API 19 MAT

This draft document for comments only. The deadline for submission of comments is August 20, 2024.

Guidance on Materials and Quality Requirements for Development of Completion Equipment Standards

Introduction

This document has been developed by subject matter experts in metallic materials, non-metallic materials and Quality from the user/operator, supplier/manufacturer, and consulting communities. This document is intended to be a guideline for materials and quality requirements within SC19 standards for downhole completion equipment. This document is not intended as a specification for equipment, materials selection, or to establish individual requirements.

Use of sections of this document, as appropriate, will allow for greater standardization of materials and quality requirements within SC19 equipment specifications and is at the discretion of the individual product specification working group.

This guidance was developed as potential additions or inserted text in a product specification. Individual task groups within SC19 should harmonize the content of this document with current product specifications and determine the final requirement(s).

This document is not intended to replace sound engineering judgment or knowledge of the specific equipment in the standard being created or revised. Each task group shall review sections of 19MAT and incorporate in part, in whole, or modify to suit the individual product specifications.

As used in this document, the terms ‘shall’ and ‘should’ only have meaning when the text from this document is included within a product specification. The task group responsible for developing individual equipment specifications should review and consider all instances of ‘shall’ and ‘should’ and make an appropriate determination of requirements and recommendations.

1 Scope

This document applies to metallic materials, non-metallic materials, and quality requirements used in downhole completion equipment in the petroleum and natural gas industry. It provides a suggested template of requirements for equipment standards under SC19, including guidance for materials, environmental compatibility, welding, NDE, and quality control.

This document does not include requirements for equipment verification and validation which are included in the equipment specifications. It also does not provide guidance for materials selection or establish individual materials property requirements. Materials produced by additive manufacturing, are not addressed herein.

NOTE: This document is not intended to be specified or referenced. It is intended to be cut and pasted in part, or in entire sections, and modified as applicable to the specific product needs. It is not intended as additive text or replacement text in existing and new SC19 standards.

2 Normative References

The following referenced documents should be considered for inclusion in the normative reference section of the parent document if used in the text below.

AMPP NACE MR0175 [1], *Petroleum and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production—Parts 1, 2, and 3* (Identical to ISO 15156-1:2009.15156-2:2009, and 15156-3:2009)

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

ASNT SNT-TC-1A [2], *Personnel qualification and certification in nondestructive testing*

ASME *Boiler and Pressure Vessel Code* (*BPVC*) [3], *Section V: Non-destructive examination*

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section VIII; Division 1; UW-51: Radiographic Examination of Welded Joints*

ASME *Boiler and Pressure Vessel Code* (*BPVC*), *Section IX: Welding and Brazing Qualifications*

ASTM A370, *Standard Test Methods and definition for Mechanical Testing of Steel Products*

ASTM A388/A388M [4], *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

ASTM A609/A609M, *Standard Practice for Castings, Carbon, Low-alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof*

ASTM D297, *Standard Test Methods for Rubber Products—Chemical Analysis*

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

[3] ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

[4] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM D395, *Standard Test Methods for Rubber Property—Compression Set*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension*

ASTM D429, *Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates*

ASTM D624, *Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D792, *Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement*

ASTM D1414, *Standard Test Methods for Rubber O Rings*

ASTM D1415, *Standard Test Methods for Rubber Property—International Hardness*

ASTM D1708, *Standard Test Method for Tensile Properties of Plastics by Use of Micro-tensile Specimens*

ASTM D2240, *Standard Test Methods for Rubber Property—Durometer Hardness*

ASTM D6147, *Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomer—Determination of Force Decay (Stress Relaxation) in Compression*

ASTM E8, *Standard Test Methods for Tension Testing of Metallic Materials*

ASTM E10, *Standard Test Methods for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E23, *Notched Bar Impact Testing of Metallic Materials*

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E140, *Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness*

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

ASTM E186, *Standard Reference Radiographs for Heavy Walled [2 to 4 1/2 in. (51 to 114 mm)] Steel Castings*

ASTM E280, *Standard Reference Radiographs for Heavy Walled [4 1/2 to 12 in. (114 to 305 mm)] Steel Castings*

ASTM E384, *Standard Test Methods for Microindentation Hardness of Materials*

ASTM E446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness*

ASTM E709, *Standard Guide for Magnetic Particle Examination*

ISO 34-2 [5], *Rubber, vulcanized or thermoplastic—Determination of tear strength—Part 2: Small (Delft) Test Pieces*

ISO 37, *Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties*

ISO 48, *Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 527-1, *Plastics -- Determination of tensile properties -- Part 1: General principles*

ISO 815-1, *Rubber, vulcanized or thermoplastic -- Determination of compression set -- Part 1: At ambient or elevated temperatures*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

ISO 2781, *Rubber, vulcanized or thermoplastic -- Determination of density*

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 3384-1, *Rubber, vulcanized or thermoplastic -- Determination of stress relaxation in compression -- Part 1: Testing at constant temperature*

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

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

ISO 6506-1, *Metallic materials—Brinell hardness test—Part 1: Test method*

ISO 6507-1, *Metallic materials—Vickers hardness test—Part 1: Test method*

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6892-1, *Metallic materials—Tensile testing—Part 1: Method of test at room temperature*

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

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

ISO 15156 (all parts), *Petroleum and natural gas industries—Materials for use in H_2S containing environments in oil and gas production*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO 10893-4 *Non-destructive testing of Steel Tubes – Part 4*

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

ISO 10893-5 *Non-destructive testing of Steel Tubes – Part 5*

ISO 23936-1:2009, *Petroleum, petrochemical and natural gas industries—Non-metallic materials in contact with media related to oil and gas production—Part 1: Thermoplastics*

ISO 23936-2:2011, *Petroleum, petrochemical and natural gas industries—Non-metallic materials in contact with media related to oil and gas production—Part 2: Elastomers*

SAE AS568, *Aerospace Size Standard for O-Rings*

SAE AMS 2750 [6], *(R) Pyrometry*

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.1 Terms and Definitions

For the purposes of this guidance document, the following terms and definitions should be considered for inclusion in the terms and definitions section of the parent document if used in the text below.

3.1.1
coating/plating
A surface layer that provides improved protective, decorative, change, or a combination thereof, to the functional properties of a substrate material.

(API 20P)

NOTE 1: This can be applied by a vapor, liquid, liquefiable, or mastic composition that, after application to a surface, is converted into a solid protective, decorative, or functional adherent film.

NOTE 2: Coatings / Platings, which includes paints, can be:

- sprayed;
- thermally diffused;
- plated; or
- applied with hand tools (specific to the surface, environment, and application goals).

NOTE 3: Some Surface Treatments may be considered Coatings.

