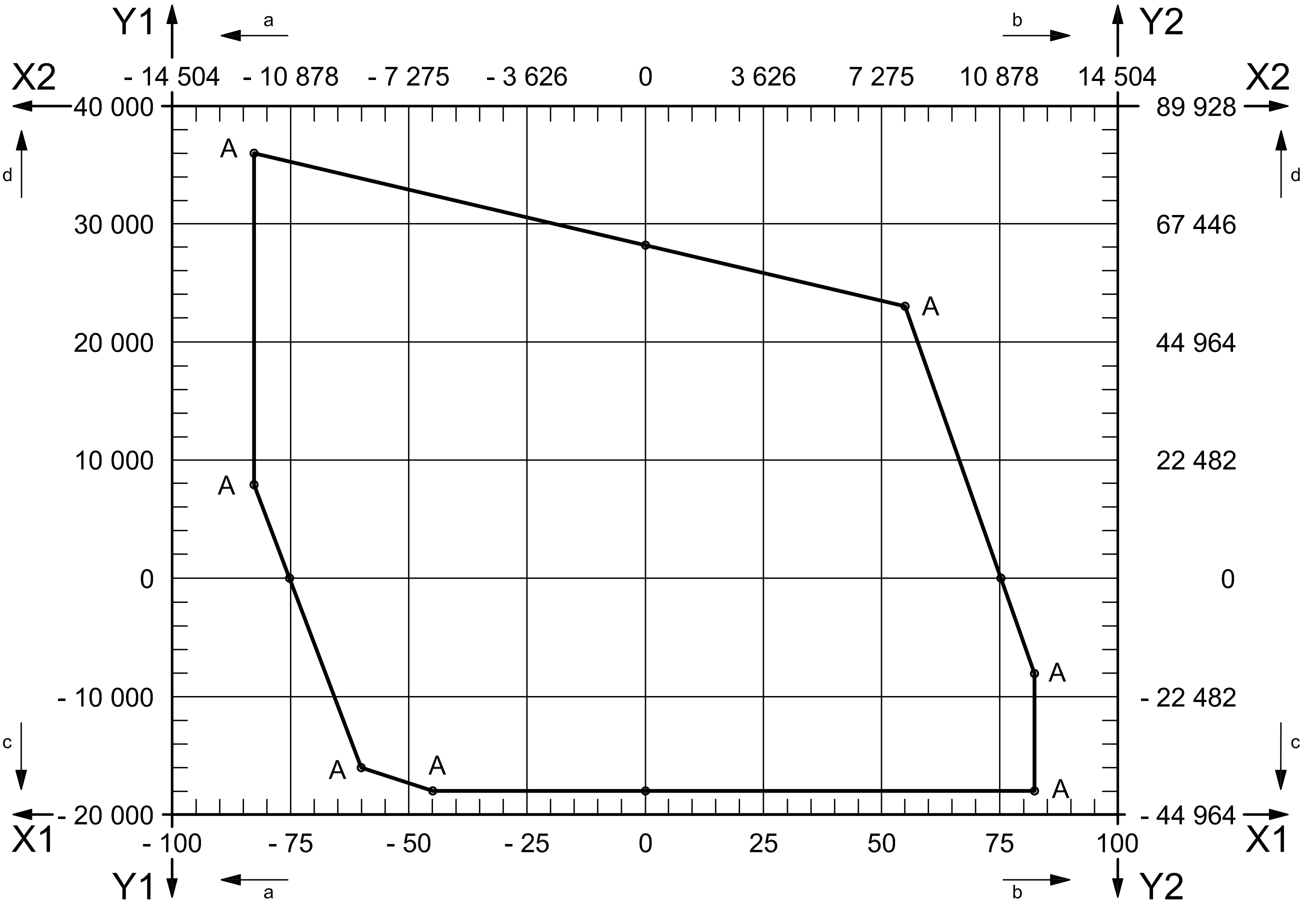
— Products with IDs shall be represented with the ID not plugged unless specified with the envelope.

— The ratings of the end connections shall not be included.

— Axis and sign convention shall be oriented as shown in Figure 1.

— More than one graph may be displayed with the envelope if a legend is included for explanation. For example, various shear device options can be displayed, as shown in Figure 2.

— The product(s) covered by the envelope shall be specified with the envelope. If the envelope covers two or more products that are used together down-hole, then this shall be stated on the envelope.

