7.2.14 Operating Sealing Components and Consumables

Identification of non-wellbore nonmetallic components, such as elastomeric seals used in ram and annular type BOP actuation systems, shall be in accordance with the manufacturer written specifications.

Ram assemblies and operators shall be provided with a separate certificate showing conformance or compatibility (where applicable).

Specialized components, including proprietary design BOP seals and packing units, shall be stored in accordance with the OEM/CEM recommendations.

7.2.15 Drift Test

A drift test shall be required on ram BOP, annular BOP, hydraulic connectors, drilling spools, and adapters.

After the closed-preventer test, a drift mandrel shall be passed through the bore of the assembly after all pressure testing, with no external force being applied to the drift.

Annular drift testing shall occur within 30 minutes after closing pressure has been removed, with no external force being applied to the drift.

Drift mandrel dimensions shall be in conformance with API 16A.

7.2.16 Visual Inspection

After final acceptance, testing equipment shall be visually inspected for wear or damage and results shall be recorded.

7.3 Dimensional Check

For repair and remanufacture, the sealing dimensions shall be within product definition (OPD/CPD) tolerances.

Corrosion shall be removed and parts dimensionally verified to be in conformance with the product definition (OPD/CPD)

Wear tolerances defined in the product definition (OPD or CPD) shall be used to verify if the part is suitable for service.

Dimensional checks shall include the following as a minimum:

— wear of all critical sealing surfaces as defined in the product definition,

— flange and bore dimensions,

— pressure-retaining components,

— pressure-controlling components,

— any critical areas per the product definition.

Dimensions shall be documented by a technician who is competent to record and take measurements in accordance with the established QMS.

7.4 NDE—Initial Inspection

The following inspections shall be performed before proceeding with remanufacture of equipment.

— All parts that require remanufacturing or any pressure-containing and pressure-controlling parts with unknown hardness values shall be hardness tested as per 4.5.2.

— All well-fluid-wetted surfaces shall be inspected by magnetic particle inspection (MPI) or dye penetrant inspection (DPI).

— All welds shall be inspected by MPI or DPI.

— External surfaces shall be 100 % visually inspected and any anomalies further investigated with MPI or DPI.

— Unacceptable indications, as per 4.5, found with MPI or DPI shall be removed.

If full weld records are not available, all machined surfaces of the components with missing records shall be acid etched to determine the location of previous welds.

7.5 Inspection on Closure Bolting (Pressure Retaining)

If closure bolting traceability is lost as defined in the API 16A, that bolting shall be replaced.

If closure bolting or other closing devices are intended for reuse, they shall undergo a thorough inspection that includes:

— wet particle MPI or DPI of the threads and non-threaded areas of the part,

— hardness measurements on bolts and nuts,

— threads (internal/external) inspection for wear and stretch,

— bolt holes threads inspected for wear and stretch,

— bolt holes verified for weld repairs and etched when traceability of repairs has been lost,

— full-dimensional inspection of the closure bolting.

7.6 Visual Inspection at Disassembly

All parts shall be 100 % visually inspected and includes but is not limited to:

— critical wear areas and body structure,

— all threaded lifting bolt holes,

— sealing surfaces,

— door/bonnet assembly alignment,

— straightness of parts,

— flatness of seal areas,

— damage to running surfaces,

— corrosion/pitting.

7.7 Replacement Parts

All replacement parts shall be designed and manufactured to meet or exceed the requirements of Annex J and API 16A.

Replacement parts shall be documented in the PHF. Unique markings of the part shall provide the traceability that allows verification of the part design status.

Equipment shall be reassembled in accordance with documented specifications of the manufacturer.

7.8 General Equipment Specifications

Equipment repaired and/or remanufactured under API 16AR shall meet the general equipment standard in conformance with Annex A.

7.9 Documentation

Repair and remanufacture activities performed on the product shall be fully documented, supported by the required certification, and added to the PHF as defined in Annex B and Annex C.

Documentation shall provide traceability as required under API 16A.

7.10 Failure Reporting

The owner of drill-through equipment shall provide a failure notification to the equipment remanufacturer if equipment failure investigation is required.

The remanufacturer shall, on request of the equipment owner, provide a failure report of any malfunction or failure that occurs in conformance with Annex D.