3.1.2
compound
Combination of constituent elements of the formulation of a non-metallic material from a particular supplier.

3.1.3
critical characteristic

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

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

A dimension, property, or aspect of a component or assembly that is deemed by the Supplier / manufacturer's Engineering group to be critical to the design.

3.1.4
design acceptance criteria
(DAC)
Requirements applied to characteristics or combinations of those characteristics, of materials, products, or
Components to achieve conformity to the specified design requirements and/or required design performance.

(API Q1)

3.1.5
environment
Set of conditions to which the product is exposed.

3.1.6
environmentally assisted cracking
The degradation of metallic materials' properties (especially toughness reduction) upon exposure to a specific environmental condition.

Examples include: 1) Hydrogen Embrittlement (HE), 2) Stress Corrosion Cracking (SCC), and 3) Corrosion Fatigue (CF)

3.1.7
heat
material originating from a final melt or cast lot having the same chemistry.

NOTE: For re-melted alloys, the heat is the raw material originating from a single re-melted ingot.

3.1.8
heat treatment
heat treating
heating and cooling a solid metal or alloy in such a way as to obtain desired properties

NOTE : Heating for the sole purpose of hot working is not considered heat treatment.

3.1.9
heat treat lot
group or quantity of piece parts, sub-assemblies or assemblies that are grouped or processed together during the heat treatment process.

3.1.10
job lot
material or components having undergone the same process or series of processes as a single production lot.

3.1.11
qualified person
Individual or individuals with characteristics or 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.

3.1.12
sour service
Exposure to oilfield environments that contain H_2S and can cause cracking of materials by the mechanisms addressed in AMPP NACE MR0175.

NOTE Adapted from AMPP NACE MR0175-1.

3.1.13
stress corrosion cracking
Cracking of metal involving anodic processes of localized corrosion and tensile stress (residual and/or applied) in the presence of water and dissolved halides and/or H_2S.

NOTE Dissolved halide salts, H_2S, O_2 and/or other oxidants, and elevated temperature increase the susceptibility of metals to this mechanism of attack.

3.1.14
stress relief
heating of a material to a predetermined and controlled temperature and duration/time for the purpose of reducing residual stresses.

3.1.15
sulfide stress cracking
Cracking of metal involving corrosion and tensile stress (residual and/or applied) in the presence of water and H_2S.

NOTE: Sulfide stress cracking is a form of hydrogen stress cracking and involves embrittlement of the metal by atomic hydrogen that is produced by acid corrosion on the metal surface. Hydrogen uptake is promoted in the presence of sulfides. The atomic hydrogen can diffuse into the metal, reduce ductility, and increase susceptibility to cracking. High strength metallic materials and hard weld zones are prone to Sulfide stress cracking.

[AMPP NACE MR0175-1]

3.1.16
Type 1
Welds or metallic components that isolate pressure and/or may be loaded in tension as the result of axial loads on the product.

3.1.17
Type 2
Welds or Metallic components that are not classified as Type 1.

3.2 Acronyms, Abbreviations, and Symbols

COC	certificate of conformance
CRA	Corrosion Resistant Alloy
HRC	Rockwell C hardness
ID	inside diameter

MTR	material test report
NDE	nondestructive examination
OD	outside diameter
QMS	quality management system
L	length
t	thickness

4 Functional Specification

Environmental Compatibility

The following shall be identified to ensure environmental compatibility as applicable:

a) Production/injection/annulus fluid chemical and physical composition, including solids (sand production, scale, etc.), to which the equipment is exposed during its full operating life.

b) In cases where the user/purchaser has access to corrosion-property historical data and/or research that is applicable to the functional specification, the user/purchaser should state to the supplier/manufacturer which materials have the ability to perform as required within the anticipated service environment.

c) It is the equipment user/purchaser's responsibility to ensure that any material specified for use is satisfactory in the service environment. If the user/purchaser requires analysis for metals beyond conformance with AMPP NACE MR0175 in sour service, then those fluids, contaminants, and testing/qualification requirements shall be specified in the functional specification.

NOTE 1: AMPP NACE MR0175 provides guidelines for selection of metallic materials in sour service for cracking resistance. AMPP NACE MR0175 prescribes laboratory testing procedures and methodologies that can qualify alloys for general use in all environments or as fit-for-service testing for a project specific environment. The standard addresses the following environmental variables: the minimum in situ water pH, the maximum chloride concentration, the maximum partial pressure of H_2S in the gas phase, minimum and maximum temperatures, and the presence of solid elemental sulfur. It is important to consider both the immediate short-term environment and changes that may occur in the longer term, such as increases in the partial pressure of H_2S due to reservoir souring from water injection.

NOTE 2: API 13TR1 Provides guidance on brine compatibility.

d) Non-metallic materials, if required by the User / Purchaser, shall be evaluated in accordance with the supplier/manufacturer's documented procedures or other relevant international standards as agreed upon between the user/purchaser and supplier/manufacturer for suitability.

NOTE: Any known characteristics of the well or well operations that would negatively impact the materials used in the equipment being provided.

5 Technical Specification

5.6 Materials

5.6.1 General

a) All materials used for equipment construction shall be documented by the supplier/manufacturer and be suitable for the functional specification. The supplier/manufacturer shall have documented specifications for all materials. All materials used shall conform to those specifications.

b) The user/purchaser may specify materials for the specific environment in the functional specification. If the supplier/manufacturer proposes to use another material, the supplier/manufacturer shall state that this material has performance characteristics suitable for all parameters specified in the well and production/injection parameters. This applies to metallic and nonmetallic components.

c) Material substitution is a temporary (not permanent) change to a production bill of material for a validated component which does not change the rating of the product. These temporary material substitutions are allowed without re-validation. The supplier / manufacturer's selection criteria for these substitutions shall be documented and the substituted material shall conform to the design, functional, and technical requirements of the component / equipment.

d) Material substitutions require approval by a qualified person from the supplier/manufacturer and the supporting documentation incorporated into the manufacturing records for those units affected. In cases where the user/purchaser specifies material(s) of construction, deviations from such materials shall require user/purchaser notification and approval

5.6.2 Metals

5.6.2.1 The supplier/manufacturer’s specifications for Type 1 components shall define those characteristics critical to the performance of the material, such as the following, when applicable:

a) chemical-composition limits;

b) heat treatment and/or cold work condition;

c) melting practice;

d) mechanical-property limits, as applicable:

   1) tensile strength,

   2) yield strength,

   3) elongation,

   4) hardness

   5) Charpy impact toughness

NOTE 1 Test methods are defined in Section 6.3.8.2

NOTE 2 Materials loaded primarily in compression typically do not have design requirements for yield strength, tensile strength, or elongation.

