Specification for Completion Accessories

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ISO 14998:2013(E) (Modified), Petroleum and natural gas industries—Downhole equipment—Completion accessories







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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 of 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 that 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.

Specification for 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, quality requirements, redress, repair, shipment, and storage. This International Standard covers the pressure-containing, nonpressure-containing, load-bearing, disconnect/reconnect, tubing-movement, and opening-a-port functionalities of completion accessories.

Products covered under another API or international specification are not included. Also not included are other products such as liner/tubing hangers, downhole well test tools, inflow control devices, surface-controlled downhole chokes, downhole artificial lift equipment, control lines and fittings, and all functionalities relating to electronics or fiber optics. This International Standard does not cover the connections to the well conduit. Installation, application, and operation of these products are outside the scope of this International Standard.

2 Normative References

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

API Specification 5CRA, Specification for Corrosion Resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock

API Specification 5CT, Specification for Casing and Tubing

API Technical Report 5C3, Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing

API Specification 20A, Carbon Steel, Alloy Steel, Stainless Steel, and Nickel Base Alloy Castings for Use in the Petroleum and Natural Gas Industry

ANSI ¹/NACE MR0175 ²/ISO 15156 ³ (all parts), Petroleum and natural gas industries—Materials for use in H_2 S-containing environments in oil and gas production

ASME Boiler and Pressure Vessel Code (BPVC)⁴, Section IX: Welding and Brazing Qualification

ASNT SNT-TC-1A⁵, Personnel Qualification and Certification in Nondestructive Testing

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

¹ American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

² NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.

³ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

⁴ ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

⁵ American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

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

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 outside diameter (OD).

3.4

casing

Pipe extending from the surface and intended to line the walls of a drilled well.

3.5

chemical injection mandrel

Completion accessory with provision to attach conduit(s) for injection of chemicals.

3.6

completion accessory

Equipment that forms an integral part of the tubing and is not covered by any other API/ISO downhole equipment standards.

3.7

component

Individual part of an assembly.

3.8

conduit

Casing, tubing, or liner, either metallic or nonmetallic.

3.9

crossover See tubing adapter.

3.10

design validation

Process of proving a design by testing to demonstrate conformity of the product to design requirements.

(Source: API Q1:2013, Section 3.1.9.)

3.11

design verification

Process of examining the result of design and development output to determine conformity with specified requirements.

(Source: API Q1:2013, Section 3.1.10.)

disconnect load

Load at which a completion accessory is designed to disconnect.

3.13

downhole artificial lift equipment

Equipment integral to the conduit that provides additional energy to the production fluids.

3.14

downhole well test tools

Downhole tools temporarily set in place for the purpose of evaluating the production potential of the chosen formation.

3.15

drift diameter

Inside diameter (ID) of a completion accessory, expressed as the OD of the drift bar utilized during assembly inspection, as outlined in 7.4.11.

3.16

end connection

Thread or other mechanism connecting the completion accessory to the conduit.

3.17

entry (reentry) guide

Completion accessory used to facilitate entry/reentry.

3.18

expansion (travel) joint

Completion accessory that facilitates tubing movement.

3.19

exposed component

Flow-wetted component, internally wetted component, and/or component contacted by well fluid in the annulus.

3.20

extension (spacer) sub

Completion accessory that has threaded connections on each end and maintains pressure integrity.

NOTE May include items such as mill-out extension or sand control extension.

3.21

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.

3.22

filter mandrel

Completion accessory with provision to attach or include control line filter(s).

NOTE Unported designs of filter mandrels are covered by definition of mandrel.

3.23

flow coupling

Completion accessory with anti-erosion provision on the ID.

flow-wetted component

Component that comes in direct contact with the dynamic movement of well fluids in the flow stream.

3.25

gauge mandrel

Completion accessory with provision to attach permanent monitoring devices.

3.26

gauge OD

Maximum specified product OD.

3.27

grade

Category or rank given to different requirements for quality or design validation.

3.28

indicator

Completion accessory that provides an identification of linear position within a conduit typically used in sand control operations.

3.29

inflow control device

Device that regulates the flow into the production conduit.

3.30

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.

3.31

job lot

Batch of material or components that have undergone the same process or series of processes.

3.32

job lot traceable

The ability for parts to be identified as originating from a job lot that identifies the included heat(s).

3.33

liner

Pipe not extending from the surface and intended to line the walls of a drilled well.

3.34

liner (tubing) hanger

Mechanical device used for transferring the load of an inner liner (tubing) to the casing below the wellhead.

3.35

locator

Completion accessory with provision to disconnect or reconnect the tubing to a designed receptacle.

3.36

mandrel

Component(s) of a completion accessory that contains an end connection and provides a conduit through the completion accessory.

manufacturing

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

NOTE 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.

3.38

mill-out extension

Completion accessory used below a packer to facilitate removal by milling.

NOTE May be pressure-containing or nonpressure-containing.

3.39

nonconformance

Nonfulfillment of a specified requirement.

3.40

nonsealing space out joint

Completion accessory with provision to accommodate tubing movement used to adjust tubing lengths, but without provision to hold pressure.

3.41

number of disconnects [(re)connects]

Number of times a completion accessory can be disconnected [(re)connected] and perform its intended function.

3.42

number of strokes

Maximum number of times a completion accessory can be moved through its stroke length and perform its intended function.

3.43

one-piece mandrel

Mandrel or completion accessory that does not have leak paths excluding the end connections.

NOTE Welded one-piece mandrels are outside the scope of this definition.

3.44

on-off tool

Completion accessory with provision to disconnect or reconnect the tubing.

3.45

open/close cycle

Opening and then closing a port.

3.46

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.

parting tool

Completion accessory that is designed to separate control line(s) or cable(s) to facilitate tubing removal.

3.48

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.

3.49

performance envelope

Graph that illustrates the combined ratings of differential pressure and axial loads.

3.50

polished bore receptacle

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

3.51

port flow area

Area for the passage of fluids from the ID of the tubing to the annulus, or vice versa.

3.52

pressure reversal

Change in direction of the pressure differential.

3.53

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.

3.54

(re)connect temperature

Temperature at which the completion accessory can be (re)connected and performs its intended function.

3.55

redress

Replacement of components on a completion accessory after original manufacture.

3.56

repair

Redress and remanufacture of the completion accessory to restore it to the original functionality.

3.57

sand control expansion joint

Completion accessory that facilitates tubing movement in a sand control completion.

3.58

sand control sliding sleeve

Sand control completion accessory that has a sleeve designed to open or close communication.

3.59

seal assembly

Completion accessory that seals in a designed receptacle.

6

seal bore extension

Completion accessory designed to accept a seal assembly or similar device.

3.61

sealing device

Device providing a barrier to the passage of liquid and/or gas across the interface between two components.

3.62

sealing space out joint

Completion accessory with provision to accommodate tubing movement used to adjust tubing lengths with a provision to hold pressure.

3.63

shear device

Component designed to disconnect one time at a predetermined load.

3.64

shear-out safety joint

Completion accessory with provision to disconnect the tubing at a predetermined load through use of a shear device.

3.65

sliding sleeve

Completion accessory that is activated to open or close communication between the tubing and annulus by moving a sleeve.

3.66

stroke

Movement from one end of the stroke length to the other end.

3.67

stroke distance

Cumulative distance determined by the number of rated strokes multiplied by the stroke length.

3.68

stroke length

Distance between the fully collapsed position and fully expanded position for a completion accessory with provision to accommodate tubing movement.

3.69

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.

3.70

surface-controlled downhole choke

Surface-controlled downhole device used to restrict flow.

3.71

surface-controlled sliding sleeve

Tubing-mounted device that is activated to open or close communication between the tubing and annulus by moving a sleeve without thru-tubing intervention.

telescoping swivel sub

Completion accessory with provision to rotate and accommodate tubing movement.

3.73

temperature cycle range

Specified range of temperature fluctuation over which the product is designed to operate.

NOTE The temperature cycle range is applicable anywhere within the product's temperature range.

3.74

temperature range

Specified range of temperature at which the product is designed to operate.

3.75

temporary pressure-retaining device

Completion accessory that provides tubing pressure integrity and the capability of providing temporary tubing pressure retention and release, when defined conditions are met.

3.76

tubing

Pipe placed within a well to serve as a production or injection conduit.

3.77

tubing adapter

Completion accessory that connects two different end connections.

3.78

tubing seal receptacle

Completion accessory with designed receptacle used for one or more disconnect(s) or reconnect(s) of the tubing by accepting a locator, seal assembly, or similar device.

3.79

tubing size

Nominal tubing OD as specified in API 5CT/API 5CRA.

3.80

Type 1 component or weld

Component or weld 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.

3.81

Type 2 component or weld

Component or weld that does not meet the criteria of a Type 1 component.

3.82

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.

3.83

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.

8

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

4 Acronyms and Abbreviations

- AQL acceptance quality limit
- COC certificate of compliance
- FEA finite element analysis
- ID inside diameter
- MTR material test report
- NDE nondestructive examination
- OD outside diameter
- QC quality control
- UNS unified numbering system

5 Functional Specification

5.1 General

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

5.2 Functional Type Description

The user/purchaser shall specify the following functional type(s) based on the product's intended function(s).