8 Materials

8.1 General

Unless specified differently in this standard, material requirements shall be in conformance with API 16A.

NOTE Exclusion may apply to equipment manufactured before 1986 that may be in conformance with API 6A.

Equipment manufactured under API 6A and from which material traceability records do not contain impact test results shall be considered RSL 1 and shall reference API 6A, 13th Edition in the certification.

This section describes the performance, processing and compositional requirements for materials used in:

— pressure-containing parts or members,

— pressure-controlling parts or members,

— pressure-retaining parts,

— all other parts.

All parts shall as a minimum satisfy the OPD or CPD design requirements for the product repaired and/or remanufactured under this standard.

Metallic materials exposed to wellbore fluids and gases shall meet the design requirements of NACE MR0175/ISO 15156 (all parts). Permitted exclusions allow shear blades not to be sulfide stress cracking (SSC) resistant. For shear blades that do not conform to these hardness limitations, their suitability for, and their sealing capability in, SSC environment are the responsibility of the user.

8.2 Metallic Parts

A written material specification shall be required for all new manufactured parts or parts to a weldment of metallic pressure-containing, pressure-controlling, and pressure-retaining parts.

The remanufacturer shall meet or exceed the material specifications for the product as listed in the OPD or CPD. The OPD or CPD shall contain the following information:

— acceptance and/or rejection criteria;

— material composition with tolerance;

— material qualification;

— allowable melting practice(s);

— forming practice(s);

— heat treatment procedure, including cycle time and temperature with tolerances, heat treating equipment, and cooling media;

— NDE requirements;

— mechanical property requirements.

NOTE For existing parts remanufactured to RSL 1 or RSL 2, it is recognized that some of this information may not be available.

8.3 Nonmetallic Parts

Each manufacturer (OEM and CEM) shall have written specifications for all elastomeric materials used in the repair and remanufacture of drill-through equipment.

These specifications shall include the following physical tests and limits for acceptance and control:

— acceptance and/or rejection criteria;

— physical property requirements;

— material qualification, which shall meet the equipment temperature and pressure class requirement;

— storage and age-control requirements;

— hardness in accordance with ASTM D2240 or ASTM D1415;

— tensile and elongation properties in accordance with ASTM D412 or ASTM D1414;

— compression set in accordance with ASTM D395 or ASTM D1414;

— immersion (fluid compatibility) testing in accordance with ASTM D471 or ASTM D1414;

— test liquid, temperature, and duration of test shall be defined.

8.4 Base Metal Material Identification

8.4.1 General

In order to start the remanufacturing process, material composition shall be established.

8.4.2 Material Test Records

If MTRs for metallic parts are not available, the following shall be tested and documented to establish material property requirements for pressure-containing members to meet RSL 1:

— determining hardness and approximate tensile values,

— determining chemical composition.

Materials to be included in analysis shall include the following elements:

— copper,

— carbon,

— manganese,

— silicon,

— phosphorus,

— sulfur,

— nickel,

— chromium,

— molybdenum,

— vanadium,

— boron.

8.4.3 Determining Hardness and Approximate Ultimate Tensile Values

Determining hardness and approximate tensile values shall be done in accordance with the following.

a) Brinell:

— ASTM E10 (Brinell),

— ASTM E110 (portable testing),

— ISO 6506-1.

b) Rockwell:

— ASTM E18 (Rockwell),

— ASTM E110 (portable testing),

— ISO 6508-1.

c) Vickers:

— ASTM E384 for Vickers,

— ISO 6507-1.

Hardness conversion shall be done in accordance with ASTM E140.

NOTE The hardness of a material is in principle related to the ultimate tensile strength (UTS) and not to the YS. UTS and YS show a linear correlation with hardness for most steels. However, for steel that shows evidence of strain hardening, a lower strength can be measured for a given hardness. There can be a nonlinear relation between strength and hardness.

If uncertainty exists with respect to the material specification, the material properties as per the RSL (see 4.7) shall be validated.

8.4.4 Determining Chemical Composition

In absence of material specifications for the parts of the system, calibrated positive material identification (PMI) shall be used to confirm that the material from the pressure-containing and pressure-controlling parts meets the requirements of the product definition.