5.6.2.1 Specified mechanical properties shall be determined by tests conducted on a representative sample from the same heat (such as prolongation or sacrificial part). The material test sample shall experience the same thermomechanical processing and be heat treated with the same material it represents. For remelt materials the sample shall be from the same final remelt heat. The mechanical property results shall be documented on a certified material test report (MTR) (see 6.*3.11*).

5.6.2.2 Separate test pieces removed prior to heat treatment may be utilized as representative samples with a documented and validated test procedure, when permitted by applicable specifications or by the equipment user.

5.6.2.3 When compliance to AMPP NACE MR0175 is specified, the metallic materials and weldments shall comply with the material requirements of AMPP NACE MR0175 (as applicable).

NOTE 1: Castings – When pressure-containing castings are employed, the specification of API 20A can provide guidance.

NOTE 2: Fasteners – When load-bearing bolting materials are employed, the specification of API 20E (alloy and carbon steel bolting) or API 20F (corrosion-resistant bolting) can provide guidance.

5.6.3 Nonmetals

5.6.3.1 General

The supplier/manufacturer shall have documented procedures, including acceptance criteria, for evaluation or testing non-metal materials (e.g. polymeric seals) to the limits for which the component is rated.

NOTE: API 20L requirements may be considered for supplier qualification of polymeric seals.

Verification or validation shall establish that the non-metal seal or other component used is suitable for the specific configuration, environment and application. The evaluations or tests shall conform with the technical and functional requirements and shall consider mechanical loads, applied pressure, temperature range, design geometry, sealing environment, and required service life.

5.6.3.2 Elastomeric Compound Assessment

Assessment of elastomeric compounds shall take into consideration:

a. If required in the functional specification, an ageing evaluation shall be conducted by the supplier/manufacturer to evaluate the cumulative effects of an environment on an elastomeric material per ISO 23936-2, Clause on “requirements for aging tests” or in accordance with the supplier/manufacturer’s documented testing procedure compliant to an industry specification and agreed to by the user/purchaser. This evaluation may include the determination of potential service life. The exposure test temperatures shall meet or exceed the maximum rated operating temperature of the equipment.

   Fluids and other test conditions such as temperature and pressure, as well as boundary condition for material coupons, shall be agreed between the equipment purchaser and the equipment supplier. A standard simulated production fluid for either sweet or sour, either single phase or multiphase are listed in ISO 23936-2 and can be referred for conducting compound qualification test. If not specified, the acceptance criteria for the ageing test shall meet ISO 23936-2 as a minimum.

   The test condition shall not introduce different degradation mechanism at elevated temperatures, it may require longer testing time to reveal or prove long term performance of a compound if testing at elevated temperatures introduces a different degradation mechanism (e.g. thermal degradation)) compared to what is expected at the application temperature. Excessively high temperature could introduce thermal degradation deteriorate the material beyond chemical reaction. Also exposure to higher temperature could activate chemistry between material and aging medium that would not be present in well condition.

b. If required in the functional specification, a rapid gas decompression evaluation shall be conducted by the supplier/manufacturer on an elastomeric material per ISO 23936-2. The recommended acceptance criteria shall be a rating of 0 or 1 for the seal component cross section if user/purchaser does not specify an acceptance criterion. Fluid composition, test temperatures, test pressures, and depressurization rate shall be specified in the user/purchaser functional specification.

c. Scaling shall be conducted per applicable API equipment standard. Additional material qualification/requalification because of the scaling may be required.

   NOTE: Specific grades of elastomers and raw materials used to make elastomers can affect environmental resistance

   Caution should be exercised for the following aspects:

- Test temperature and duration are sufficient to demonstrate real trends
- Samples are fully saturated in target aging fluid before chemical aging begins
- Samples were properly cured or vulcanized before aging data is used for life prediction

d. The appropriate mechanical property is used for lifetime prediction. The test condition shall not introduce different or unexpected degradation mechanism at elevated temperatures. It may require longer testing time to reveal or prove the long-term performance.

5.6.3.3 Thermoplastic Compound Assessment

Assessment of elastomeric compounds shall take into consideration:

a. If required by the user/purchaser, an aging evaluation shall be conducted by the supplier/manufacturer to evaluate the cumulative effects of an environment on the thermoplastic per the supplier/manufacturer's documented testing procedure compliant to an industry specification and agreed to by the user/purchaser. This evaluation may also include the determination of an effective service life. The service temperature shall meet or exceed the maximum rated operating temperature of the equipment,

b. Fluids and other test conditions such as temperature, pressure, and boundary conditions of material coupons, shall be agreed between the equipment purchaser and the equipment supplier. A standard simulated production fluid for either sweet or sour, either single phase or multiphase are listed in ISO 23936-1 and can be referred for conducting compound qualification test. The acceptance criteria for the aging test shall be agreed between the parties.

Caution should be exercised for the following aspects:

- Test temperature and duration are sufficient to demonstrate real trends
- Samples are fully saturated in hydrocarbon fluid before chemical aging begins
- Samples are in a stable state of crystallinity before aging data is used for life prediction

c. The appropriate mechanical property is used for lifetime prediction. The test condition shall not introduce different degradation mechanism at elevated temperatures, it may require longer testing time to reveal or prove the long-term performance.

5.6.3.4 Bonding to Substrates (Bonded Seals)

Nonmetallic seal components may be bonded to substrates for additional reinforcement or to perform other functions. If the bond of the nonmetallic to the substrate is critical to performance, the integrity of the bond shall be evaluated in the same manner as the performance of the seal component itself per the supplier/manufacturer's defined methods and acceptance criteria. The allowable failure modes, percentage of bonding and/or adhesion strength shall be defined by the equipment supplier/manufacturer. If required by the user/purchaser in the functional specification, a temperature/chemical ageing evaluation on the bond line strength shall be conducted.

NOTE: ASTM D429 and ASTM D413 provide methods for adhesion testing.

Substrate metals shall conform to the requirements for metallic components; non-metallic substrates shall conform to the requirements for non-metallic components.

5.6.3.5 Nonmetallic Components Physical and Mechanical Property Verification

The supplier/manufacturer shall have written specifications for nonmetallic components that shall include handling, packaging, storage, and labelling requirements, including material type, the cure date for elastomers, batch number, material identification, and shelf life appropriate to each material, and shall define those characteristics critical to the performance of the material. It is recommended to verify the mechanical and/or physical property of the nonmetallic material per the supplier/manufacturer's documented testing procedures or per industry specifications listed in Table 1.

6 Quality Control

6.1 General

Quality control work shall be controlled by documented instructions that include, or reference, acceptance criteria. All documents and records that show conformance to this document shall be controlled and maintained in accordance with the requirements of API Q1.