- Nonpressure-containing, such as:
 - entry (reentry) guide (3.17);
 - nonsealing space out joint (3.40);
 - mill-out extension (3.38);
 - perforated sub (3.48).
- Pressure-containing, such as:
 - blast joint (3.3);
 - chemical injection mandrel (3.5);
 - crossover (3.9) or tubing adapter (3.77);
 - extension (spacer) sub (3.20);
 - filter mandrel (3.22);
 - flow coupling (3.23);
 - gauge mandrel (3.25);

- indicator (3.28);
- parting tool (3.47);
- temporary pressure-retaining device (3.75);
- tubing adapter (3.77);
- y-block (3.84).
- Disconnect/(re)connect, such as:
 - anchor (3.1);
 - locator (3.35);
 - on-off tool (3.44);
 - shear-out safety joint (3.64);
 - tubing seal receptacle (3.78).
- Tubing movement, such as:
 - expansion (travel) joint (3.18);
 - polished bore receptacle (3.50);
 - sand control expansion joint (3.57);
 - seal assembly (3.59);
 - seal bore extension (3.60);
 - sealing space out joint (3.62);
 - telescoping swivel sub (3.72).
- Open a port in the conduit; such as:
 - fill valve (3.21);
 - sand control sliding sleeve (3.58);
 - sliding sleeve (3.65);
 - unloader sub (3.82).

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, and 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/fiber-optic) that must pass through or bypass 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 parameter(s).

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 should 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 gas, 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, requirements for compliance with ANSI/NACE MR0175/ISO 15156 shall be stated.

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

- flow-wetted components (3.24);
- internally wetted components (3.30);
- exposed components (3.19).

5.6 Compatibility with Related Well Equipment

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

- top and bottom tubular connection(s), the material, including any supplemental and/or annex requirements required in an internationally recognized standard such as API 5CT or API 5CRA, and dimensions of the connections to the conduit(s);
- internal receptacle profile(s), bore dimensions(s), OD, ID, 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 6.5.1 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 (QC), as defined in 7.4.1.

6 Technical Specification

6.1 General

The supplier/manufacturer shall prepare a technical specification that 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 datasheet 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 (3.80) or Type 2 (3.81).

6.3.3 Materials

6.3.3.1 General

Materials (both metallic and nonmetallic), and/or compliance with ANSI/NACE MR0175/ISO 15156, shall be stated by the supplier/manufacturer and shall be suitable for 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 substitution is a temporary change to a bill of material for a validated item that does not decrease the performance capabilities of the product. 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 6.4. 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 from the supplier/manufacturer and the supporting documentation incorporated into the manufacturing records.

6.3.3.2 Metals

6.3.3.2.1 Specifications

The manufacturer's specifications shall define:

- a) unified numbering system (UNS) number or 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 user/purchaser, 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.

6.3.3.3 Nonmetals

The manufacturer's documented specifications for nonmetallic 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:
 - 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, (re)connect, and 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/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.
- Some products (typically of a single component) may be represented by a curved or elliptical envelope as shown below in Figure 3. Points on the curved envelope within any quadrant where the maximum magnitude of either the load or pressure value exceeds the magnitude of the load or pressure value at the axes are considered maximum operational limit points of the tool as shown in Figure 3.
- 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 downhole, then this shall be stated on the envelope.



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

Figure 1—Example of a Rated Performance Envelope

6.4 Design Verification

6.4.1 General

Design verification shall be performed to ensure that each completion accessory design meets the supplier/manufacturer's technical specifications, including all conveyance, operational, removal methods/tools, 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.

6.4.2 Design Assumptions

The supplier/manufacturer shall apply a design margin to each component and/or assembly using a documented methodology and practice. The documented design margins shall be utilized in the creation of component or assembly capabilities and/or ratings.

The completion accessory design(s) shall be analyzed to determine the supplier/manufacturer's stated performance limits. The minimum material condition and minimum material yield strength shall be used in the calculations.



Figure 2—Example of Shear Device Options

6.4.3 Design Calculations

6.4.3.1 General

Completion accessory design calculations may be performed using one of the following methodologies.

6.4.3.2 Distortion Energy Theory

The distortion energy theory, also known as the von Mises yield criterion, shall be used for the design calculation of pressure-containing components.

NOTE ASME BPVC Section VIII, Division 3, KD-131(b) provides the equations to calculate the equivalent stress.

The equivalent stress shall be calculated and be limited by the supplier's documented design margin methodology and practice.

Stress concentrations and discontinuities are beyond the scope of this methodology.



Figure 3—Example of an Elliptical Envelope

6.4.3.3 Triaxial Yield and Uniform Axial Equations

API 5C3, Annex A (Discussion of Equations for Triaxial Yield of Pipe Body) shall be used to derive the triaxial yield stress of a cylinder.

Tensile (axial) stress calculations shall be performed per the requirements of API 5C3, Annex A, Section A.1.2.3 (Uniform Axial Stress).

6.4.3.4 Finite Element Analysis

Finite element analysis (FEA) is a design verification methodology that analyzes more complex geometries and/or complex loading where conventional verification methodologies are considered incomplete by the design engineer or qualified person. FEA methodology may be used for single or combined loading situations.

FEA analysis inputs and outputs shall be archived such that the study can be reevaluated/reproduced at a later date.

6.5 Design Validation

6.5.1 General

This International Standard specifies seven 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. 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. Completion accessories that are not pressure-containing and have no other functional type (see 5.2) shall be validated per Annex A, grades V6, V5, or V3.

The supplier/manufacturer shall document the validation test procedure, acceptance criteria, and results and shall have on file material specifications, material certifications, and drawings that show all the applicable dimensions and tolerances of parts contained in the validation-tested product. Pretest 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 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 API 11D1.

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

Completion accessories that meet the functionality requirements of Table 1 have been summarized in Table 3. For reference, these tools have been associated with the required annex(es) to which the tools shall be tested.

6.5.2 Validation by Design Calculation

One-piece mandrels or nonpressure-containing completion accessories may be validated by one of the following.

- Design calculation per one of the methodologies listed in 6.4.3 and an internal pressure test shall be performed to the tool's internal pressure rating at ambient temperature. Validation by design calculation is limited to V3.
- Testing to the requirements of Annex A.

NOTE 1 An internal pressure test is not required for nonpressure-containing completion accessories.

NOTE 2 For the purpose of this specification, one-piece mandrels with a provision for a ported connection are considered to be one-piece mandrels. These connections are outside of the scope of this specification.

6.5.3 Validation Test Requirements

6.5.3.1 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.

When testing to a specific annex, tests shall be conducted in series without redressing critical components, such as seals. Redress or adjustment of nonvalidated components, such as fixtures or connections, is accepted.

	Annex A: Validation Test Requirements for All Products ^a		Annex B: Validation Test	Annex C:	Annex D: Validation Test
Validation Grade	Nonpressure- containing or One-piece Mandrels	Pressure- containing	Requirements for Disconnect/ (Re)connect Functionality	Validation Test Requirements for Tubing-movement Functionality	Requirements for Opening/ Closing a Port Functionality
V6	Supplier/ manufacturer- defined	Supplier/ manufacturer- defined	Supplier/ manufacturer- defined	Supplier/ manufacturer- defined	Supplier/ manufacturer- defined
V5	Not applicable	Liquid test or axial load test at rated temperature	Single disconnect/ (re)connect plus liquid test	Single stroke plus liquid test	Single open/close plus liquid test
V4	Not applicable	Liquid test or axial load test at rated temperature	Single disconnect/ (re)connect plus liquid test	Single stroke with pressure plus liquid test	Single open/close plus liquid test
V3	Axial loads at rated temperature or design calculations	Liquid test plus axial loads plus temperature cycling	Multiple disconnect/ (re)connects plus liquid test	Multiple strokes with pressure plus liquid test	Multiple open/close plus liquid test
V2	Not applicable	Gas test plus axial loads at rated temperature	Multiple disconnect/ (re)connects plus gas test	Multiple strokes with pressure plus gas test	Multiple open/close plus gas test
V1	Not applicable	Gas test plus axial loads plus temperature cycling	Multiple disconnect/ (re)connects plus gas test	Multiple strokes with pressure plus gas test	Multiple open/close plus gas test
VO	Not applicable	Gas test plus axial loads plus temperature cycling plus zero bubble acceptance criterion	Multiple disconnect/ (re)connects 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

Table 1—Summary o	f Design	Validation	Grades
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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, V3, V4, V5, and V6	
V3	V3, V4, V5, and V6	
V4	V4, V5, and V6	
V5	V5 and V6	
V6	V6	

Completion Accessory	Required Test Annex(es)	Pressure-containing
Anchor	A and B	Yes
Blast joint	A	Yes
Chemical injection mandrel	A	Yes
Entry (reentry) guide	A	No
Expansion (travel) joint	A and C	Yes
Extension (spacer) sub	A	Yes
Fill valve	A and D	Yes
Filter mandrel	A	Yes
Flow coupling	A	Yes
Gauge mandrel	A	Yes
Indicator	A	Yes
Locator	A and B	Yes
Mill-out extension	A	No
Nonsealing space out joint	A	No
On-off tool	A and B	Yes
Parting tool	A	Yes
Perforated sub	A	No
Polished bore receptacle	A and C	Yes
Sand control expansion joint	A and C	Yes
Sand control sliding sleeve	A and D	Yes
Seal assembly	A and C	Yes
Sealing space out joint	A and C	Yes
Seal bore extension	A and C	Yes
Shear-out safety joint	A and B	Yes
Sliding sleeve	A and D	Yes
Telescoping swivel sub	A and C	Yes
Temporary pressure-retaining device	A	Yes
Tubing adapter	A	Yes
Tubing seal receptacle	A and B	Yes
Unloader sub	A and D	Yes
y-block	A	Yes

Table 3—Required Test Annex(es)

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. Other completion accessories not listed in this table but meeting the functionality requirements of Table 1 may also be covered by this specification and tested accordingly.