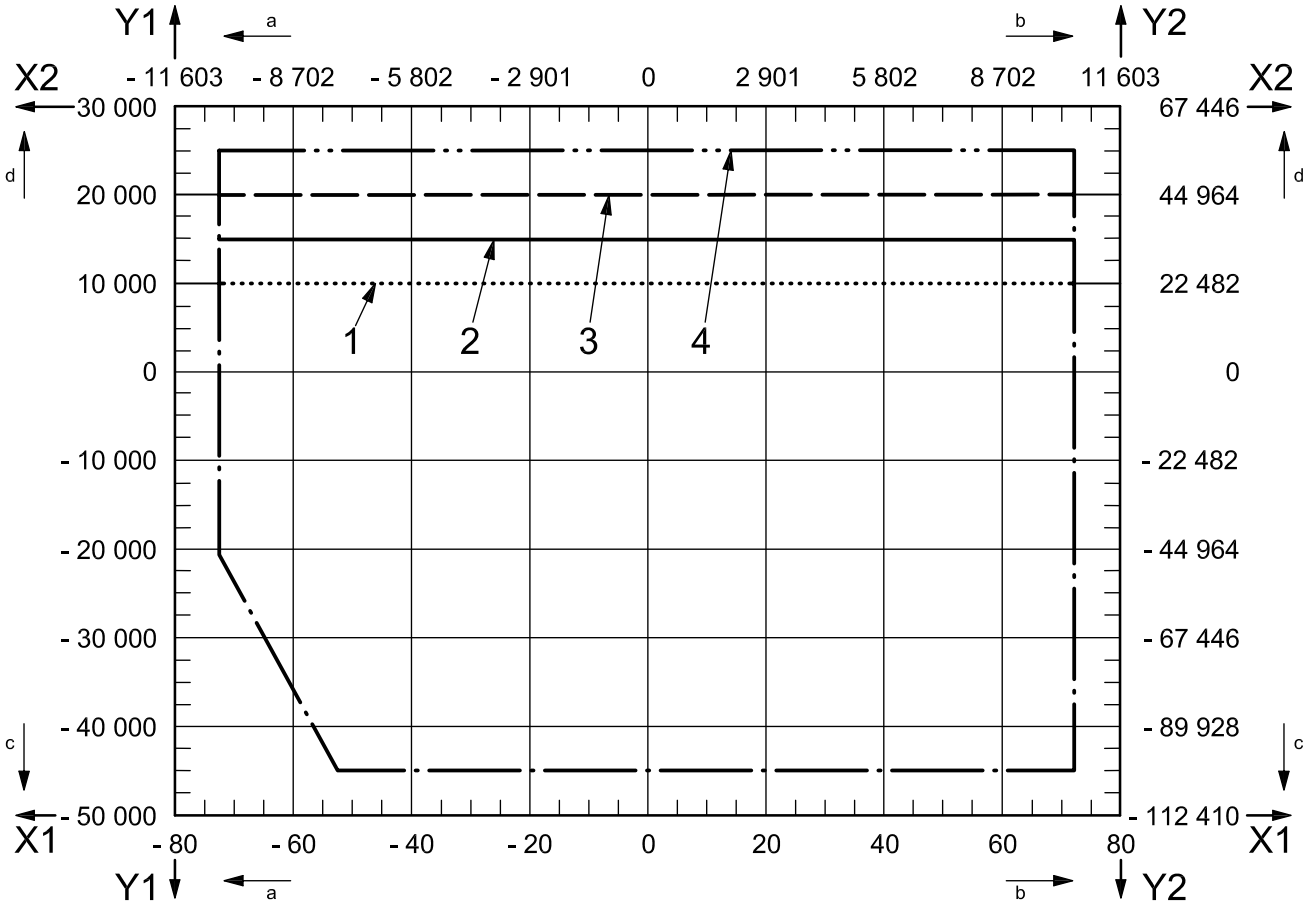


Key

X1	pressure, expressed in megapascals	a	External.
X2	pressure, expressed in pounds per square inch	b	Internal.
Y1	force, expressed in decanewtons	c	Compression.
Y2	force, expressed in pounds	d	Tensile.

NOTE Points labelled “A” are intersection points of two or more operational limits.

Figure 1 — Example of a rated performance envelope



Key

X1	pressure, expressed in megapascals	3	envelope for 20 000 daN (44 964 lb) shear ring
X2	pressure, expressed in pounds per square inch	4	envelope for 25 000 daN (56 205 lb) shear ring
Y1	force, expressed in decanewtons	a	External.
Y2	force, expressed in pounds	b	Internal.
1	envelope for 10 000 daN (22 482 lb) shear ring	c	Compression.
2	envelope for 15 000 daN (33 723 lb) shear ring	d	Tensile.

Figure 2 — Example of shear device options

6.4 Design verification

Design verification shall be performed to ensure that each completion accessory design meets the supplier's/manufacturer's technical specifications including all operational, contingency, and all rated functionalities. Design verification includes activities such as design reviews, design calculations, comparison with similar designs and historical records of defined operating conditions. Verification results shall be approved by a qualified person and records of the results shall become a portion of the design documentation.

6.5 Design validation

6.5.1 General

This International Standard specifies 7 grades of design validation. Each product design shall be validated to the grade selected by the user/purchaser. Products shall be supplied to at least the design

validation grade specified. In the event a validation grade is not selected by the user/purchaser, grade V6 shall apply.

The validation grades are summarized in Table 1 and validation grade specifics are defined in Annexes A through D. The supplier/manufacturer shall meet the validation test requirements of Annex A to the selected validation grade. Completion accessories rated for other functionalities listed in Table 1 shall meet the additional validation test requirements of the appropriate annex (B through D) to the same validation grade as the Annex A testing.

The supplier/manufacturer shall document the validation test procedure and results and shall have on file material specifications and drawings that show all the applicable dimensions and tolerances of parts contained in the validation tested product. Pre-test and post-test dimensional inspection of critical operational areas as determined by the supplier/manufacturer shall be conducted, documented, and maintained by the supplier/manufacturer. Validation test results and dimensional test results shall be approved by a qualified person other than the person performing them and records of the results shall become a portion of the design documentation. Evaluation and justification for any dimensions that changed from pre-test inspection shall be documented as part of the acceptance and become part of the design file.

NOTE The levels of design validation are consistent with the requirements in the corresponding design validation grades specified in ISO 14310.

Table 1 — Summary of design validation grades

Validation Grade	Annex A: Validation test requirements	Annex B: Validation test requirements for disconnect/reconnect functionality	Annex C: Validation test requirements for tubing movement functionality	Annex D: Validation test requirements for opening a port functionality
V6	Supplier/ manufacturer-defined	Supplier/ manufacturer-defined	Supplier/ manufacturer-defined	Supplier/ manufacturer-defined
V5	Liquid test or axial load test	Single disconnect/ reconnect plus liquid test	Single stroke plus liquid test	Single open/close plus liquid test
V4	Liquid test plus axial loads	Single disconnect/ reconnect plus liquid test	Single stroke with pressure plus liquid test	Single open/close plus liquid test
V3	Liquid test plus axial loads plus temperature cycling	Multiple disconnect/ reconnects plus liquid test	Multiple strokes with pressure plus liquid test	Multiple open/close plus liquid test
V2	Gas test plus axial loads	Multiple disconnect/ reconnects plus gas test	Multiple strokes with pressure plus gas test	Multiple open/close plus gas test
V1	Gas test plus axial loads plus temperature cycling	Multiple disconnect/ reconnects plus gas test	Multiple strokes with pressure plus gas test	Multiple open/close plus gas test
V0	Gas test plus axial loads plus temperature cycling plus zero bubble acceptance criterion	Multiple disconnect/ reconnects plus gas test plus zero bubble acceptance criterion	Multiple strokes with pressure plus gas test plus zero bubble acceptance criterion	Multiple open/close plus gas test plus zero bubble acceptance criterion

Products qualified to higher grades of design validation may be considered qualified for lower grades of design validation in accordance with Table 2.