There are three quality grades or levels that may be specified by the user / purchaser. Quality requirements are summarized in Table 1.

6.2 Quality Grades / Levels

6.2.1 Quality Level 1 – The highest level of quality verification

6.2.2 Quality Level 2 – An intermediate level of quality verification

6.2.3 Quality Level 3 – Minimum level of quality verification

If the user / purchaser does not specify the applicable Quality Level, the minimum of QL3 level shall be supplied.

Table 1 Standard Quality Requirements

Requirements	Quality Grade Requirements		
	QL1	QL2	QL3
	Requirement	Requirement	Requirement
Metallic raw material Properties – Type 1	MTR and COC	MTR and COC	MTR and COC
Metallic raw material Properties – Type 2	COC	COC	Per Supplier / Manufacturer requirements
Bonded Seals	Test Report	COC	COC
Non-metallic material Properties	MTR COC	COC	COC
Heat treatment	Heat treatment certificate showing time and temperature for each step. COC	COC	COC

Documentation for validated processes: (e.g. coatings, welding and brazing)	COC	COC	COC
Component traceability – Type 1	Unique serialization	Job-lot identification	Job-lot identification
Component traceability – Type 2	Job-lot identification	Job-lot identification	Per Supplier / Manufacturer requirements
Inspection Requirement: Welding – Type 1	100 % of Type 1 welds NDE inspected	Sampling of Type 1 welds NDE inspected	Per Supplier / Manufacturer requirements
Inspection Requirement: Welding – Type 2	Visual Inspection Per Supplier / Manufacturer requirements	Visual Inspection Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements
Assembly Traceability	Unique serialization Required for each unit	Job Lot Serialization	Per Supplier / Manufacturer requirements
Hardness – Type 1	100 % of Type 1 components after final machining prior to coating / plating	Sampling hardness inspection of Type 1 components after final machining prior to coating / plating	Per Supplier / Manufacturer requirements
Hardness – Type 2	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements
Component NDE – Type 1	100 % of Type 1 components	Sampling of Type 1 components	Per Supplier / Manufacturer requirements
Component NDE – Type 2	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements
Component dimensions– Type 1	100 % of components inspected	Sampling	Sampling
Component dimensions– Type 2	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements
Visual inspection of Type 1 components	100 % of components inspected	Sampling	Per Supplier / Manufacturer requirements
Visual inspection of Type 2 components	Sampling	Per Supplier / Manufacturer requirements	Per Supplier / Manufacturer requirements
Shear Devices and Burst Discs	Shear verification Burst Disc verification	Shear verification Burst Disc verification	Shear verification Burst Disc verification
Assembly Verification – See Warning below	Pressure Test Functional Test ID Drift	Pressure Test Functional Test ID Drift	Per Supplier / Manufacturer requirements

	OD Drift Torque documentation when specified	OD Drift Torque Documentation when specified	
Document Retention	API Q1 unless Equipment Standard requires longer.	API Q1 unless Equipment Standard requires longer.	API Q1 unless Equipment Standard requires longer.
NOTE 1: Where sampling is allowed above, it shall be performed in accordance with clause 6.3 NOTE 2: The product groups to determine which Assembly Verification tests are applicable to their products.			

6.3 Sampling

Sampling plan inspections , when allowed by Table 1, shall be performed within the following limitations.

6.3.1 The supplier/manufacturer shall have a documented sampling plan procedure and the inspections performed shall have the same practices and acceptance criteria as the 100% inspections.

6.3.2 Unless specified elsewhere, the lot or batch being sampled shall conform to the limits defined in Table 2. Sampled units shall be randomly selected and shall be inspected according to the supplier/manufacturer's documented specifications. For the purpose of these sampling requirements “Random” is defined as all items having an equal chance of being selected for examination.

6.3.3 Alternately an AQL of 2.5 can be applied, which follows the requirements of a national or international specifications such as ISO 2859-1 or ANSI / ASQ Z1.4 and the supplier/manufacturer's documented variation history. A minimum of four units from each lot or batch shall be inspected, unless the lot or batch includes less than 4 units where all shall be inspected.

6.3.4 Sampling plans of component inspections shall conform to the applicable section(s) of 6.2 and the supplier/manufacturer's documented procedures, including the applicable acceptance criteria.

6.3.5 In the event that one component of a sampled lot or batch is identified as non-conforming in any of the applied inspections, the entire lot or batch shall be inspected utilizing the identical procedures.

6.3.6 Components identified as non-conforming in the inspections shall be dispositioned as defined in the supplier/manufacturer's QMS.

6.3.7 Nonmetals - Sampling procedures and the basis for acceptance or rejection of a batch lot shall be in accordance with ISO 2859-1, general inspection level II at a 2.5 AQL for O-rings and a 1.5 AQL for other seal components. For other non-metallic components the requirements for O-rings shall be utilized until a documented variation history can be established and a sampling procedure determined based on the documented variation history.

Table 2 Sampling Plan Unit Count Requirements

Identifier	Total number of units in the Lot or batch	Minimum number of inspected units
I	2 to 8	4 units where available
II	9to 50	8 units
III	51 to 90	13 units
IV	91 to 150	20 units
V	151 to 280	32 units
VI	281 to 500	50 units
VII	501 to 1200 or more	80 units
Based upon ANSI/ASQ Z1.4 Table 1, General inspection level II information		

6.3.8 Mechanical and Physical Properties

6.3.8.1 Nonmetals

6.3.8.1.1 Mechanical and bonding properties required by the material specification shall be validated by test conducted on a material sample produced from the same batch of material. Properties to be considered are noted in Table 3. When required by the material specification, testing shall be performed as noted in Table 3.

Adhesion of bonded seals shall be tested in accordance with ASTM D429 utilizing a sample of 1 per job lot.

Table 3 Nonmetallic Material Property Verification

Elastomer	Material properties, when specified	Test Standard
	Tensile strength (at break) and tensile modulus (at 50 % or 100 %, as applicable)	ASTM D412, ASTM D1414 (O-ring) or ISO 37
	Elongation (at break)	ASTM D412, ASTM D1414 (O-ring) or ISO 37
	Durometer hardness	ASTM D2240, ASTM D1415 (O-ring) or ISO 48
	compression set (periodically)	ASTM D395, ASTM D1414 (O-ring) or ISO 815-1
	Optional	
	Density/specific gravity	ASTM D297 or ISO 2781
	Compression relaxation	ASTM D6147 or ISO 3384-1, ISO 6056 (O-ring)
	Tear resistance	ASTM D624 or ISO 34-2
	Tensile or compressive data for FEA analysis	Supplier/manufacturer's procedure
Thermoplastics	Recommended	Test Standard
	Yield strength or tensile strength	ASTM D638, ASTM D1708 or ISO 527-1
	Elongation at yield or at break	ASTM D638 or ISO 527-1
	Durometer hardness	ASTM D2240 or ISO 48
	Optional	
	Density/specific gravity	ASTM D792 or ISO 1183-1
	Modulus of elasticity	ASTM D638 or ISO 527-1

6.3.8.2 Metals Testing

6.3.8.2.1 Mechanical Testing

- Tensile testing shall be in accordance with ISO 6892-1 or ASTM E8 or A370 for the metallic materials used for traceable components. When testing at elevated temperatures ASTM E21 shall be used.
- Charpy testing shall be in accordance with ASTM E23 (ISO 148) or ASTM A370.