When testing to multiple annexes is required, the order of testing is left up to the supplier/ manufacturer.

For liquid test validation grades V5, V4, and V3, the test medium shall be water, with or without additives, or hydraulic oil. The mass density of the test fluid shall be less than 1100 kg/m³ (68.67 lbm/ft³) and shall be visibly free from particulate matter or other material that could plug a small leak. Acceptance criteria for pressure testing shall be no more than 1 % reduction in the maximum rated differential pressure over the hold period after sufficient time has been allowed for stabilization. All hold periods shall be maintained for a minimum of 15 minutes after stabilization of all temperatures, pressures, and applied loads. The time period for stabilization is at the discretion of the supplier/manufacturer.

For gas test validation grades V2, V1, and V0, the test medium shall be air, nitrogen, or other gases or mixtures of gases. For validation grades V2 and V1, the acceptance criteria for pressure testing shall be no more than 20 cm³ of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. For validation grade V0, the acceptance criteria shall be zero bubbles of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. For validation grade V0, the acceptance criteria shall be zero bubbles of gas accumulated in a graduated cylinder over the hold period after sufficient time has been allowed for stabilization. Graduated cylinders for accumulated gas shall be at atmospheric pressure. For all gas tests, the bubble rate shall not increase during the hold period. All hold periods shall be maintained for a minimum of 15 minutes after stabilization of all temperatures, pressures, and applied loads. The time period for stabilization is at the discretion of the supplier/manufacturer.

WARNING —Tests using gas, including unloading tests using gas and/or the actuation of tools with gas, present significant safety risks. Adequate precautions should be taken to ensure safety of personnel during testing. The gas volume should be considered by the supplier/manufacturer's allowable pressure/volume curves for the test facility.

6.5.3.2 Validation Requirements for Functionalities Not Addressed in Table 1

Functionalities not addressed in Table 1 shall be validated by testing 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 (3.69). 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 nonsubstantive 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 a 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

Scaling may be used to validate variations of a validated product in the same product family and be of the same nominal tubing size, type, and model. Only products that have been previously validated to grades V5 through V0 (see 6.5) and in accordance with the requirements and limitations of 6.7.2 can be scaled. The product validated by scaling shall carry the same validation grade as the validated product.

A product family is a group of assemblies where the same design configuration principles apply to materials, geometry, and functionality.

The supplier/manufacturer shall establish the maximum stress within the previously validated design Type 1 components and in the same components of the scaled design. The mode of stress and same method of calculation(s)/verification(s) shall be applied to the identified components of the base design and the scaled design. For the Type 1 component with the highest design stress factor, the scaled design's stress factors shall not exceed the stress factor of the same component of the validated design. Stress factor is the ratio of stress to the minimum yield strength of the material.

Design scaling shall be approved by a qualified person, and records of the results shall become a portion of the design documentation.

6.7.2 Limitations of Scaling

Limitations of scaling are defined in A.4, 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 section 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, QC, 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 5 years from date of manufacture or repair. 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 the following information, where applicable:

- manual reference number;
- parts list;
- operational procedures and related tools;
- preinstallation inspection procedures;
- representative drawing showing major dimensions (ODs, IDs, and lengths);
- troubleshooting;
- installation instructions;
- testing instructions;
- requirements for handling, shipment, and storage;
- requirements for redress and repair, including items such as procedures, tools, and spare parts.

7.2.3 Product Datasheet

Product datasheets shall be available to the user/purchaser, as required in 6.1, and shall contain the following information, where applicable:

- name of supplier/manufacturer;
- manufacturer product number;
- manufacturer product name;
- ANSI/NACE MR0175/ISO 15156 compliance;
- metallic materials;
- nonmetallic materials;
- drift diameter;
- minimum ID;
- gauge OD;
- overall length;
- temperature range;
- temperature cycle range;

- disconnect ratings;
 - disconnect unloading pressure;
 - number of disconnects;
 - disconnect load;
- (re)connect ratings;
 - (re)connect temperature;
 - number of (re)connects;
- tubing-movement ratings;
 - stroke length (3.68);
 - number of strokes (3.42);
 - stroke distance (3.67);
- ratings for opening a port in the conduit;
 - unloading pressure;
 - direction of unloading pressure (internal and/or external);
 - 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 V1 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 (6.5.3.2);
- 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 4.

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).

7.4.2 Material

7.4.2.1 General

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

- a certificate of compliance (COC) to the manufacturer stating that the material meets the supplier/manufacturer's documented specifications; or
- a material test report (MTR) to the manufacturer so that the supplier/manufacturer can verify that the material meets the supplier/manufacturer's documented specifications.

7.4.2.2 Type 1 Components

For Type 1 components supplied to quality grades Q1 and Q2, the supplier/manufacturer shall provide an MTR that verifies the material meets the supplier/manufacturer documented specification.

Table 4—Summary of Quality Requirements

ltom	Quality Grade ^a				
item	Q3	Q2	Q1		
Metallic	COC or MTR (7.4.2.1)	MTR for Type 1 components	MTR for Type 1 components (7.4.2.2)		
material		COC or MTR for Type 2 components (7.4.2.1)	COC or MTR for Type 2 components (7.4.2.1)		
Nonmetallic material	COC or MTR (7.4.2.1)	COC or MTR (7.4.2.1)	COC or MTR (7.4.2.1)		
Castings	COC (7.4.3)	MTR (7.4.3)	As required by API 20A, CSL-3 (7.4.3)		
Heat treatment	COC (subcontractor)	COC (subcontractor)	COC (subcontractor)		
	Job lot verification (supplier/manufacturer)	Job lot verification (supplier/manufacturer) (7.4.4.1)	Job lot verification (supplier/manufacturer)		
	(7.4.4.1)		Heat treat certificate for Type 1 components (7.4.4.1)		
Component traceability	Job lot traceable for Type 1 components (7.4.5)	Job lot traceable for Type 1 components (7.4.5)	Heat per heat treat lot traceable for Type 1 components (7.4.5)		
Component dimensions	Sampling plan (7.4.6)	Sampling plan (7.4.6)	100 % for Type 1 components (7.4.6)		
Welding					
Type 1 welds	Visual (7.4.9)	Surface NDE per sampling plan and visual (7.4.9)	Volumetric and surface NDE 100 % (7.4.9)		
Type 2 welds	Visual (7.4.9)	Visual (7.4.9)	Visual (7.4.9)		
Hardness					
Type 1 components	None	Per sampling plan (7.4.8)	100 % sampling (7.4.8)		
Type 2 components	None	None	None		
Component ND	E				
Type 1 components	None	Surface NDE per sampling plan (7.4.9)	Volumetric and surface NDE 100 % (7.4.9)		
Type 2 components	None	None	Visual (7.4.9)		
Shear devices	Shear verification (7.4.10)	Shear verification (7.4.10)	Shear verification (7.4.10)		
Assembly	None	Internal pressure test (7.4.11.2)	Internal pressure test (7.4.11.2)		
verification		ID drift (7.4.11.3)	ID drift (7.4.11.3)		
			OD dimensional (7.4.11.4)		
			Torque documentation (7.4.11.5)		
			Opening/closing force ^b (7.4.11.6)		
Assembly traceability	None	None	Assembly serialization (7.4.12)		
QC documentation	Supplier/manufacturer retained	Supplier/manufacturer retained	Supplier/manufacturer retained		
 "None" indicates there are no requirements listed in 7.4.2 through 7.4.15. Only applicable to items that are validated according to Annex D. 					

7.4.3 Castings

For Q3 components, the casting subcontractor or supplier shall provide a COC to the supplier/manufacturer stating that the casting meets the supplier/manufacturer's documented specifications.

For Q2 components, an MTR shall be required that meets the supplier/manufacturer's documented specifications.

For Q1 components, all castings, with the exception of slips and components primarily loaded in compression, shall conform to the requirements of API 20A, CSL-3.

Slips and components primarily loaded in compression shall conform to documented requirements defined by the supplier/manufacturer.

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 per 7.4.4.2.
- 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/manufacturer's documented specifications.
- If heat treatment is performed by the supplier/manufacturer, heat treatment shall comply with the supplier/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

Furnaces shall be calibrated in accordance with one of the following procedures:

- procedures specified in an international or national standard such as SAE AMS-2750E;
- supplier/manufacturer's documented specifications, including acceptance criteria that 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 3 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 per heat treat lot 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 nonmetallic 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/ASQ 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 and welders shall meet the requirements of ASME BPVC Section IX or an equivalent international or national standard.
- Type 2 welds and welders shall meet the requirements of ASME BPVC Section IX, or an equivalent international or national standard, or the supplier/manufacturer's approved procedures.
- Components that are welded and used in H₂S environments must comply with ANSI/NACE MR0175/ISO 15156.
- Repairs to welds, where the repair is greater than either 25 % of the original wall thickness or 25.4 mm (1 in.), whichever is less, shall be examined by either radiography or ultrasonic methods after all welding and postweld heat treatment. Examinations shall include at least 12.7 mm (¹/₂ in.) of adjacent base metal on all sides of the weld.
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/ASQ 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 ASTM E10, ASTM E18, 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 D2240 or ASTM D1415. A test specimen manufactured from each batch may be used.
- Hardness testing of nonmetallic and nonelastomeric components shall conform to the supplier/manufacturer's documented specifications.