Table 2 — Design validation grade hierarchy

Design validation grade	Grades covered
V0	V0, V1, V2, V3, V4, V5 and V6
V1	V1, V2, V3, V4, V5 and V6
V2	V2, V4, V5 and V6
V3	V3, V4, V5 and V6
V4	V4, V5 and V6
V5	V5 and V6
V6	V6

6.5.2 Validation test requirements

6.5.2.1 General

The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to the validation grade. Test data shall identify the leak rate, if applicable, for the duration of the subject test. If no leakage occurred, this shall be clearly stated.

6.5.2.2 Validation requirements for functionalities not addressed in Table 1

Functionalities not addressed in Table 1 shall be validated by test to their rated limits or fully evaluated to documented procedures including acceptance criteria and be approved by a qualified person(s). The procedures and results shall be incorporated into the design file.

6.6 Design changes

All design changes shall be documented and reviewed against the design verification and design validation to determine if the change is a substantive design change (see 3.64). A design that undergoes a substantive change becomes a new design requiring design verification as specified in 6.4 and design validation as specified in 6.5. Design changes identified as non-substantive shall include documented justification.

The supplier/manufacturer shall, as a minimum, consider the following:

— stress levels of the modified or changed components;

— material changes;

— functional changes.

Changes to a component or series of components may be identified as a substantive change and require design validation. This may be done by testing only the component or series of components, rather than the entire assembly. The test shall adequately simulate the loading conditions that would be present if the entire assembly were tested. The supplier/manufacturer shall document the detailed test results and analysis that demonstrate that the component test adequately simulates the required loading conditions. Evaluation results shall be approved by qualified person other than the person performing them and records of the results shall become a portion of the design documentation.

6.7 Design validation scaling

6.7.1 General

Products within the same product family, where there have been designs previously validated to grades V5 through V0 (see 6.5), can be validated by scaling within the same tubing size in accordance with the

requirements and limitations of 6.7.2 and 6.7.3. The product validated by scaling shall carry the same validation grade as the tested product.

6.7.2 Product family for scaling

A product family is a group of assemblies that meets the following design requirements:

— configuration: the design principles for the geometry, materials and functionality are the same;

— design stress levels: the design stress levels in relation to material mechanical properties are based on the same acceptance criteria.

6.7.3 Limitations of scaling

Limitations of scaling are defined in A.9, B.9, C.9, and D.9 for each of the rated functionalities shown in Table 1.

7 Supplier/manufacturer requirements

7.1 General

This clause contains the detailed requirements to verify that each product manufactured meets the requirements of the functional and technical specifications. These include requirements for documentation and data control, product identification, quality control, functional testing, repair, redress, shipping, and storage.

7.2 Documentation and data control

7.2.1 General

The supplier/manufacturer shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this International Standard. These documents and data shall be maintained to demonstrate conformance to specified requirements. All documents and data shall be legible and shall be stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. Documents and data may be in any form of type of media, such as hard copy or electronic media. All documents and data shall be available and auditable by the user/purchaser.

All documentation and data associated with design verification (see 6.4), design validation (see 6.5), design change justification (see 6.6), and the design file, shall be maintained for 10 years after date of last manufacture.

Quality documentation includes all documents and data necessary to demonstrate conformance to 7.4.1 through 7.4.15. Quality documentation shall be retained by the supplier/manufacturer for a minimum of five years from date of manufacture. These shall be available and auditable by the user/purchaser.

7.2.2 Operating manual

An operating manual shall be available for all assemblies supplied in accordance with this International Standard.

Operating manuals shall contain at least the following information:

— manual reference number;

— operational procedures and related tools;

— pre-installation inspection procedures;

— representative drawing showing major dimensions (ODs, IDs, and lengths);

— requirements for handling, shipment, and storage.

— requirements for redress and repair

7.2.3 Product data sheet

Product data sheets shall be supplied at delivery to the user/purchaser, as required in 6.1, and shall contain the following information, where applicable:

— name and address of supplier/manufacturer;

— manufacturer product number;

— manufacturer product name;

— service;

— metallic materials;

— non-metallic materials;

— drift diameter;

— gauge OD;

— overall length;

— temperature range;

— temperature cycle range;

— disconnect ratings;

  — disconnect unloading pressure;

  — number of disconnects;

  — disconnect load;

— reconnect ratings;

  — reconnect temperature;

  — number of reconnects;

— tubing movement ratings;

  — stroke length (3.63);

  — number of strokes (3.40);

  — stroke distance (3.62);

— ratings for opening a port in the conduit;

  — unloading pressure;

  — number of open/close cycles;

  — port flow area;

  — shifting force;

  — shifting direction to open/close:

  - shifting tools type and size;
- landing nipple profile and size;
- rated performance envelope for V4 through V0;
- shear device min and max values;
- internal and external differential pressure ratings or tension and compression ratings for V6 and V5;
- top connection(s);
- bottom connection(s);
- casing or tubing range, size and mass and/or minimum and maximum casing or tubing IDs;
- maximum conveyance OD, inclusive of running/repositioning equipment;
- conveyance and retrieval, tools;
- any other rated functionalities (6.5.2.2)
- quality grade;
- design validation grade;
- operating manual reference number.