The tensile and Charpy testing samples shall be taken from material that is from the same heat / heat treat lot for the components it represents.

6.3.8.2.2 Hardness Testing

6.3.8.2.2.1 Hardness testing shall be in accordance with:

a) ISO 6506-1 or ASTM E10 for Brinell Test

b) ISO 6508-1 or ASTM E18 for Rockwell Test

c) Microhardness testing per ISO 6507-1 or ASTM E384 may be used if ISO 6506-1 or ISO 6508-1 cannot be applied due to size, accessibility, or other limitations.

6.3.8.2.2.2 When hardness testing is performed on a finish-machined component and the final surface condition will not permit hardness indentations, the testing may be performed on a separate test coupon that has been heat treated in the same heat treat lot and is of the same heat as the material it represents.

6.3.8.2.2.3 Hardness conversion to other measurement units shall be in accordance with ASTM E140, with the stipulations noted in AMPP NACE MR0175 for materials that are intended for use in sour service. Supplier/manufacturer may establish documented correlations for individual materials not covered in ASTM E140.

NOTE AMPP NACE MR0175 is equivalent to ISO 15156 (all parts)

6.3.8.3 Heat Treatments

6.3.8.3.2 General

Heat treatment of raw material and production parts shall be performed according to documented procedures with heat treating equipment that has been surveyed per 6.4.1. Calibration shall be in accordance with 6.4.2

If heat treatment is performed by a subcontractor, the subcontractor shall provide a COC to the supplier/manufacturer stating that the heat treatment meets the supplier/manufacturer's documented specifications. For QL 1 a Heat Treat certificate is also required showing time and temperature for each step.

Samples from each individual heat in each heat treat lot of material shall be tested for conformance to the mechanical properties specified in the supplier / manufacturer's material specification.

NOTE Heat treatment includes operations such as normalizing, austenitize / quenching, tempering, solution annealing, annealing, or aging.

Stress relieving requires only hardness testing to demonstrate conformance with the hardness requirements of the supplier/manufacturer's specifications. A record of time and temperature is required for QL1.

6.3.8.3.3 Furnace Instrumentation

The requirements for furnace instrumentation are as follows:

a) automatic controlling and recording instruments shall be used.

b) thermocouples shall be located in the furnace working zone(s) and protected from furnace atmospheres; where practical, thermocouples shall also be attached to the material being heat treated and used for the determination of attaining the required temperatures and times.

c) temperature controlling and recording instruments used for the heat treatment processes shall possess an accuracy of at least ±1 % of their full-scale range.

d) Furnace instrumentation shall be calibrated in accordance with 6.4.2

Note: Compliance with API 20H or API 20N satisfies the requirements of this section.

6.3.9 Processes That Require Validation

The organization shall validate processes when the resulting output cannot be verified by subsequent monitoring or measurement, and consequently, deficiencies become evident after the product has been delivered or is in use. Validation shall demonstrate the ability of these processes to achieve planned results. The following processes require validation:

6.3.9.1 Coatings / Plating when determined to be critical to the operating design.

The application of coatings shall be controlled using documented procedures, acceptance criteria, and qualified personnel. Certificates of conformance to these specifications shall be supplied with finished components.

Any surface treatment/coating used in sour service shall comply with requirements of AMPP NACE MR0175,as applicable.

NOTE 1: API 20P can provide guidance for approving suppliers of Plating / Coating and some surface treatments.

NOTE 2: Steel Structures Painting Council (SSPC) and AMPP (NACE) standards can be used for guidance in surface preparation and inspection.

NOTE 3: Specific industry standards for post process heat treatments can be used for guidance where applicable.

6.3.9.2 Welding and Brazing

Welding including overlays and brazing shall require the following:

a) welding and brazing procedure and personnel qualification shall be in accordance with ASME *BPVC* Section IX or equivalent.

b) weld materials and practices not listed in the ASME *BPVC* Section IX shall be applied using weld procedures qualified in accordance with the methods of ASME *BPVC* Section IX or equivalent.

c) in addition to the above, welding for sour service components shall meet the requirements of AMPP NACE MR0175/ISO 15156.

NOTE: API 20G can provide additional guidance for welding and brazing.

6.3.9.3 Heat Treatment

Heat treatment shall be controlled using documented procedures, acceptance criteria, qualified personnel, and equipment per 6.3.8.3

NOTE: API 20H and 20N can be used for guidance on heat treatment.

6.3.9.4 Nondestructive Examination

Nondestructive Examination shall be controlled using documented procedures, acceptance criteria, qualified personnel, and equipment per 6.5.

NOTE: API 20D can be used for guidance on Nondestructive Examination

6.3.9.5 Process Changes

Changes to processes listed in 6.3.9 that affect the results of that process shall require.

6.3.10 Traceability and Documentation

6.3.10.1 All Type 1 components, weldments, subassemblies, and assemblies necessary for the performance of the product to meet the design acceptance criteria (DAC) (3.1.3) shall be traceable per the requirements in Table 1 for the applicable quality level. Type 1 components and weldments shall have their included heat(s) or Heat Treat lot lot(s) identified.All Type 2 assemblies, components, weldments and subassemblies of equipment supplied shall, as a minimum, be traceable to a job lot.

6.3.10.2 Traceability marking shall be in accordance with the supplier/manufacturer's documented procedures.

6.3.10.3 Traceability for equipment is considered sufficient if the equipment meets the requirements of this specification when it leaves the supplier/manufacturer's facility for shipment to the user / purchaser.

6.3.11 Material and Process Certifications

6.3.11.1 Raw Material

Raw material used in the manufacture of components shall meet the requirements of 1 and 2:

1) COC stating that the raw material meets the supplier/manufacturer's documented specifications. COC's shall note the specifications and revision levels utilized for testing and be traceable to the material or services it represents. The issuer of the COC must have access to the documents, e.g. mill test reports, inspection records, manufacturing records, etc., that show conformance to the requirements. These documents shall be made available to the manufacturer / supplier upon request.