7.4.9 NDE of Components/Welds

Nondestructive examination (NDE) of components and welds shall meet the following requirements.

- Type 1 welds for Q3 shall be visually inspected per supplier/manufacturer's documented specifications.
- Type 1 welds for Q1 and Q2 shall be visually inspected per the requirements of an international or national standard such as ASME BPVC.
- Type 1 components and welds for Q2 shall be NDE inspected using liquid penetrant or magnetic particle methods per a sampling plan that meets the requirements of an international or national standard such as ISO 2859-1 or ANSI/ASQ Z1.4.
- Type 1 components and welds for Q1 shall be 100 % inspected using liquid penetrant or magnetic particle methods and visual inspection.
- Type 1 components and welds for Q1 shall be volumetrically inspected by either radiography or ultrasonic methods. Welds for Q1 shall be 100 % examined after all welding, postweld heat treatment, and machining operations but prior to machining operations that limit effective interpretation of the results of the examination. Volumetric inspection is not required on components that are primarily loaded in compression.
- Type 2 welds for all quality levels shall be visually inspected per supplier/manufacturer's documented specifications.
- Type 2 components for Q1 shall be visually inspected per the supplier/manufacturer's documented specifications.
- When surface NDE is required, visual inspection and either magnetic particle inspection or liquid penetrant inspection shall be performed in the final material condition. Surface NDE shall be performed on all external surfaces and to the maximum extent on internal surfaces.
- Magnetic particle inspection shall meet the requirements of an international or national standard such as ISO 10893-5 or ASTM E709.

- Liquid penetrant inspection shall meet the requirements of an international or national standard such as ISO 10893-4 or ASTM E165.
- When volumetric inspection is required, each part shall be volumetrically inspected with the entire volume inspected as completely as possible. This inspection shall be conducted after heat treatment with the following exceptions.
 - If volumetric NDE is performed prior to a stress relief or other thermal processes performed at a temperature lower than tempering or aging treatments, it is not required to be reperformed.
 - If volumetric NDE is performed prior to retempering to lower hardness on quenched and tempered materials, it is not required to be reperformed.
 - If volumetric NDE is performed prior to precipitation hardening of finished components, it is not required to be reperformed. A surface NDE shall be performed after precipitation hardening.
 - If volumetric NDE is performed prior to tempering of finished components, it is not required to be reperformed. A surface NDE shall be performed after tempering.
 - If volumetric NDE is performed prior to surface hardening treatments, reperforming volumetric NDE is not required. A surface NDE shall be performed after surface hardening treatments.
- NDE acceptance criteria shall be according to the supplier/manufacturer's documented specifications. NDE for nonmetallic components shall be visual inspection.
- 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.
- All NDE instructions shall be approved by a Level III examiner qualified in accordance with ASNT SNT-TC-1A, ISO 9712, or equivalent national or international standard.
- 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 acceptance quality limit (AQL) for O-rings and a 1.5 AQL for other nonmetallic seals until a documented variation history can be established. Sampling procedures shall also conform to supplier/manufacturing documented criteria that are established based on the documented variation history.

7.4.10 Shear Device Verification

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

7.4.11 Assembly Verification and Functional Test

7.4.11.1 General

Each completion accessory manufactured to this specification shall be functionally tested in conformance with the supplier/manufacturer's procedures and acceptance criteria. Functional testing shall validate the equipment's proper assembly, operation, and integrity. Results of the functional test shall be traceable to the validated equipment and the testing results shall be documented in accordance with 7.2. Table 5 contains a summary of assembly verification requirements per quality grade.

In the event that a completion accessory design has operational features that are incompatible with the requirements of the primary functional testing procedure, the supplier/manufacturer shall document the evaluation method and procedures that are selected and implemented for that feature. The supplier/manufacturer shall include these evaluations in the functional testing procedures, results, and documentation.

Assembly verification shall meet the following requirements.

Critorian	Quality Grade			
Criterion	Q3	Q2	Q1	
Internal pressure test	Not required	7.4.11.2	7.4.11.2	
Internal diameter drift test	Not required	7.4.11.3	7.4.11.3	
External diameter inspection Not required		Not required	7.4.11.4	
Torque verification Not required		Not required	7.4.11.5	
Open/close operation	Not required	Not required	7.4.11.6	

Table 5—Summary of Assembly Verification Requirements

7.4.11.2 Internal Pressure Test

A low-pressure internal test shall be performed on each pressure-containing completion accessory by 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 nonsealing connections/components are excluded from this requirement. Test duration and acceptance criteria shall be defined by the supplier/manufacturer's documented procedures.

7.4.11.3 Internal Diameter Drift Test

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 (seal bores). Drift bar diameter shall match the rated drift diameter of the completion accessory. Drift bar length shall meet the requirements for tubing specified in API 5CT or API 5CRA as applicable.

7.4.11.4 External Diameter Inspection

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

7.4.11.5 Torque Verification

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/manufacturer's documented specifications. End connections are specifically excluded from this requirement.

7.4.11.6 Open/Close Operation

For completion accessories that are rated according to the validation requirements of Annex D, a functional test shall include an opening and closing operation according to the supplier/manufacturer's documented procedure and acceptance criteria, including shifting force. Where a tool redress or repair after opening/closing is required, or performance rating is affected, this test is not required.

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 Nonconformance

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 nonconforming assemblies or components.

The responsibility for review and authority for the disposition of nonconforming assemblies or components shall be defined by the supplier/manufacturer. Nonconforming 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 that are no less stringent than those used for new products.

7.4.14 Calibration Systems

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 3 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 1 year. Calibration standards used to calibrate measuring equipment shall be checked and approved at least once every 3 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 after original manufacture shall be defined by the supplier/manufacturer's procedures.

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. Repaired products shall be marked with an "R" after the original manufacture date to indicate that the product has been repaired.

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 for All Products

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 stated.

A.2 Nonpressure-containing Product Design Validation Requirements

A.2.1 General

Nonpressure-containing completion accessories such as entry (reentry) guide, mill-out extension, and nonsealing space out joint do not require a pressure test.

A.2.2 Grade V6: Supplier/Manufacturer-defined

The supplier/manufacturer shall define the design validation procedures and acceptance criteria. These documented results shall be approved by a qualified person and validate the product designs ratings and capabilities.

A.2.3 Grade V3: Axial Load Test at Maximum Rated Temperature

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

- Products shall be tested to the maximum rated tensile and/or compression loading, as applicable.
- Run entire test at maximum rated temperature.
- Maintain a minimum hold period of 15 minutes for tensile or compressive tests.
- Acceptance criterion: no more than 1 % reduction in the applied tensile or compressive load 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.3 Pressure-containing Completion Accessories

A.3.1 General

Pressure-containing completion accessories shall be validated to the selected validation grade.

A.3.2 Grade V6: Supplier/Manufacturer-defined

The supplier/manufacturer shall define the design validation procedures and acceptance criteria. These documented results shall be approved by a qualified person and validate the product's design ratings and capabilities.

A.3.3 Grade V5: Liquid Test

One-piece mandrels are not covered under this validation grade.

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 shall be conducted in accordance with the test requirements defined for liquid tests in 6.5.3.1.

A.3.4 Grade V4: Liquid Test Plus Axial Loads

One-piece mandrels are not covered under this validation grade.

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.
- If the rated performance envelope is an elliptical envelope (see Figure 3), then test to all intersection points of the envelope with the axes and all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit.
- If the rated performance envelope is a combination of an elliptical envelope and ratings defined by intersection points of load and pressure, then test to all intersection points of the rated envelope, all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit, and all intersection points of the envelope with the axes.

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

— Test shall be conducted in accordance with the test requirements defined for liquid tests in 6.5.3.1.

A.3.5 Grade V3: Liquid Test Plus Axial Loads Plus Temperature Cycling

See 6.5.2 for exceptions for one-piece mandrels.

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.
- If the rated performance envelope is an elliptical envelope (see Figure 3), then test to all intersection
 points of the envelope with the axes and all points on the envelope where the magnitude of load or
 pressure reaches its maximum operational limit.
- If the rated performance envelope is a combination of an elliptical envelope and ratings defined by intersection points of load and pressure, then test to all intersection points of the rated envelope, all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit, and all intersection points of the envelope with the axes.

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.
- Test shall be conducted in accordance with the test requirements defined for liquid tests in 6.5.3.1.

A.3.6 Grade V2: Gas Test Plus Axial Loads

One-piece mandrels are not covered under 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.
- If the rated performance envelope is an elliptical envelope (see Figure 3), then test to all intersection
 points of the envelope with the axes and all points on the envelope where the magnitude of load or
 pressure reaches its maximum operational limit.
- If the rated performance envelope is a combination of an elliptical envelope and ratings defined by intersection points of load and pressure, then test to all intersection points of the rated envelope, all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit, and all intersection points of the envelope with the axes.

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

— Test shall be conducted in accordance with the test requirements defined for gas tests in 6.5.3.1.

A.3.7 Grade V1: Gas Test Plus Axial Loads Plus Temperature Cycling

One-piece mandrels are not covered under this validation grade.

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.
- If the rated performance envelope is an elliptical envelope (see Figure 3), then test to all intersection
 points of the envelope with the axes and all points on the envelope where the magnitude of load or
 pressure reaches its maximum operational limit.
- If the rated performance envelope is a combination of an elliptical envelope and ratings defined by intersection points of load and pressure, then test to all intersection points of the rated envelope, all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit, and all intersection points of the envelope with the axes.