7.3 Product identification

Each product furnished to this International Standard shall be permanently identified according to the supplier/manufacturer's specifications. The manufacturer's specifications shall define the type, method of application and location of the identifications. The following information shall be included as a minimum:

- manufacturer identification;
- manufacturer product number;
- date of manufacture (mm/yy);
- quality grade;
- design validation grade;
- for quality grade Q1, a unique serial and traceability number.

7.4 Quality requirements

7.4.1 General

This International Standard defines three quality grades, Q1, Q2 and Q3. Products shall be supplied to at least the quality grade specified. When no quality grade is selected by the user/purchaser a minimum of Q3 shall be supplied. Quality requirements are detailed in 7.4.2 through 7.4.15 and summarized in Table 3.

Table 3 — Summary of quality requirements

Item	Quality grade[a]		
	Q3	Q2	Q1
Metallic material	COC or MTR	COC or MTR	Verify MTR for Type 1 components COC or MTR for Type 2 components
Non-metallic material	COC or MTR	COC or MTR	COC or MTR
Castings	COC	COC	COC
Heat treatment	COC (subcontractor) Job lot verification (supplier/manufacturer)	COC (subcontractor) Job lot verification (supplier/manufacturer)	COC (subcontractor) Job lot verification (supplier/manufacturer) Heat treat certificate for Type 1 components
Component traceability	Job lot traceable for Type 1 components	Job lot traceable for Type 1 components	Heat traceable for Type 1 components
Component dimensions	Sampling plan	Sampling plan	100 % for Type 1 components
Welding			
Type 1 welds	Visual	Surface NDE per sampling plan and visual	Surface NDE 100 % and visual
Type 2 welds	Visual	Visual	Visual
Hardness			
Type 1 components	None	Sampling plan	100 %
Type 2 components	None	None	None
Component NDE			
Type 1 components	None	Surface NDE per sampling plan	Surface NDE 100 %
Type 2 components	None	None	Visual
Shear devices	Shear verification	Shear verification	Shear verification
Assembly verification	None	Internal pressure test ID drift	Internal pressure test ID drift OD dimensional Torque documentation Opening/closing force[b]
Assembly traceability	None	None	Assembly serialization
QC documentation	Supplier/manufacturer retained	Supplier/manufacturer retained	Supplier/manufacturer retained

[a] "None" indicates there are no requirements listed in 7.4.2 through 7.4.15.

[b] only applicable to items which are validated according to Annex D

7.4.2 Material

7.4.2.1 General

Material, metallic or non-metallic, used in the manufacture of components shall meet one of the following requirements:

— a COC to the manufacturer stating that the material meets the supplier's/manufacturer's documented specifications; or

— a MTR to the manufacturer so that the supplier/manufacturer can verify that the material meets the supplier's/manufacturer's documented specifications.

For products supplied to quality grade Q1, the supplier/manufacturer shall verify through testing that the chemical/mechanical properties of metallic materials meet the manufacturer's specifications for Type 1 components. Chemical/mechanical property determination shall be in accordance with a national or international standard.

7.4.3 Castings

The casting subcontractor or supplier shall provide a COC to the supplier/manufacturer stating that the casting meets the supplier/manufacturer's documented specifications.

7.4.4 Heat treatment

7.4.4.1 General

Heat treatment of components or raw material shall meet the following requirements.

— Heat treating shall be performed with heat-treating equipment that has been calibrated and surveyed.

— If heat treatment is performed by a subcontractor, the subcontractor shall provide a COC to the manufacturer stating that the heat treatment meets the supplier's/manufacturer's documented specifications.

— If heat treatment is performed by the supplier/manufacturer, heat treatment shall comply with the supplier's/manufacturer's documented specifications.

— For Type 1 components, a heat treatment certificate showing actual times and temperatures is required for Q1.

7.4.4.2 Heat-treating equipment qualification

7.4.4.2.1 Furnace calibration

Furnace calibration shall meet the following requirements.

— Each furnace shall be surveyed within one year prior to heat-treating operations. When a furnace is repaired or rebuilt, a new survey shall be required before heat treating.

— Batch type and continuous type heat-treating furnaces shall be calibrated in accordance with one of the following procedures:

  — procedures specified in an international or national standard such as SAE AMS-H-6875A;

  — procedures specified in an international or national standard such as BS 2M 54;

  — supplier's/manufacturer's documented specifications, including acceptance criteria which are not less stringent than the procedures identified above.

7.4.4.2.2 Instrumentation

Instrumentation shall meet the following requirements.

— Automatic controlling and recording instruments shall be used.

— Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres.

— The controlling and recording instruments used for the heat treatment processes shall possess an accuracy of ± 1 % of their full scale range.

— Temperature controlling and recording instruments shall be calibrated at least once every three months until a documented calibration history can be established. Calibration intervals shall then be established based on repeatability, degree of usage and documented calibration history.

— Equipment used to calibrate the production equipment shall possess an accuracy of ± 0,25 % of full scale range.

7.4.5 Component traceability

Component traceability shall meet the following requirements.

— Type 1 components shall be job lot traceable for Q2 and Q3.

— Type 1 components shall be heat traceable for Q1.

— Components that are castings, or are manufactured from castings, shall be excluded from traceability for grade Q3 and grade Q2.

7.4.6 Component dimensional inspection

Component dimensional inspection shall be performed and shall meet the following requirements.

— Thread tolerances, inspection requirements, gauges, gauging practice, gauge calibration and certification for connections shall conform to the documented thread specifications for all quality grades.

— Dimensional tolerances of O-rings shall be in accordance with ISO 3601-1 or equivalent. Other non-metallic seals shall meet dimensional tolerances of the supplier/manufacturer's documented specifications.

— All Type 2 and Type 1 components for Q2 and Q3 shall be dimensionally inspected per a sampling plan that meets the requirements of an international or national standard such as ISO 2859-1 or ANSI/ASQC Z1.4.

— Type 1 components shall be 100 % dimensionally inspected for Q1.