2) MTR so that the supplier/manufacturer can verify that each batch of raw material meets their documented specifications. MTRs shall note the specifications and revision levels utilized for testing.

6.3.11.2 Outsourced Processes

6.3.11.2.1 Outsourced processes that require validation shall, as a minimum:

1) Identify the items to which the COC applies, e.g. purchase order and serial number.

2) Identification of the standards and specifications, including revision levels, used in the process.

3) Have a statement that all requirements of the purchase order have been met. The supplier shall maintain the applicable records showing conformance to the requirements.

4) Be signed, or otherwise authenticated, by a qualified person authorized by their company to issue the COC.

6.3.11.2.2 Outsourced processes not requiring validation

Components or assemblies undergoing external processes at a subcontractor shall require the following:

1) a COC stating the materials and/or processes meet the supplier/manufacturer's documented specifications.

2) records indicating that the materials or processes meet the supplier/manufacturer's requirements.

6.3.12 The issuer of the COC or MTR must have access to the documents, e.g. mill test reports, inspection records, manufacturing records, etc., that show conformance to the requirements. These documents shall be made available to the manufacturer / supplier upon request.

6.3.13 MTRs provided by the material sub-supplier or the supplier/manufacturer are acceptable documentation of mechanical properties. MTRs shall be legible and reproducible and shall be an original or direct copy of a document unaltered as issued by its source. MTRs shall contain records of mechanical property testing showing conformance to the supplier/manufacturer's specifications and shall be approved by a qualified person.

6.3.14 Documentation shall be maintained as prescribed by the equipment standard, API Q1, or the supplier / manufacturer requirements whichever is more stringent.

6.4 Calibration Systems

6.4.9 Furnace Calibration

Each furnace shall have been surveyed within one year prior to heat treating operations or whenever a significant repair / modification has been made. Batch-type and continuous-type heat treating furnaces shall be calibrated in accordance with SAE AMS 2750 or another equivalent internationally recognized standard.

In addition to the requirements of 6.4.2, temperature-controlling and temperature-recording instruments shall be calibrated at least once every three months.

NOTE: Conformance with API 20H or API 20N satisfies requirements of this section

6.4.10 Measuring/Testing Equipment Calibration

6.4.2.1 Inspection, measuring, and testing equipment shall be used only within its calibrated range and shall be identified, controlled, calibrated, and adjusted at specific intervals in accordance with written procedures that are based on manufacturer's standards, or internationally recognized standards such as ISO / IEC 17025.

6.4.2.2 Technologies for inspections with verifiable accuracies less than those listed in this standard may be applied with appropriate documentation and when approved by a qualified person(s).

6.4.3.3 Calibration intervals for measuring and testing equipment shall be established based on repeatability, amount of usage, environment and past history for that type of instrument. For standard, adjustable, hand measurement tools the initial calibration interval shall be three months until a recorded calibration history for that instrument can be established. Intervals may then be lengthened or shortened. The calibration interval cannot be increased by more than twice the previous interval and shall not exceed more than one year.

6.4.3.4. Non-standard, or non-adjustable measurement devices such as surface plates, threaded plug / ring gauges, co-ordinate measuring machines, optical comparators, etc. shall be calibrated initially and the calibration interval set based on equipment type, usage, and operating environment. Calibration intervals shall not exceed three years for this type of equipment.

6.4.3.5 Calibration standards used to calibrate measuring equipment shall be checked and approved at least once every three years by qualified individuals using qualified equipment with traceability to the applicable national or international standards agency.

6.4.3.6 Instruments and calibration standards that have not been used during the calibration interval and that have been maintained in accordance with defined practice may have their calibration cycle extended for an amount equal to the designated cycle.

6.4.3.7 Pressure measuring devices shall be:

a. readable to at least ±0.5 % of full-scale range;
b. calibrated to maintain ± 2% accuracy of full-scale range.

6.4.3.8 Pressure measuring devices shall only be used within the calibrated range and be calibrated with a master pressure measuring device or a dead weight tester. Spring style pressure gauges shall only be used within 25% to 75% of the gauge range. Calibration intervals for pressure measuring devices shall be a maximum of three months until documented calibration history can be established. Calibration intervals shall then be established based on repeatability, degree of usage, environment, and documented history.

6.4.3.8 Temperature measuring devices shall be calibrated in accordance with SAE AMS 2750, Pyrometry, to an accuracy of 0.25% of the full range and be readable to at least 1°. Equipment used to calibrate the production equipment shall possess an accuracy of ±0.25 % of the useable full-scale range.

6.4.3.10 Measuring devices used for the dimensional inspection shall provide sufficient accuracy to minimize the measurement uncertainty. Where practical the measurement uncertainty shall not exceed 25% of the characteristic's tolerance limit. The measurement uncertainty may be determined through measurement studies, equipment manufacturer's accuracy statements, calibration certificates, or other recognized methodologies deemed appropriate by a qualified person.

6.5. Nondestructive Examination

6.5.1. General Requirements

6.5.1.1. All NDE procedures shall be approved by a Level III examiner qualified in accordance with ISO 9712 or ASNT-TC-1A.

6.5.1.2. Type 1 welds shall be magnetic particle or liquid penetrant inspected for surface defects and shall be volumetrically inspected by radiographic and / or ultrasonic techniques to verify conformance with the supplier/manufacturer's written specifications. Final NDE shall be performed after all welding, post-weld heat treatment (including stress relief), and applicable machining operations on welded areas. If the machining creates a geometry that does not permit 100% inspection for the volumetric inspection, it may be performed prior to the machining, or at an intermediate geometry that permits 100% coverage.

NOTE: It is not recommended that liquid penetrant examination be used on braze joints as residual penetrant may negatively impact the ability to perform a rework on the braze joint.

6.5.1.3. Type 1 components manufactured from castings or wrought products (including wrought raw materials) shall be volumetrically inspected by radiographic and / or ultrasonic techniques after heat treatment for properties, but prior to any machining that may interfere with 100% evaluation. Magnetic particle or liquid penetrant inspection shall be performed after final machining (includes stress relief when performed) for surface defects.

6.5.1.4. The durometer hardness of O-rings or other elastomeric seal components shall be determined in accordance with ISO 48 or ASTM D 2240. Sampling shall meet the requirements of 6.3.

NOTE: For the purposes of these provisions, ASTM D1415 is equivalent to ISO 48.

6.5.1.5. Personnel performing NDE evaluations and interpretations for methods other than leak testing and visual inspection shall be qualified in accordance with ISO 9712 or SNT-TC-1A, to at least Level II, or equivalent. Personnel performing visual or leak testing shall be qualified in accordance with the supplier / manufacturer's documented requirements.