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.
- Test shall be conducted in accordance with the test requirements defined for gas tests in 6.5.3.1.

A.3.8 Grade V0: Gas Test Plus Axial Loads Plus Temperature Cycling Plus Zero Bubble Acceptance Criterion

One-piece mandrels are not covered under this validation grade.

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.
- If the rated performance envelope is an elliptical envelope (see Figure 3), then test to all intersection
 points of the envelope with the axes and all points on the envelope where the magnitude of load or
 pressure reaches its maximum operational limit.
- If the rated performance envelope is a combination of an elliptical envelope and ratings defined by intersection points of load and pressure, then test to all intersection points of the rated envelope, all points on the envelope where the magnitude of load or pressure reaches its maximum operational limit, and all intersection points of the envelope with the axes.

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.
- Test shall be conducted in accordance with the test requirements defined for gas tests in 6.5.3.1.

A.4 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/(Re)Connect Functionality

B.1 General

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

Completion Accessory	Minimum (Re)connect Requirements		
	V6, V5, and V4	V3, V2, V1, and V0	
Anchor	As required	Two connect and reconnect ^a	
Locator	As required	Two connect and reconnect ^a	
On-off tool	As required	Two connect and reconnect ^a	
Shear-out safety joint	As required	As required	
Tubing seal receptacle	As required	Two connect and reconnect ^a	
^a For grades V3 to V0, tools rated for	one disconnect/(re)connect	t, only one disconnect/(re)connect is required.	

Table B.1—Minimum (Re)connected Requirements Based on Completion Accessory

Other completion accessories not listed in Table B.1 that are rated for the following functionalities shall also meet the requirements of Annex B for the selected design validation grade:

- unloading pressure (3.83);
- number of disconnects (3.41);
- disconnect load (3.12);
- (re)connect temperature (3.54);
- number of (re)connects (3.41).

The maximum rated number of (re)connects for validation grades V3 to V0 shall be greater than or equal to the minimum rated number of (re)connects in Table B.1 for each completion accessory.

B.2 Grade V6: Supplier/Manufacturer-defined

The supplier/manufacturer shall define the design validation procedures and acceptance criteria. These documented results shall be approved by a qualified person and validate the product's design ratings and capabilities.

B.3 Grade V5: Single Disconnect/(Re)connect 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 per 6.5.3.1.

- Products that are rated for (re)connection shall be disconnected and (re)connected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- 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 (re)connecting shall be pressure tested to one pressure reversal per Annex A, V5 after the (re)connect.

B.4 Grade V4: Single Disconnect/(Re)connect 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 per 6.5.3.1.
- Products that are rated for (re)connection shall be disconnected and (re)connected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- 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 (re)connecting shall be pressure tested to one
 pressure reversal per Annex A, V4 after the (re)connect.

B.5 Grade V3: Multiple Disconnect/(Re)connects Plus Liquid Test

- Products that are rated for pressure unloading will be tested at the maximum rated unloading pressure when disconnecting. Use a liquid test medium per 6.5.3.1.
- Products that are rated for multiple (re)connections shall be (re)connected and disconnected to the maximum rated number of (re)connects and per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one connection only shall be connected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturer's documented procedure at the maximum rated disconnect temperature.
- 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 (re)connects, products that are rated for pressure holding capability after (re)connecting shall be pressure tested to only one pressure reversal per Annex A, V3.

B.6 Grade V2: Multiple Disconnect/(Re)connects Plus Gas 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 gas test medium per 6.5.3.1.
- Products that are rated for multiple (re)connections shall be (re)connected and disconnected to the maximum rated number of (re)connects and per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one connection only shall be connected once per the supplier/manufacturer's
 documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturer's documented procedure at the maximum rated disconnect temperature.
- 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 (re)connects, products that are rated for pressure holding capability after (re)connecting shall be pressure tested to only one pressure reversal per Annex A, V2.

B.7 Grade V1: Multiple Disconnect/(Re)connects Plus Gas Test

- Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when disconnecting. Use a gas test medium per 6.5.3.1.
- Products that are rated for multiple (re)connections shall be (re)connected and disconnected to the maximum rated number of (re)connects and per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one connection only shall be connected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturer's documented procedure at the maximum rated disconnect temperature.
- 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 (re)connects, products that are rated for pressure holding capability after (re)connecting shall be pressure tested to only one pressure reversal per Annex A, V1.

B.8 Grade V0: Multiple Disconnect/(Re)connects 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.

- Products that are rated for pressure unloading will be tested at the maximum rated unloading pressure when disconnecting. Use a gas test medium per 6.5.3.1.
- Products that are rated for multiple (re)connections shall be (re)connected and disconnected to the maximum rated number of (re)connects and per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one connection only shall be connected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- Products that are rated for one disconnection only shall be disconnected once per the supplier/manufacturer's documented procedure at the maximum rated (re)connect temperature.
- 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 (re)connects, products that are rated for pressure holding capability after (re)connecting 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, or higher (re)connect temperature than the tested product.
- Scaling shall not be used to cover products with a higher number of disconnects/(re)connects than the tested product for grades V3 to 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 Accessory	Minimum Stroke Distance Requirements	
	V6, V5, and V4	V3, V2, V1, and V0
Expansion (travel) joint	As rated	15.24 m (50 ft)
Polished bore receptacle	As rated	15.24 m (50 ft)
Sand control expansion joint	As rated	7.62 m (25 ft)
Seal assembly	As rated	15.24 m (50 ft)
Sealing space out joint	As rated	15.24 m (50 ft)
Seal bore extension	As rated	15.24 m (50 ft)
Telescoping swivel sub	As rated	3.05 m (10 ft)

Table C.1—Minimum Stroke Distance Requirements Based on Completion Accessory

Other completion accessories not listed in Table C.1 that are rated for stroke length (3.68) shall also meet the requirements of Annex C for the selected design validation grade. Test to the maximum rated stroke distance (3.67), which is greater than or equal to the minimum required stroked distance as defined in Table C.1.

C.2 Grade V6: Supplier/Manufacturer-defined

The supplier/manufacturer shall define the design validation procedures and acceptance criteria. These documented results shall be approved by a qualified person and validate the product's design ratings and capabilities.

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.

- Test to the maximum rated stroke distance (3.67).
- Use a liquid test medium per 6.5.3.1. 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 (3.66) 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.

— Test to the maximum rated stroke distance (3.67).

- Product shall be stroked while maintaining a minimum of 50 % of the rated internal differential pressure. Use a liquid test medium per 6.5.3.1.
- Run entire test at or above maximum rated temperature and with pressure applied internally to the product.
- Products shall be pressure tested to only one pressure reversal at each end of the stroke (3.66) 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 (3.67).
- Product shall be stroked while maintaining a minimum of 50 % of the rated internal differential pressure.
 Use a liquid test medium per 6.5.3.1.
- Run entire test at or above maximum rated temperature and with pressure applied internally to the product.
- 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 (3.67).
- Product shall be stroked while maintaining a minimum of 50 % of the rated internal differential pressure.
 Use a gas test medium per 6.5.3.1.
- Run entire test at or above maximum rated temperature and with pressure applied internally to the product.
- 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

- Test to the maximum rated stroke distance (3.67).
- Product shall be stroked while maintaining a minimum of 50 % of the rated internal differential pressure. Use a gas test medium per 6.5.3.1.
- Run entire test at or above maximum rated temperature and with pressure applied internally to the product.
- 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 (3.67).
- Product shall be stroked while maintaining a minimum of 50 % of the rated internal differential pressure. Use a gas test medium per 6.5.3.1.
- 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 or 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 V5 to V0.
- Scaling shall not be used to cover a product with more number of strokes than the tested product for grades V3 to 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/Closing 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.

Table D.1—Minimum Cycle and Unloading Pressure Requirements Based on Completion Accessory

Completion According	Minimum Cycles and Unloading Pressure Requirements ^a		
Completion Accessory	V6, V5, and V4	V3, V2, V1, and V0	
Fill valve	As rated	Three cycles at 345 kPa (500 psi)	
Sand control sliding sleeve	As rated	Three cycles at 345 kPa (500 psi)	
Sliding sleeve	As rated	Three cycles at 345 kPa (500 psi)	
Unloader sub	As rated	Three cycles at 345 kPa (500 psi)	
^a Products that are rated for one opening/closing only shall be opened/closed once.			

Other completion accessories not listed in Table D.1 that are rated for the following functionalities shall also meet the requirements of Annex D for the selected design validation grade:

- unloading pressure (3.83);
- number of open/close cycles (3.45).

The maximum rated open/close cycles and maximum unloading pressure for validation grades V3 to V0 shall be greater than or equal to the minimum rated open/close cycles and minimum unloading pressure in Table D.1 for each completion accessory.

D.2 Grade V6: Supplier/Manufacturer-defined

The supplier/manufacturer shall define the design validation procedures and acceptance criteria. These documented results shall be approved by a qualified person and validate the product's design ratings and capabilities.