7.4.7 Welds

Welds shall meet the following requirements.

— Type 1 welds (3.74) shall meet the requirements of an international or national standard such as ASME Boiler and Pressure Vessel Code, Section IX.

— Type 2 welds shall conform to the supplier/manufacturer's documented requirements.

— Each welded component shall be stress-relieved in conformance with the manufacturer's documented specifications that include acceptance criteria.

7.4.8 Hardness inspection of components

Hardness inspection of components shall meet the following requirements.

— Type 1 components for Q2 shall be hardness inspected per a sampling plan that meets the requirements of an international or national standard such as ISO 2859-1 or ANSI/ASQC Z1.4.

— 100 % of Type 1 components for Q1 shall be hardness inspected.

— Type 2 components do not require hardness inspection.

— Hardness inspection of metallic components shall meet the requirements of an international or national standard such as ISO 6506-1, ISO 6507-1 or ISO 6508-1.

— The durometer hardness of O-rings or other elastomeric packing elements shall be determined in accordance with an international or national standard such as ASTM D 2240 or ASTM D 1415. A test specimen manufactured from each batch may be used.

— Hardness testing of non-metallic and non-elastomeric components shall conform to the supplier/manufacturers documented specifications

7.4.9 NDE of components/welds

NDE of components and welds shall meet the following requirements.

— Welds shall be visually inspected per the requirements of an international or national standard such as ASME Boiler and Pressure Vessel Code, Section V, Article 9.

— NDE for non-metallic components shall be visual inspection per supplier/manufacturer's documented specifications.

— NDE for metallic components shall be magnetic particle inspection or liquid penetrant inspection for Q2 and Q1.

— Sampling procedures, and the criteria for acceptance or rejection of a batch lot, shall be in accordance with ISO 2859-1, General Inspection Level II at a 2,5 AQL for O-Rings and a 1,5 AQL for other non-metallic seals until a documented variation history can be established. Sampling procedures shall also conform to supplier/manufacturing documented criteria that is established based on the documented variation history.

— Visual inspection of O-rings shall be in accordance with ISO 3601-3 or equivalent.

— Visual inspection of components other than O-rings shall be in accordance with the supplier/manufacturer's documented specifications.

— Magnetic particle inspection shall meet the requirements of an international or national standard such as ISO 10893-5 or ASTM E 709.

— Liquid penetrant inspection shall meet the requirements of an international or national standard such as ISO 10893-4 or ASTM E 165.

— NDE acceptance criteria shall be according to the supplier's/manufacturer's documented specifications.

— All NDE instructions shall be approved by a Level III examiner qualified in accordance with ISO 9712.

NOTE For the purposes of these provisions, ASNT SNT-TC-1A is equivalent to ISO 9712.

— Type 1 components and welds for Q2 shall be NDE inspected per a sampling plan that meets the requirements of an international or national standard such as ISO 2859-1 or ANSI/ASQC Z1.4.

— Type 1 components and welds for Q1 shall be 100 % NDE inspected using liquid penetrant or magnetic particle methods and visual inspection.

— Type 2 components for Q1 shall be visually inspected per the supplier/manufacturer's documented specifications.

— Type 2 welds and Type 1 welds for Q3 shall be visually inspected per supplier/manufacturer's documented specifications.

7.4.10 Shear device verification

At least one shear device per heat lot shall be sheared in accordance with the supplier's/manufacturer's documented procedure to verify that the shear value meets the supplier's/manufacturer's documented specification.

7.4.11 Assembly verification

Assembly verification shall meet the following requirements.

— For Q2 and Q1, a low pressure internal test shall be performed on each completion accessory by plugging the end connection(s) (3.16) and pressurizing to a minimum of 350 kPa (approximately 50 psi) using either liquid or gas as the test medium. One-piece mandrels or mandrels with only internal metal-to-metal sealing connections, or non-sealing connections/components are excluded from this requirement. Test duration and acceptance criteria shall be defined by the supplier's/manufacturer's documented procedures. Functional test data shall be recorded, dated and signed by the qualified person performing the tests.

— For Q2 and Q1, ID drift each completion accessory per the supplier/manufacturer's documented specifications. ID drift shall only apply to completion accessory IDs not designed as sealing surfaces (sealbores). Drift bar diameter shall match the rated drift diameter of the completion accessory. Drift bar length shall meet the requirements specified in ISO 11960.

— For Q1, the OD shall be inspected according to the supplier's/manufacturer's documented specifications. OD dimensional inspection shall verify that the entire OD of the assembly is less than, or equal to, the maximum specified OD.

— For Q1, actual torque values and any other thread suppliers/manufacturer's requirements for all metal-to-metal sealing connections shall be recorded and verified to be within thread supplier's/manufacturer's documented specifications. End connections are specifically excluded from this requirement.

— For Q1, completion accessories which are rated according to the validation requirements of Annex D, a functional test shall include an opening and closing operation according to the supplier's/manufacturer's documented procedure and acceptance criteria including shifting force.

7.4.12 Assembly traceability

Assembly serialization shall be used to provide traceability of all Type 1 components within each assembly for Q1 products.

7.4.13 Manufacturing non-conformance

The supplier/manufacturer shall establish and maintain documented procedures to ensure that an assembly or component that does not conform to specified requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when applicable), and disposition of non-conforming assemblies or components.

The responsibility for review and authority for the disposition of non-conforming assemblies or components shall be defined by the supplier/manufacturer. Non-conforming assemblies or components may be

— reworked to meet the specified requirements;

— accepted with or without repair by concession; or

— rejected or scrapped.

Repaired and/or reworked assemblies or components shall be inspected in accordance with the requirements of the appropriate quality grade and the documented specifications of the supplier/manufacturer which are no less stringent than those used for new products.