6.5.1.6. Personnel performing NDE, visual or leak test examinations shall have an annual eye examination, as applicable to the discipline to be performed, in accordance with ISO 9712 or SNT-TC-1A.

6.5.1.7. All other personnel performing inspection for acceptance shall be qualified in accordance with the supplier / manufacturer's documented requirements.

6.5.2. Radiography

6.5.2.1. Radiographic inspection of weldments shall be carried out as follows:

a. method: in accordance with ASTM E94;

b. acceptance criteria: in accordance with ASME BPVC Section VIII, Division 1, UW-51.

6.5.2.2. Radiographic inspection of castings shall be carried out as follows:

a. method: in accordance with ASTM E94;

b. acceptance criteria:

1) in accordance with ASTM E186, when applicable

2) in accordance with ASTM E280, when applicable

3) in accordance with ASTM E446.when applicable
4) The maximum defect severity levels for Items .1, .2, and .3 above are given in Table 4

Table 4—Maximum Defect Severity Levels for Castings

Defect Category	Maximum Defect Severity Level
A	2
B	2
C (all types)	2
D	None acceptable
E	None acceptable
F	None acceptable
G	None acceptable
NOTE: The defect categories, types, and severity levels are defined in ASTM E186, ASTM E280, and ASTM E446, as applicable.	

6.5.2.3. Radiographic Inspection of wrought products shall be carried out as follows:

a. Method in accordance with ASTM E94.

b. Acceptance criteria of which any of the following defects shall be basis for rejection:
   1) any type of crack or lap**,**
   2) any other elongated indication with length, L, and wall thickness, t, as follows:
   3) L > 6.4 mm (1/4 in.) for t ≤ 19 mm (3/4 in.),
   4) L > 1/3t for 19 mm < t ≤ 57.2 mm (3/4 in. < t ≤ 2 1/4 in.),
   5) L > 19 mm (3/4 in.) for t > 57.2 mm (2 1/4 in.).
   6) any group of indications in a line that have an aggregate length greater than t in a length of 12t.

6.5.3.Ultrasonic Inspections

6.5.3.1. Ultrasonic Inspection of Weldments shall be carried out as follows:
a. method: in accordance with ASME BPVC Section V, Article 4;
b. acceptance criteria:

   1) indications characterized as cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length;

   2) other imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths that exceed:

      1. L > 6.4 mm (1/4 in.) for t ≤ 19 mm (3/4 in.),

      2. L > 1/3t for 19 mm < t ≤ 57.2 mm (3/4 in. < t ≤ 2 1/4 in.),

      3. L > 19 mm (3/4 in.) for t > 57.2 mm (2 1/4 in.);

      4. Where *t* is the thickness of the weld excluding any allowable reinforcement.

      5. For a butt weld joining two members having different thicknesses at the weld, *t* is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

      6. For welds that include a fillet weld, the thickness of the throat of the fillet shall be included in *t.*

6.5.3.2. Ultrasonic Inspection of Castings shall be carried out as follows:

a. method: in accordance with ASTM A609;

b. acceptance criteria: in accordance with ASTM A609 at an ultrasonic testing quality level 1, minimum.

6.5.3.3. Ultrasonic inspection of forgings and wrought products shall be carried out as follows:

a. The method utilized shall be in accordance with the requirements of ASTM A388 using the following calibration methods, as appropriate to the item geometry:

1) flat bottom hole technique (may be used for all geometries): the distance amplitude curve shall be based on a 1.6 mm (1/16 in) flat bottom hole for thicknesses up to , and including 38 mm (1-1/2 in), 3.2 mm (1/8 in.) flat bottom hole for thicknesses from 38 mm (1-1/2 in) through 150 mm (6 in.) and a 6.4 mm (1/4 in.) flat bottom hole for thicknesses greater than 150 mm (6 in.),

2) angle beam technique (when required, and under the constraints, noted in ASTM A388): the distance amplitude curve shall be based on a notch of a depth equal to the lesser of 9.5 mm (3/8 in.) or 3 % of the nominal section thickness [9.5 mm (3/8 in.) maximum], a length of approximately 25.4 mm (1 in.) and a width no greater than twice its depth;

b. acceptance criteria: any of the following forging or wrought product defects shall be basis for rejection:

1) For flat bottom hole technique: indications equal to or larger than the indications observed from the calibration flat bottom hole,

2) For angle beam technique: amplitude of the discontinuities exceeding those of the reference notch.

6.5.3.4. Ultrasonic Inspection of Tubulars shall be carried out as follows:

a. The method utilized shall be in conformance with ASTM A388 or ASTM E213 utilizing the calibration and acceptance requirements from 5.6.6.3 above.

b. If ASTM E213 is utilized then the straight beam testing of A388 shall also be performed.

6.5.3.5. Magnetic Particle Inspections

6.5.3.5.1. Wet Magnetic Particle Examination as follows:

a. method: in accordance with ISO 10893-5 or ASTM E709;

b. relevant indications:

1) indications with major dimensions greater than 1.6 mm (1/16 in.),

2) linear indication is any indication in which the length is equal to or greater than three times its width,

3) rounded indication is any indication which in which the length is less than three times its width;

c. acceptance criteria:

1) any relevant indication greater than or equal to 4.8 mm (3/16 in.) shall be considered unacceptable,

2) no relevant linear indications shall be allowed,

3) no more than 10 relevant indications shall be present in any 39 cm^2 (6 $in.^2$) area,

4) four or more rounded relevant indications in a line separated by less than 1.6 mm (1/16 in.) shall be considered unacceptable.

6.5.3.6. Liquid Penetrant Inspections

6.5.3.6.1. Liquid penetrant inspection shall be carried out as follows:

a. method: in accordance with ISO-10893-4 or ASTM E165;

b. relevant indications:

1) indications with major dimensions greater than 1.6 mm (1/16 in.),

2) linear indication is any indication in which the length is equal to or greater than three times its width,

3) rounded indication is any indication which in which the length is less than three times its width;

c. Acceptance criteria:

1) no relevant linear indications;

2) no relevant rounded indications greater than 5 mm (3/16 in.)

3) no more than four or more relevant rounded indications in a line separated by 1.6 mm (1/16 in.) or less (edge to edge).

4) no more than 10 relevant indications shall be present in any 39 cm^2 (6 $in.^2$) area.

6.6. Visual Inspections

6.6.1. The supplier/manufacturer shall have documented procedures, including acceptance criteria, for visual inspection of all accessible surfaces for defects and damage before assembly of the equipment. Visual acceptance criteria to be in accordance with the supplier / manufacturer's documented requirements.