D.3 Grade V5: Single Open/Close Plus Liquid Test

- Products that are rated for pressure unloading shall be tested at the maximum rated unloading pressure when opening. Use a liquid test medium per 6.5.3.1.
- Products shall be opened once per the supplier/manufacturer's documented procedure.
- Products shall be closed once per the supplier/manufacturer's 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 per 6.5.3.1. The sealing devices shall be completely covered by liquid prior to start of the unloading test. Using a gas cap charge, or other means to maintain unloading pressure, a volume of liquid equal to or greater than the volume of the tool must pass through the port(s) during unloading.
- Products shall be opened once per the supplier/manufacturer's documented procedure.
- Products shall be closed once per the supplier/manufacturer's 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

- Products that are rated for unloading pressure shall be tested at the maximum rated unloading pressure when opening. Use a liquid test medium per 6.5.3.1. The sealing devices shall be completely covered by liquid prior to start of the unloading test. Using a gas cap charge, or other means to maintain unloading pressure, a volume of liquid equal to or greater than the volume of the tool must pass through the port(s) during unloading.
- Products that are rated for multiple open/close cycles shall be opened and closed the maximum rated number of cycles and per the supplier/manufacturer's documented procedure.
- Products that are rated for one opening only shall be opened once per the supplier/manufacturer's documented procedure.
- Products that are rated for one closing only shall be closed once per the supplier/manufacturer's 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.

- Products that are rated for unloading pressure will be tested at the maximum rated unloading pressure when opening. Use a gas test medium per 6.5.3.1. 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/manufacturer's documented procedure.
- Products that are rated for one opening only shall be opened once per the supplier/manufacturer's documented procedure.
- Products that are rated for one closing only shall be closed once per the supplier/manufacturer's 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

- Products that are rated for unloading pressure shall be tested at the maximum rated unloading pressure when opening. Use a gas test medium per 6.5.3.1. 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/manufacturer's documented procedure.
- Products that are rated for one opening only shall be opened once per the supplier/manufacturer's documented procedure.
- Products that are rated for one closing only shall be closed once per the supplier/manufacturer's 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.

- Products that are rated for unloading pressure will be tested at the maximum rated unloading pressure when opening. Use a gas test medium per 6.5.3.1. 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/manufacturer's documented procedure.
- Products that are rated for one opening only shall be opened once per the supplier/manufacturer's documented procedure.
- Products that are rated for one closing only shall be closed once per the supplier/manufacturer's 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 and corresponding flow port area 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 to V0.

Annex E

(normative)

Identification and Explanation of Deviations

E.1 Introduction

The API Subcommittee on Completion Equipment (SC19) that voted to adopt ISO 14998:2013(E) as American National Standard ANSI/API Specification 19AC has determined that the following modifications were necessary. These deviations from the ISO standard have been incorporated directly into the text and marked with a change bar in the margin.

E.2 List of Modifications

#	Clause/Subclause	Modifications		
	1 Scope	Added quality requirements to the functional specifications and technical specifications.		
1	Explanation: The existing scope w listed in section 7.4	Explanation: The existing scope was missing the requirement for quality requirements, but they are listed in section 7.4		
2	1 Scope	Added nonpressure-containing tools to this International Standard.		
2	Explanation: Because not all convalidation, this functionality was additionality was additionality was additionality was additional to the second s	mpletion accessories are pressure containing but may require detected to the Scope of this standard.		
3	1 Scope	Removed references to ISO standards listed by standard number and replaced with API or other international specifications.		
	Explanation: To allow for future covered, this statement was made	documents that may cover specific accessories not currently broader to allow for future changes.		
	1 Scope	Control lines and fittings and all functionalities relating to electronics or fiber optics were omitted from this specification.		
4	Explanation: These tools do not meet the definition of "completion accessories" as defined in the document. The application and operation of the tools was excluded as this document pertains to functional and technical specifications of these products and not the use of the product.			
_	2 Normative References	Added the API and ASNT specifications listed in this specification.		
5	Explanation: Updated normative references to match API and ASNT specifications added to the document.			
6	3 Terms and Definitions	Added the following definitions: entry (reentry) guide, extension (spacer) sub, filter mandrel, indicator, one-piece mandrel, parting tool, sand control expansion joint, sand control sliding sleeve, sealing space out joint, temporary pressure-retaining device.		
	Explanation: Due to the vast number of completion accessories, definitions were added to address functionalities that were not defined in ISO 14998.			
7	3 Terms and Definitions	Removed the following definitions: free-passage, heat traceable, sour service, standard service, and wireline entry guide.		
	Explanation: These definitions we	re removed because they were not used in the document.		

#	Clause/Subclause	Modifications	
8	3 Terms and Definitions	Updated the following definitions: casing, design verification, inflow control devices, mill-out extension, pressure reversal, redress, seal bore extension, sliding sleeve, surface-controlled downhole choke, surface-controlled sliding sleeve, temperature cylce range, tubing seal receptacle, and tubing size.	
	Explanation: These definitions we	re modified to add clarity.	
9	3.43 one-piece mandrel	Defined as mandrel or completion accessory that does not have leak paths excluding the end connections. NOTE Welded one-piece mandrels are outside the scope of this definition.	
	Explanation: Definition was add nonpressure-containing completion	led to assist the user in determining the requirements of accessories.	
	4 Acronyms and Abbreviations	Added: UNS Unified numbering system.	
10	Explanation: UNS was added to material chemical composition.	6.3.3.2.1 as an optional means to define the metal	
	5.2 Functional Type Description	Removed primary and secondary functionality language.	
11	Explanation: The primary and second to be identified by the user/purchas	ondary functionally was removed for clarity. All functionalities are er.	
	5.2 Functional Type Description	Expanded list of tools to match Table 3 based on functionality.	
12	Explanation: The list of tools and functionality type was expanded to provide further guidance.		
12	5.5.2 Well Environment	Replaced the use of "standard service" and "sour service" with "compliance with ANSI/NACE MR0175/ISO 15156."	
15	Explanation: Replaced "shall" with could be an audit finding.	n "should" because this information is not always available and	
	5.5.3 Material Designation	Replaced the use of "standard service" and "sour service" with "compliance with ANSI/NACE MR0175/ISO 15156."	
14	Explanation: The requirements for standard and sour service are covered in ANSI/NACE MR0175/ISO 15156.		
	5.6 Compatibility with Related Well Equipment	Added that the user/purchaser shall identify "any supplemental and/or annex requirements required in an internationally recognized standard such as API 5CT or API 5CRA."	
15	Explanation: Incomplete information related to compatibility with related well equipment may be used unless requirement that the user/purchaser also include any supplemental requirements for the OCTGs.		
10	6.3.3.1 General	Replaced "service" with ANIS/NACE MR0175/ISO 15156 compliance.	
16	Explanation: "Material substitution" was defined as a temporary change to provide clarity.		
	6.3.3.1 General	Defined a material substitution as a temporary change in a bill of material.	
17	Explanation: "Material substitution temporary change, the material documentation shall be included in	n" was defined as a temporary change to provide clarity. As a substitution must meet requirements of 6.4, and supporting the manufacturing records.	

#	Clause/Subclause	Modifications	
	6.3.3.2.1 Specifications	Added UNS number to list.	
18	Explanation: UNS was added to p material chemical composition.	rovide the user/purchaser an optional means to define the metal	
10	6.3.3.2.2 Mechanical Property Verification	Mechanical property verification requirements by quality grade were removed.	
19	Explanation: Mechanical property changed to be invoked by contract.	y verification requirement by quality grade was removed and	
	6.3.4 Performance Rating	Added notes and example graph for defining performance envelopes of tools with elliptical envelopes.	
20	Explanation: Some products (typic envelope and follow an elliptical p provided to help the supplier/manua	cally of a single component) will not have a standard performance performance curve due to von Mises stresses. Guidance was facturer determine the maximum operational limit points.	
	6.4.1 General	Added conveyance and removal methods/tools to be part of design verification.	
21	Explanation: Conveyance and rem that all aspects of the completion a	noval methods/tools were included in design verification to ensure ccessory perform as specified.	
	6.4.2 Design Assumptions	Design assumptions were modified to include use of a documented methodology to align with other API documents.	
22	Explanation: To be consistent wit design assumptions were modified	h other API documents such as API 14A and API 11D1 HPHT, in this specification.	
	6.4.3 Design Calculations	Design calculation options were added for guidance.	
23	Explanation: Three methodologies for design calculations for completion accessories were added. These may also be used for "Validation by Design Calculation" for nonpressure-containing and one-piece mandrel completion accessories, per 6.5.2.		
24	6.5.1 General	Removed default validation grade if not selected by user/purchaser.	
	Explanation: Intention is for user/p	purchaser to specify the required validation grade.	
25	6.5.1 General and Table 1	Added requirements and guidance for testing nonpressure-containing completion accessories.	
23	Explanation: Because these acce requiring load and/or temperature v	ssories do not contain pressure, specific test requirements only vere developed for these accessories in Annex A, section A.2.	
	6.5.1 General	Added requirements for documentation of the validation testing results.	
26	6 Explanation: Added requirements for validation test procedure to have documented accept criteria and for documented material certifications for the validated tested product to be part o validation test results.		
27	6.5.1 General	Added Table 3 that lists completion accessories with their required test annexes based on tool functionality and guidance on pressure containing or nonpressure containing.	
	Explanation: To help aid the users of this document, Table 3 was added to guide the users as to which validation grades are required based on tool type.		
20	6.5.2 Validation by Design Calculation	Added options for design validation by calculation for one-piece mandrels or nonpressure-containing completion accessories.	
20	Explanation: Option was added accessories to avoid unnecessary results and the second secon	for one-piece mandrels or nonpressure-containing completion requirements for these simpler accessories.	