7.4.14 Calibration systems

The supplier/manufacturer shall establish and implement specifications for all quality processes used on products conforming to this International Standard. These specifications shall include the procedures, inspection methods and acceptance criteria and shall be approved by a qualified person(s). Inspection, measuring and testing equipment used for acceptance shall be used only within its calibrated range and shall be identified, controlled, calibrated and adjusted at specific intervals in accordance with the manufacturer's procedures that are based on an internationally recognized standard, such as ISO/IEC 17025 or ANSI/NCSL Z540-3. Technologies for inspections with verifiable accuracies equal to or better than those listed in this International Standard may be applied with appropriate documentation and when approved by a qualified person(s). Calibration intervals for measuring and testing equipment shall be established based on repeatability and degree of usage. Calibration intervals shall be a maximum of three months until a recorded calibration history can be established. Intervals may then be lengthened or shortened based on documented repeatability, amount of usage and calibration history. The calibration interval cannot be increased by more than twice the previous interval, which is not to exceed one year. Calibration standards used to calibrate measuring equipment shall be checked and approved at least once every three years by an independent outside agency with traceability to the applicable recognized national or international standards agency.

7.4.15 Personnel qualifications

Personnel performing NDE shall be qualified in accordance with an international or national standard such as ISO 9712, Level 2 minimum for evaluation and interpretation.

Personnel performing visual examinations shall have an annual eye examination in accordance with an international or national standard such as ISO 9712, as applicable to the discipline to be performed.

All personnel performing inspections for acceptance shall be qualified per the supplier/manufacturer's documented specifications.

8 Redress and repair

Redress activities for completion accessories shall be defined by the supplier/manufacturers procedures. Redressed products shall be marked with an "R" after the original manufacture date to indicate that the product has been redressed.

Repair activities to completion accessories shall return the product to a condition meeting all requirements stated in this International Standard or the edition in effect at the time of original manufacture.

9 Shipment and storage

Completion accessories shall be stored per the documented specifications of the supplier/manufacturer to prevent deterioration (caused by atmospheric conditions, debris, radiation, etc.) prior to transport.

Completion accessories shall be packaged for transport per the documented specifications of the supplier/manufacturer to prevent normal handling loads and contamination from harming the equipment. These specifications shall address the protection of external sealing elements, sealing surfaces, and exposed threaded connections.

Annex A
(normative)

Validation test requirements

A.1 General

The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to the validation grade. Test data shall identify the leak rate, if applicable, for the duration of the subject test. All defined criteria shall be successfully completed to validate the design to the validation grade. If no leakage occurred, this shall be clearly stated.

A.2 Grade V6: Supplier/manufacturer-defined

The supplier/manufacturer defines the validation method and acceptance criteria.

A.3 Grade V5: Liquid test or axial load test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Products with no pressure containing capability shall be tested to maximum rated tensile or compression loading, as applicable.

— Run entire test at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa.

— Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3) and shall be visibly free from particulate matter or other material that could plug a small leak.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: no more than 1 % reduction in the maximum rated differential pressure over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer.

A.4 Grade V4: Liquid test plus axial loads

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Run entire test at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa.

— Test to all intersection points of the rated performance envelope. If the rated performance envelope is a straight line, then test to the end points that define the maximum operational limits.

NOTE Rated performance envelopes can have ratings of zero for pressure if applicable.

— Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3) and shall be visibly free from particulate matter or other material that could plug a small leak.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: no more than 1 % reduction in the maximum rated differential pressure over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer.

A.5 Grade V3: Liquid test plus axial loads plus temperature cycling

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Run entire test, except for the temperature cycle, at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa.

— Test to all intersection points of the rated performance envelope. If the rated performance envelope is a straight line, then test to the end points that define the maximum operational limits.

NOTE Rated performance envelopes can have ratings of zero for pressure if applicable.

— Test a minimum of one temperature cycle. Start temperature cycle at or above maximum rated temperature and cool down by at least the maximum rated temperature cycle range. A pressure hold is required at the low end of the temperature cycle range and after heating back up to the maximum rated temperature.

— Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3) and shall be visibly free from particulate matter or other material that could plug a small leak.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: no more than 1 % reduction in the maximum rated differential pressure over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer.

A.6 Grade V2: Gas test plus axial loads

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Run entire test, except for the temperature cycle, at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa. Test to all intersection points of the rated performance envelope. If the rated performance envelope is a straight line, then test to the end points that define the maximum operational limits.

NOTE Rated performance envelopes can have ratings of zero for pressure if applicable.

— Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: no more than 20 cm^3 of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer. The bubble rate shall not increase during the hold period. Graduated cylinders for accumulated gas shall be at atmospheric pressure.

A.7 Grade V1: Gas test plus axial loads plus temperature cycling

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Run entire test, except for the temperature cycle, at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa.

— Test to all intersection points of the rated performance envelope. If the rated performance envelope is a straight line, then test to the end points that define the maximum operational limits.

NOTE Rated performance envelopes can have ratings of zero for pressure if applicable.

— Test a minimum of one temperature cycle. Start temperature cycle at or above maximum rated temperature and cool down by at least the maximum rated temperature cycle range. A pressure hold is required at the low end of the temperature cycle range and after heating back up to the maximum rated temperature.

— Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: no more than 20 cm^3 of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer. The bubble rate shall not increase during the hold period. Graduated cylinders for accumulated gas shall be at atmospheric pressure.

A.8 Grade V0: Gas test plus axial loads plus temperature cycling plus zero bubble acceptance criterion

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products with no axial load capability, or that have axial load capability in one direction, may be restrained by the test fixture to prevent movement.

— Run entire test, except for the temperature cycle, at or above maximum rated temperature.

— Test pressure retaining capabilities at or above maximum rated differential pressure.

— Perform a minimum of two pressure reversals at or above the maximum rated pressure from internal to external or vice versa.

— Test to all intersection points of the rated performance envelope. If the rated performance envelope is a straight line, then test to the end points that define the maximum operational limits.

NOTE Rated performance envelopes can have ratings of zero for pressure if applicable.