6.6.2. Visual inspection of O-rings shall be in accordance with ISO 3601-3 Class S. Other seal components shall be visually inspected in accordance with the supplier/manufacturer's documented specifications. Sampling shall meet the requirements of 6.3.

NOTE: MIL STD 413 has been rescinded and replaced by ISO 3601-3.

6.7. Component Dimensional Inspection

6.7.1. On Type 1 components, 100% of the dimensional characteristics specified on a component drawing on 100% of the components is required. Inspection shall be performed during or after the manufacture of the components but prior to assembly, unless assembly is required for proper measurement. Non-conformances shall be dispositioned in accordance with the supplier's documented procedure on control of nonconforming material.

NOTE: Broken edges can be considered under the visual criteria.

6.7.2. Dimensional tolerances of elastomeric O-rings shall be in accordance with ISO 3601-1. Other seal components shall meet dimensional tolerances of the supplier/manufacturer's written specifications. Sampling shall meet the requirements of 6.3.

NOTE: For the purposes of this provision, SAE AS568B is equivalent to ISO 3601-1, Class A.

6.8. Shear Device Verification

At least one Shear Device per Heat / Heat-Lot shall be sheared in accordance with the supplier / manufacturer's documented procedure to verify the shear values meet the documented specification.

6.9. Burst Disc Verification

At least one Burst Disc from each manufactured lot shall be ruptured in accordance with the supplier / manufacturer's documented procedure to verify that the burst pressure meets the documented specification.

6.10. Assembly Verification

6.10.1. General

6.10.2. The product specification groups need to define the actual requirements for assembly verification. General areas to be considered are as follows:

6.10.2.1. Pressure Test
6.10.2.2. Functional Test
6.10.2.3. ID Drift – this includes defining drift bar requirements
6.10.2.4. OD Drift – this includes defining drift equipment requirements

6.10.2.5. Torque Verification and recording of value(s). Actual torque values for all connections where torque values are specified shall be recorded and verified to be within the supplier/manufacturer's documented specifications.

7. Storage and Preparation for Transport

Caution shall be taken to protect components and final products from deterioration and damage during storage and shipment. Additional protection shall be provided to prevent the inadvertent contact of Corrosion Resistant Alloys (CRA) materials with alloy / carbon steels where there may be a transfer of free iron to the CRA material.

Bibliography

[1] AIAG FMEA [7], *Potential Failure Mode and Effects Analysis*

[2] ANSI/ASQ Z1.4: Sampling Procedures and Tables for Inspection by Attributes

[3] API Technical Report 1PER15K-1, *Protocol for Verification and Validation of High-pressure, High-temperature Equipment*

[4] API 13TR1 *Stress Corrosion Cracking of Corrosion Resistant Alloys in Halide Brines Exposed to Acidic Production Gas*

[5] ISO/TS 29001:2003 [8], *Petroleum, petrochemical and natural gas industries—Sector-specific quality management systems—Requirements for product and service supply organizations*

[6] API Bulletin 5C3, *Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties*

[7] API Recommended Practice 5C5, *Recommended Practice on Procedures for Testing Casing and Tubing Connections*

[8] API Bulletin 6J, *Testing of Oilfield Elastomers (A Tutorial)*

[9] API Recommended Practice 17C, *Recommended Practice on TFL (Through Flowline) Systems*

[10] API Specification 20A, Carbon Steel, Alloy Steel, and Nickel Base Alloy Castings for use in the Petroleum and Natural Gas Industry

[11] API Standard 20H, Heat Treatment Services – Batch Type for Equipment Used in the Petroleum and Natural Gas Industry

[12] API Standard 20N, Heat Treatment Services – Continuous Line for Equipment Used in the Petroleum and Natural Gas Industry

[13] API Standard 20P, Qualification of Applicators of Coating / Plating Services for Equipment Used in the Petroleum and Natural Gas Industry

[14] API Specification 20E, Alloy and Carbon Steel Bolting for use in the Petroleum and Natural Gas Industry

[15] API Specification 20F, Corrosion Resistant Bolting for use in the Petroleum and Natural Gas Industry

[16] API Standard 20L, Qualification of Polymeric Seals *for Use in the Petroleum and Natural Gas Industry*

[17] *API Standard 20D, Qualification of Nondestructive Examination Services for Equipment Used in the Petroleum and Natural Gas Industry*

[7] Automotive Industry Action Group, 26200 Lahser Road, Suite 200, Southfield, Michigan 48033-7100, www.aiag.org.

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

[18] API Specification 11D1, *Packers and Bridge Plugs*

[19] API Specification 19G1, *Side-pocket Mandrels*

[20] API Specification 19G2, *Flow-control Devices for Side-pocket Mandrels*

[21] API Specification 19G3, *Running Tools, Pulling Tools, and Kick-over Tools and Latches for Side-pocket Mandrels*

[22] API Specification 19G4, *Practices for Side-pocket Mandrels and Related Equipment*

[23] API Specification 19V, *Subsurface Barrier Valves and Related Equipment*

[24] API Specification 20D, *Nondestructive Examination Services for Equipment Used in the Petroleum and Natural Gas Industry*

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

[26] API Technical Report 6J1, *Elastomer Life Estimation Testing Procedures*

[27] ASME *Boiler and Pressure Vessel Code* (*BPVC*) [9], *Section II*: *Properties (Customary) Materials*

[28] ASTM D413, Standard Test Methods for Rubber Property—Adhesion to Flexible Substrate

[29] IEC 60812 [10], *Analysis techniques for system reliability—Procedure for failure mode and effects analysis (FMEA)*

[30] ISO 10414-1, *Petroleum and natural gas industries—Field testing of drilling fluids—Part 1: Water based fluids*

[31] ISO 10432, *Petroleum and natural gas industries—Downhole equipment—Subsurface safety valve equipment*

[32] ISO 13665, Seamless and welded steel tubes for pressure purposes—Magnetic particle inspection of the tube body for the detection of surface imperfections

[33] ISO 13679, *Petroleum and natural gas industries—Procedures for testing casing and tubing connections*

[34] ISO 13879, *Petroleum and natural gas industries—Content and drafting of a functional specification*

[35] ISO 14998, *Petroleum and natural gas industries—Downhole equipment—Completion accessories*

[36] ISO 17050, *Supplier's declaration of conformity assessment (Parts 1 and 2)*

[37] ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

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

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

[38] ISO/TS 16949, *Quality management systems—Particular requirements for the application of ISO 9001:2008 for automotive production and relevant service part organizations*

[39] SAE ARP 5580-2001 21 [11], *Recommended Failure Modes and Effects Analysis (FMEA) Practices for Non-Automobile Applications*

[40] SAE J1739, *Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)*

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