#	Clause/Subclause	Modifications	
	6.5.3.1 General	Address requirements for redressing tools when testing to multiple annexes.	
29 Explanation: As some completion accessories are required to be tested to multiple ann were put in place to ensure that the same critical components were used throughout the qualification.		accessories are required to be tested to multiple annexes, limits same critical components were used throughout the duration of	
	6.5.3.1 General	Moved test medium requirements from each annex to this section.	
30	Explanation: No changes were made to the requirement of liquid or gas testing. The requirements for test medium were moved to the general section so that each annex did not have to define the test medium. The requirements were reworded to follow the API 11D1 HPHT annex.		
31	6.5.3.1 General	Modified existing warning statement and moved it from the individual test annexes to the general section.	
	Explanation: Moved warning state	ment to the general section to help guide safety in all gas tests.	
32	6.7.1 General	Section 6.7.1 and 6.7.2 were combined and additional requirements were added to match the maximum stress levels of the Type 1 components of previously validated and scaled designs.	
	Explanation: Modified section on s parent design.	caling to strengthen the requirements and limit variation from the	
22	7.2.1 General	Added quality documentation retention to include those for repairs.	
55	Explanation: Strengthened the requirements for quality documentation to include repaired assemblies.		
34	7.2.2 Operating Manual	Added requirements for operating manual to include parts list, trouble shooting, installation instructions, and testing instructions.	
	Explanation: To improve usefulness of any Operating Manual to the user/purchaser, intended content was expanded.		
25	7.2.2 Operating Manual	Added requirements for redress and repair to include procedures, tools, and spare parts.	
30	Explanation: To improve usefulness of any Operating Manual to the user/purchaser, requirements for redress and repair were expanded to add more detailed information.		
	7.2.3 Product Datasheet	Replaced "supplied at delivery" with "available."	
36	Explanation: The broad range of completion accessories may not require delivery of product datasheets. New requirements require them to be available when requested rather than always delivered.		
27	7.2.3 Product Datasheet	Added minimum ID to be included in product datasheet.	
37	Explanation: The minimum ID strengthens the information included in the product datasheet.		
29	7.2.3 Product Datasheet	Changed mandatory inclusion of a performance envelope in the product datasheet for only validation grades V1 and V0.	
50	Explanation: Reduce unnecessary	r inclusion for lower validations.	

#	Clause/Subclause	Modifications	
	7.2.3 Product Datasheet	Replaced "service" with "ANIS/NACE MR0175/ISO 15156 compliance."	
39	Explanation: To keep consistent sour service were removed and rep	with commonly used standards, the definitions of standard and placed with references to ANSI/NACE MR0175/ISO15156.	
	7.2.3 Product Datasheet	Added "direction of unloading pressure (internal and/or external)" to ratings for opening a port in the conduit.	
40	Explanation: Added clarity so the requirements.	e user/purchaser can better match validation with operational	
41	7.4.1 General	Updated Table 4 to match new requirements for castings, metallic material, and NDE.	
	Explanation: Table 4, Summary requirements defined in the subsection	of Quality Requirements, was updated to match the new tions of section 7.4.	
42	7.4.1 General	Moved requirements for establishing and implementing specifications for all quality processes from section 7.4.14 to 7.4.1.	
	Explanation: To apply the broader	statement to all 7.4 quality requirements.	
42	7.4.2.2 Type 1 Components	Removed requirements for verification of MTR for Type 1/Q1 components.	
43	Explanation: Document was changed to remove this requirement for completion accessories, but can still be invoked by contract.		
	7.4.3 Castings	Strengthened requirements for castings to include an MTR for Q2 components and conformance with API 20A, CSL-3 for Q1.	
44	Explanation: Updated and increas standards.	sed the requirements of castings to better match other industry	
45	7.4.4.2.1 Furnace Calibration	Updated calibration requirements to meet an international or national standard such as SAE AMS-2750.	
45	Explanation: References to SAE intervals are to be defined by the st	AMS H6875 and BS 2M 54 were outdated. Furnace calibration andard.	
46	7.4.5 Component Traceability	Updated that Type 1 components be traced to heat per heat treat lot instead of heat.	
	Explanation: Task group consensus is "heat per heat treat lot" is the appropriately us term.		
47	7.4.7 Welds	Updated the requirements for welds and welders to meet the requirements of ASME <i>Boiler and Pressure Vessel Code</i> (<i>BPVC</i>), Section IX, or an equivalent international standard.	
	Explanation: The requirements were strengthened to meet the requirements of ASME <i>BPVC</i> Section IX or an equivalent.		
40	7.4.7 Welds	Limitations were added for weld repairs.	
48	Explanation: Due to the criticality repair welds were increased similar	of the service of completion accessories, the requirements on to API 11D1 HPHT requirements.	

54

#	Clause/Subclause	Modifications	
40	7.4.8 Hardness Inspection of Components	Added ASTM E10 and ASTM E18 to the list of reference standards.	
49	Explanation: Expanded the reference list of standards for hardness inspection.		
50	7.4.9 NDE of Components/Welds	Added requirements for volumetric NDE for Type 1 components and welds for Q1. Remaining section was reorganized for clarity.	
	Explanation: To ensure that the material used in Type 1 components was free of defects, volumetric NDE was added.		
54	7.4.9 NDE of Components/Welds	Added requirements for visual inspection of Type 1 welds for Q1 and Q2.	
51	Explanation: To increase inspection	on requirements on Type 1 welds for Q1 and Q2.	
	7.4.9 NDE of Components/Welds	Added requirements for qualification of Level III examiners.	
52	Explanation: To strengthen the qu	alifications of the examiners.	
52	7.4.11.1 General	Section format was modified to add a table of requirements with subsections to clarify requirements.	
53	Explanation: The layout was chat the format of the rest of the document	nged to include a table with subsections for clarity and to match	
F 4	7.4.11.2 Internal Pressure Test	Changed the internal pressure test for only pressure-containing completion accessories.	
94	Explanation: Nonpressure-containing completion accessories do not require an internal pressure test.		
55	7.4.11.4 External Diameter Inspection	Changed "maximum specified OD" to "gauge OD."	
55	Explanation: "Gauge OD" is the correct term by definition 3.26.		
56	7.4.11.6 Open/Close Operation	Removed requirement for tools that require a redress or repair after the test.	
90	Explanation: Redress or repair would invalidate the test and render it unnecessary.		
	8 Redress and Repair	Defined a redress of a component to activities after the original manufacture.	
57	Explanation: To ensure that the users of the document understand when a tool is considered redressed/repaired, the definition was updated to explain that this is only after the original manufacture of the tool.		
50	8 Redress and Repair	Corrected marking with "R" for repaired assemblies.	
58	Explanation: Previous text was incorrect; the "R" mark is to indicate a repaired assembly.		
59	Annex A, A.2 Nonpressure-containing Product Design Validation Requirements	Section was added for validation test requirements (V6 and V3) of nonpressure-containing completion accessories.	
	Explanation: Because these accessories do not contain pressure, specific test requirements only requiring load and/or temperature were developed for these accessories in Annex A, section A.2.		

#	Clause/Subclause	Modifications		
60	Annex A, A.3.2 Grade V6: Supplier/Manufacturer-defined	Strengthened V6 requirements to include design validation procedures and approval by a qualified person.		
	Explanation: Additional requireme validation grade.	nts were added to strengthen the supplier/manufacturer-defined		
61	Annex A, A.3.3 Grade V5: Liquid Test	Removed nonpressure-containing test requirements and moved test medium requirements and acceptance criteria to section 6.5.3.1.		
	Explanation: Annex A, A.2 was 6.5.3.1 was modified to include test	added to cover nonpressure-containing requirements. Section medium and acceptance criteria for all validation test grades.		
	Annex A, A.3.3, A.3.4, A.3.6, A.3.7, A.3.8	Excluded one-piece mandrels from these validation grades.		
62	Explanation: Annex A, A.3.2 and Section 6.5.2 also contains exception	A.3.5 are the only validation grades for one-piece mandrels. ons for one-piece mandrels.		
	Annex A, A.3.4 through A.3.8	Added requirements for testing tools with elliptical envelopes or combination of elliptical envelopes and intersecting points. Requirements for test medium and acceptance criteria were moved to section 6.5.3.1.		
63	Explanation: Some products (typically of a single component) will not have a standard performance envelope and follow an elliptical performance curve due to von Mises stresses. Guidance and requirements were provided to help the supplier/manufacturer. Section 6.5.3.1 was modified to include test medium and acceptance criteria for all validation test grades.			
	Annex B, B.1 General	Table was added showing completion accessory type and minimum requirements based on validation level.		
64	Explanation: Table was added to provide guidance as to which completion accessories require testing to this annex. The minimum requirements were added to aid the user/purchaser when comparing tools for operational use.			
	Annex B, B.2 Grade V6: Supplier/Manufacturer-defined	Strengthened V6 requirements to include design validation procedures and approval by a qualified person.		
65	Explanation: Additional requirements were added to strengthen the supplier/manufacturer-defined validation grade.			
66	Annex B, B.3 through B.8	Requirements for test medium and acceptance criteria were moved to section 6.5.3.1.		
	Explanation: Section 6.5.3.1 was modified to include test medium and acceptance criteria for all validation test grades.			
67	Annex B, B.3 through B.8	Added requirement that the completion accessory be disconnected/(re)connected at the maximum rated (re)connect temperature.		
	Explanation: Added for clarity to ensure that the tool was tested at the maximum rated temperature.			
	Annex B, B.3 through B.4	Removed notes on products rated for only one connection.		
68	3 Explanation: Notes were redundant with requirements of these validation grades.			