— Test a minimum of one temperature cycle. Start temperature cycle at or above maximum rated temperature and cool down by at least the maximum rated temperature cycle range. A pressure hold is required at the low end of the temperature cycle range and after heating back up to the maximum rated temperature.

— Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Maintain a minimum hold period of 15 minutes for pressure tests.

— Acceptance criterion: zero bubbles of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. Time period for stabilization is at the discretion of the supplier/manufacturer. Graduated cylinders for accumulated gas shall be at atmospheric pressure.

A.9 Limitations of scaling for Annex A validation tests

Scaling (6.7) is allowed to qualify a product family within a given tubing size with the following limitations.

— Sealing devices of the same geometry, cross-section, and material are considered to be design-validated when the allowable variation in size is within the range of ± 5 % of the nominal ID sealing diameter of a validation tested design.

— Scaling shall not be used to cover products with higher pressure ratings, higher temperature range, larger temperature cycle range, higher axial load ratings, or larger rating envelopes than the tested product.

— Scaling shall not be used to cover products with fewer sealing devices than the tested product.

— Method of calculating the ratings for the scaled product shall be the same as the tested product.

Annex B
(normative)

Validation test requirements for disconnect/reconnect functionality

B.1 General

The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to the validation grade.

Completion accessories that are rated for the following functionalities shall meet the requirements of Annex B for the selected design validation grade:

— unloading pressure (3.77);

— number of disconnects (3.39);

— disconnect load (3.12);

— reconnect temperature (3.50);

— number of reconnects (3.39).

B.2 Grade V6: Supplier/manufacturer-defined

The supplier/manufacturer defines the validation method and acceptance criteria.

B.3 Grade V5: Single disconnect/reconnect plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when disconnecting. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Products that are rated for reconnection shall be disconnected and reconnected once per the supplier/ manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/ manufacturers documented procedure.

— Test those completion accessories having shear release features to verify their operation at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— Products that are rated for pressure holding capability after reconnecting shall be pressure tested to one pressure reversal per Annex A, V5 after the reconnect.

B.4 Grade V4: Single disconnect/reconnect plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when disconnecting. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Products that are rated for reconnection shall be disconnected and reconnected once per the supplier/ manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/ manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the rated number of reconnects, products that are rated for pressure holding capability after reconnecting shall be pressure tested to only one pressure reversal per Annex A, V4.

B.5 Grade V3: Multiple disconnect/reconnects plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for pressure unloading will be tested at the maximum rated unloading pressure when disconnecting. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Products that are rated for multiple reconnections shall be reconnected and disconnected to the maximum rated number of reconnects and per the supplier/manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/ manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the rated number of reconnects, products that are rated for pressure holding capability after reconnecting shall be pressure tested to only one pressure reversal per Annex A, V3.

B.6 Grade V2: Multiple disconnect/reconnects plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when disconnecting. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Products that are rated for multiple reconnections shall be reconnected and disconnected to the maximum rated number of reconnects and per the supplier/manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the rated number of reconnects, products that are rated for pressure holding capability after reconnecting shall be pressure tested to only one pressure reversal per Annex A, V2.

B.7 Grade V1: Multiple disconnect/reconnects plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when disconnecting. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Products that are rated for multiple reconnections shall be reconnected and disconnected to the maximum rated number of reconnects and per the supplier/manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the rated number of reconnects, products that are rated for pressure holding capability after reconnecting shall be pressure tested to only one pressure reversal per Annex A, V1.

B.8 Grade V0: Multiple disconnect/reconnects plus gas test plus zero bubble acceptance criterion

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for pressure unloading will be tested at the maximum rated unloading pressure when disconnecting. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Products that are rated for multiple reconnections shall be reconnected and disconnected to the maximum rated number of reconnects and per the supplier/manufacturers documented procedure.

— Products that are rated for one connection only shall be connected once per the supplier/manufacturers documented procedure.

— Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the rated number of reconnects, products that are rated for pressure holding capability after reconnecting shall be pressure tested to only one pressure reversal per Annex A, V0.

B.9 Limitations of scaling Annex B validation tests

Scaling (6.7) is allowed to qualify a product family within a given tubing size with the following limitations.

— Sealing devices of the same geometry, cross-section, and material are considered to be design-validated when the allowable variation in size is within the range of ± 5 % of the nominal ID sealing diameter of a validation tested design.

— Scaling shall not be used to cover products with fewer sealing devices than the tested product.

— Method of calculating the ratings for the scaled product shall be the same as the tested product.

— Scaling shall not be used to cover products with a higher shear value or disconnect load, higher temperature, higher pressure, higher disconnect unloading pressure, higher reconnect temperature, than the tested product.

— Scaling shall not be used to cover products with a higher number of reconnects than the tested product for grades V3-V0.

Annex C
(normative)

Validation test requirements for tubing movement functionality

C.1 General

The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to the validation grade.

Completion accessories that are rated for stroke length (3.63) shall meet the requirements of Annex C for the selected design validation grade.

C.2 Grade V6: Supplier/manufacturer-defined

The supplier/manufacturer defines the validation method and acceptance criteria.

C.3 Grade V5: Single stroke plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Run entire test at or above maximum rated temperature.

— Products shall be pressure tested to only one pressure reversal at each end of the stroke (3.61) per Annex A, V5.

C.4 Grade V4: Single stroke with pressure plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Product shall be stroked at a minimum of 50 % of the rated internal pressure. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Run entire test at or above maximum rated temperature.

— Products shall be pressure tested to only one pressure reversal at each end of the stroke (3.61) per Annex A, V4.

C.5 Grade V3: Multiple strokes with pressure plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Test to the maximum rated stroke distance (3.62).

— Product will be stroked at a minimum of 50 % of the rated internal pressure. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Run entire test at or above maximum rated temperature.

After the maximum rated stroke distance, products shall be pressure tested to one pressure reversal at each end of the stroke per Annex A, V3.

C.6 Grade V2: Multiple strokes with pressure plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Test to the maximum rated stroke distance (3.62).

— Product shall be stroked at a minimum of 50 % of the rated internal pressure. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Run entire test at or above maximum rated temperature.

— After the maximum rated stroke distance, products shall be pressure tested to one pressure reversal at each end of the stroke per Annex A, V2.

C.7 Grade V1: Multiple strokes with pressure plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Test to the maximum rated stroke distance (3.62).

— Product shall be stroked at a minimum of 50 % of the rated internal pressure. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Run entire test at or above maximum rated temperature.

— After the maximum rated stroke distance, products shall be pressure tested to one pressure reversal at each end of the stroke per Annex A, V1.

C.8 Grade V0: Multiple strokes with pressure plus gas test plus zero bubble acceptance criterion

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Test to the maximum rated stroke distance (3.62).

— Product shall be stroked at a minimum of 50 % of the rated internal pressure. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases.

— Run entire test at or above maximum rated temperature.

— After the maximum rated stroke distance, products shall be pressure tested to one pressure reversal at each end of the stroke per Annex A, V0.

C.9 Limitations of scaling Annex C validation tests

Scaling (6.7) is allowed to qualify a product family within a given tubing size with the following limitations.

— Sealing devices of the same geometry, cross-section, and material are considered to be design-validated when the allowable variation in size is within the range of ± 5 % of the nominal ID sealing diameter of a validation tested design.

— Scaling shall not be used to cover products with fewer sealing devices than the tested product.

— Method of calculating the ratings for the scaled product shall be the same as the tested product.

— Scaling shall not be used to cover products with higher pressure ratings, higher temperature ratings, than the tested product.

— Scaling shall not be used to cover products with a longer rated stroke distance than the tested product for grades V3-V0.

— Scaling shall not be used to cover products with more connections in the seal bore than the seals passed over in the tested product.

Annex D
(normative)

Validation test requirements for opening a port functionality

D.1 General

The supplier/manufacturer shall document all parameters and results of the evaluations that demonstrate conformance to the validation grade.

Completion accessories that are rated for the following functionalities shall meet the requirements of Annex D for the selected design validation grade:

— unloading pressure (3.77);

— number of open/close cycles (3.42).

D.2 Grade V6: Supplier/manufacturer-defined

The supplier/manufacturer defines the validation method and acceptance criteria.

D.3 Grade V5: Single open/close plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when opening. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3).

— Products that are rated for multiple open/close cycles shall be opened and closed once per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V5.

D.4 Grade V4: Single open/close plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for unloading pressure will be tested at the maximum rated unloading pressure when opening. Use a liquid test medium of water, with or without additives, or hydraulic

oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3). The sealing devices shall be completely covered by liquid prior to start of the unloading test. The gas cap charge volume at the unloading pressure shall be a minimum of the internal volume of the tested product.

— Products that are rated for multiple open/close cycles shall be opened and closed once per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V4.

D.5 Grade V3: Multiple open/close plus liquid test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

— Products that are rated for unloading pressure shall be tested at the maximum rated unloading pressure when opening. Use a liquid test medium of water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1 100 kg/m^3 (68,67 lb/ft^3). The sealing devices shall be completely covered by liquid prior to start of the unloading test. The gas cap charge volume at the unloading pressure shall be a minimum of the internal volume of the tested product.

— Products that are rated for multiple open/close cycles shall be opened and closed the maximum rated number of cycles and per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V3.

D.6 Grade V2: Multiple open/close plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for unloading pressure will be tested at the maximum rated unloading pressure when opening. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases. The gas volume at the unloading pressure shall be a minimum of the internal volume of the tested product.

— Products that are rated for multiple open/close cycles shall be opened and closed the maximum rated number of cycles and per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V2.

D.7 Grade V1: Multiple open/close plus gas test

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for unloading pressure shall be tested at the maximum rated unloading pressure when opening. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases. The gas volume at the unloading pressure shall be a minimum of the internal volume of the tested product.

— Products that are rated for multiple open/close cycles shall be opened and closed the maximum rated number of cycles and per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V1.

D.8 Grade V0: Multiple open/close plus gas test plus zero bubble acceptance criterion

The supplier/manufacturer shall adhere to the following test parameters and criterion for conformance to this validation grade.

WARNING — Unloading tests using gas can present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing.

— Products that are rated for unloading pressure will be tested at the maximum rated unloading pressure when opening. Use a gas test medium of air, nitrogen, or other gases or mixtures of gases. The gas volume at the unloading pressure shall be a minimum of the internal volume of the tested product.

— Products that are rated for multiple open/close cycles shall be opened and closed the maximum rated number of cycles and per the supplier/manufacturers documented procedure.

— Products that are rated for one opening only shall be opened once per the supplier/manufacturers documented procedure.

— Products that are rated for one closing only shall be closed once per the supplier/manufacturers documented procedure.

— Test those completion accessories having shear release features at or above the maximum rated shear load.

— Run entire test at or above maximum rated temperature.

— After the opening/closing cycles, products that are rated for pressure holding capability after closing shall be pressure tested to only one pressure reversal per Annex A, V0.

D.9 Limitations of scaling for Annex D validation tests

Scaling (6.7) is allowed to qualify a product family within a given tubing size with the following limitations.

— Sealing devices of the same geometry, cross-section, and material are considered to be design-validated when the allowable variation in size is within the range of ± 5 % of the nominal ID sealing diameter of a validation tested design.

— Method of calculating the ratings for the scaled product shall be the same as the tested product.

— Scaling shall not be used to cover products with higher temperature ratings, higher pressure ratings, higher shear values, or higher unloading pressures than the tested product.

— Scaling shall not be used to cover products with more open/close cycles than the tested product for grades V3-V0.

— Scaling shall not be used to cover products with larger port flow areas (3.47) than the tested product.

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