#	Clause/Subclause	Modifications		
	Annex C, C.1 General	Table was added showing completion accessory type and minimum requirements based on validation level.		
69	Explanation: Table was added to testing to this annex. The minimu comparing tools for operational use	ation: Table was added to provide guidance as to which completion accessories require to this annex. The minimum requirements were added to aid the user/purchaser when ng tools for operational use.		
70	Annex C, C.2 Grade V6: Supplier/Manufacturer-defined	Strengthened V6 requirements to include design validation procedures and approval by a qualified person.		
70	Explanation: Additional requirement validation grade.	nts were added to strengthen the supplier/manufacturer-defined		
74	Annex C, C.3 through C.4	Requirements for testing to maximum rated stroke distance added.		
/1	Explanation: Requirements to test	to maximum rated stroke distance added to each section.		
70	Annex C, C.3 through C.8	Requirements for test medium and acceptance criteria were moved to section 6.5.3.1.		
12	Explanation: Section 6.5.3.1 was validation test grades.	modified to include test medium and acceptance criteria for all		
72	Annex C, C.4 through C.8	Added clarity that internal differential pressure be maintained at a minimum of 50% of the rated pressure.		
15	Explanation: Added clarity to the internal pressure is maintained thro	test requirement to ensure that a minimum of 50% of the rated ughout the stroking of the completion accessory.		
74	Annex C, C.9 Limitations of Scaling Annex C Validation Tests	Strengthened scaling requirements to ensure that scaled tools are not rated to a higher number of strokes than the tested product.		
	Explanation: Requirements were of strokes tested tool.	Explanation: Requirements were added to ensure that scaled tools are rated to the same number of strokes tested tool.		
	Annex D, D.1 General	Table was added showing completion accessory type and minimum requirements based on validation level.		
75	Explanation: Table was added for clarity as to which completion accessories require testing to this annex. The minimum requirements were added to aid the user/purchaser when comparing tools for operational use.			
	Annex D, D.2 Grade V6: Supplier/Manufacturer-defined	Strengthened V6 requirements to include design validation procedures and approval by a qualified person.		
76	Explanation: Additional requirement validation grade.	nts were added to strengthen the supplier/manufacturer-defined		
77	Annex D, D.3 through D.4	Removed notes on products rated for only one opening/closing.		
//	Explanation: Notes were redundant with requirements of these validation grades.			
70	Annex D, D.3 through D.8	Requirements for test medium and acceptance criteria were moved to section 6.5.3.1.		
10	Explanation: Section 6.5.3.1 was validation test grades.	modified to include test medium and acceptance criteria for all		

#	Clause/Subclause	Modifications
79	Annex D, D.4 through D.5	Requirements for minimum volume of fluid to pass through the tool were added.
	Explanation: Validation shall ensure a sufficient volume of fluid pass through the ports during the test via the gas cap charge, or other means.	
80	Annex D, D.9 Limitations of Scaling for Annex D Validation Tests	Restricted variation to the flow port area to ± 5 %; removed single restriction to larger flow port area.
	Explanation: Strengthened the requirements for scaling to include stronger limitations on flow port area changes.	
81	Bibliography	Updated to include new references and removed outdated references.
	Explanation: Updated based on changes to the document.	
82	Annex F was added to the document.	

Annex F

(informative)

API Monogram Program Use of the API Monogram by Licensees

F.1 Scope

F.1.1 Applicability

This annex is normative (mandatory) for products supplied bearing the API Monogram and manufactured at a facility licensed by API; for all other instances it is not applicable.

F.1.2 General

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to products which comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street NW, Washington, DC 20005 or call (202) 682-8145 or by email at certification@api.org.

F.2 Normative References

In addition to the referenced standards listed earlier in this document, this annex references the following standard:

API Specification Q1, Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry

For Licensees under the Monogram Program, the latest version of this document shall be used. The requirements identified therein are mandatory.

F.3 API Monogram Program: Licensee Responsibilities

F.3.1 Monogram Program Requirements

For all organizations desiring to acquire and maintain a license to use the API Monogram, conformance with the following shall be required at all times:

- a) quality management system requirements of API Q1;
- b) API Monogram Program requirements of API Q1, Annex A;
- c) requirements contained in the API product specification(s) to which the organization is licensed; and
- d) requirements contained in the API Monogram Program License Agreement.

F.3.2 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following:

- a) products that do not conform to API specified requirements shall not bear the API Monogram;
- b) each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:
 - 1) define the authority responsible for application and removal of the API Monogram and license number;
 - 2) define the method(s) used to apply the Monogram and license number;
 - 3) identify the location on the product where the API Monogram and license number are to be applied;
 - 4) require the application of the date of manufacture of the product in conjunction with the use of the API Monogram and license number;
 - require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s);
 - 6) define the application of all other required API product specification(s) and/or standard(s) marking requirements.
- c) only an API licensee shall apply the API Monogram and its designated license number to API monogrammable products;
- d) the API Monogram and license number, when issued, are site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location; and
- e) the API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee's API Monogram marking procedure if the product is subsequently found to be out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the, API Monogram Program Alternative Marking of Products License Agreement, available on the API Monogram Program website at http://www.api.org/products-and-services/api-monogram-and-apiqr/apply-renew#tab_documents.

F.3.3 Design and Design Documentation

Each licensee and/or applicant for licensing shall maintain current design documentation as identified in API Q1 for all of the applicable products that fall under the scope of each Monogram license. The design document information shall provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s) and/or standard(s). The design documentation shall be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in Advisory #6, available on API Monogram Program website at

http://www.api.org/products-and-services/api-monogram-and-apiqr#tab_advisories.

F.3.4 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that an additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their conformance with the requirements of the applicable API product specification(s) and/or standard(s).

F.3.5 Use of the API Monogram in Advertising

An API Monogram licensee shall not use the API Monogram and/or license number on letterheads, buildings or other structures, websites or in any advertising without an express statement of fact describing the scope of Licensee's authorization (license number and product specification). The Licensee should contact API for guidance on the use of the API Monogram other than on products.

F.4 Product Marking Requirements

F.4.1 General

These marking requirements shall apply only to those API Licensees wishing to mark applicable products in conjunction with the requirements of the API Monogram Program.

F.4.2 Product Specification Identification

Manufacturers shall mark products as specified by the applicable API specifications or standards. Marking shall include reference to the applicable API specification and/or standard. Unless otherwise specified, reference to the API specifications and/or standards shall be, as a minimum, "API [Document Number]" (e.g. API 6A or API 600). Unless otherwise specified, when space allows, the marking may include use of "Spec" or "Std," as applicable (e.g. API Spec 6A or API Std 600).

F.4.3 Units

Products shall be marked with units as specified in the API specification and/or standard. If not specified, equipment shall be marked with U.S. customary (USC) units. Use of dual units [USC units and metric (SI) units] may be acceptable, if such units are allowed by the applicable product specification and/or standard.

F.4.4 Nameplates

Nameplates, when applicable, shall be made of a corrosion-resistant material unless otherwise specified by the API specification and/or standard. Nameplate shall be located as specified by the API specification and/or standard. If the location is not specified, then the licensee shall develop and maintain a procedure detailing

the location to which the nameplate shall be applied. Nameplates may be attached at any time during the manufacturing process.

The API Monogram and license number shall be marked on the nameplate, in addition to the other product marking requirements specified by the applicable product specification and/or standard.

F.4.5 License Number

The API Monogram license number shall not be used unless it is marked in conjunction with the API Monogram. The license number shall be used in close proximity to the API Monogram.

F.5 API Monogram Program: Nonconformance Reporting

API solicits information on products that are found to be nonconforming with API specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification and/or standard deficiencies or nonconformities against API specified requirements. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.aspx.

Bibliography

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- [4] ANSI ⁷/ASQ Z1.4 ⁸, Sampling Procedures and Tables for Inspection by Attributes
- [5] ASME Boiler and Pressure Vessel Code (BPVC)⁹, Section V: Nondestructive Examination
- [6] ASME Boiler and Pressure Vessel Code (BPVC), Section VIII: Rules for Construction of Pressure Vessels; Division 3: Alternative Rules for Construction of High Pressure Vessels
- [7] ASTM D1415¹⁰, Standard Test Method for Rubber Property—International Hardness
- [8] ASTM D2240, Standard Test Method for Rubber Property—Durometer Hardness
- [9] ASTM E10, Standard Test Method for Brinell Hardness of Metallic Materials
- [10] ASTM E18, Standard Test Methods for Rockwell Hardness of Metallic Materials
- [11] ASTM E165, Standard Practice for Liquid Penetrant Examination for General Industry
- [12] ASTM E709, Standard Guide for Magnetic Particle Testing
- [13] SAE AMS-2750E¹¹, *Pyrometry*
- [14] ANSI/NCSL Z540-3¹², Requirements for the Calibration of Measuring and Test Equipment
- [15] ISO/IEC 17025¹³, General Requirements for the Competence of Testing and Calibration Laboratories
- [16] ISO 10893-4, Non-destructive testing of steel tubes—Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections
- [17] ISO 10893-5, Non-destructive testing of steel tubes—Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections
- [18] API Specification Q1, Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry
- [19] API Specification 11D1, Packers and Bridge Plugs

⁶ International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland, www.iso.org.

American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

⁸ American Society for Quality, 600 North Plankinton Avenue, Milwaukee, Wisconsin 53203, www.asq.org.

⁹ ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

¹⁰ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

¹¹ SAE International (formerly the Society of Automotive Engineers), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

¹² NCSL International, 5766 Central Avenue, Suite 150, Boulder, Colorado 80301, www.ncsli.org.

¹³ International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, www.iec.ch.


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