The material identification shall be done using an industry-recognized process that is capable of:

— determining carbon content,

— determining all alloying elements such that the material can be matched to a base material specification,

— determining nickel and sulfur content for NACE MR0175/ISO 15156 (all parts) applications,

— determining other types of non-iron based materials (i.e. type of overlay materials).

Prior to welding of carbon and low-alloy steel, all elements in the carbon equivalency formula shall be identified as per ASME *BPVC* Section IX, QW-403.26:

$$CE = C\ \% + Mn\ \%/6 + (Cr\ \% + Mo\ \% + V\ \%)/5 + (Ni\ \% + Cu\ \%)/15 \quad (2)$$

8.5 Pressure-containing Members

8.5.1 Property Requirements

Pressure-containing members shall be manufactured from materials as specified by the manufacturer that meet the requirements of API 16A and Table 5 and Table 6 below.

Charpy V-notch impact testing shall conform to 8.5.4.2.

Table 5—Material Property Requirements for Pressure-containing Members

Material Designation	Yield Strength 0.2 % Offset min.		Tensile Strength min.		Elongation in 50 mm min.	Reduction of Area min.
	MPa	(psi)	MPa	(psi)	%	%
36K	248	36,000	483	70,000	21	None specified
45K	310	45,000	483	70,000	19	32
60K	414	60,000	586	85,000	18	35
75K	517	75,000	655	95,000	18	35
Nonstandard	As specified	As specified	As specified	As specified	15	20

Table 6—Material Applications for Pressure-containing Members

Part	Rated Working Pressure					
	13.8 MPa (2,000 psi)	20.7 MPa (3,000 psi)	34.5 MPa (5,000 psi)	69.0 MPa (10,000 psi)	103.5 MPa (15,000 psi)	138.0 MPa (20,000 psi)
Body	36K, 45K, 60K, 75K				45K, 60K, 75K	60K, 75K
End connections	60K				75K	
Blind flanges	60K				75K	
Blind hubs	60K				75K	

Nonstandard materials may be used that have a specified minimum YS that is not less than that of the lowest strength standard material permitted for the applications above.

8.5.2 Heat Treating

NOTE 1 In principle, parts in the remanufacturing process can be fully normalized or annealed and again heat treated [quenched and tempered (Q&T)] with the aim to restore the material properties that are in conformance with the minimum requirements of API 16A.

NOTE 2 Although normalizing or annealing may lead to distortion of dimensions, surfaces, and tolerances of the part, it may in some occasions be economical to do so.

Parts that are to be Q&T and include existing welds shall have all the weld material removed before the heat treating process.

A full QTC shall be required after the full heat treatment (normalized or annealed + Q&T) is completed.

All heat treatment operations shall be performed utilizing equipment qualified in conformance with Annex H.

Care should be taken in loading of material within furnaces such that the presence of one part does not adversely affect the heat treating response of any other part.

Temperature and times for heat treatment shall be determined in accordance with the manufacturer's or remanufacturer's written specification.

Quenching shall be performed in accordance with the manufacturer's or remanufacturer's written specifications.

a) Water quenching—The temperature of the water or water-based quenching medium shall not exceed 38 °C (100 °F) at the start of the quench, nor exceed 49 °C (120 °F) at the completion of the quench.

b) Oil quenching/polymer—The temperature of any oil/polymer-quenching medium shall be greater than 38 °C (100 °F) at the start of the quench.

8.5.3 Chemical Composition

8.5.3.1 General

The remanufacturer shall specify the range of chemical composition of the material used to remanufacture pressure-containing members or manufacture replacement pressure-containing members.

Material composition for replacement pressure-containing members shall be determined on a heat basis (or a remelt ingot basis for remelt grade materials) in accordance with the manufacturer's written specification.

8.5.3.2 Composition Limits

The chemical composition limits of pressure-containing members manufactured from carbon and low-alloy steels or martensitic stainless steels shall conform to API 16A.

8.5.4 Material Qualification

8.5.4.1 Tensile Testing

If YS 0.2 % offset, tensile strength, elongation and reduction area shall be reestablished for remanufacturing in order to meet RSL 2 requirements, removing a test specimen from the part is required.

Tensile test specimens shall be removed from a part and must meet dimensions as described in 8.5.8.

Tensile tests shall be performed at room temperature in accordance with the procedures specified in ISO 6892 or ASTM A370.

A minimum of one tensile test shall be performed. The results of the tensile test(s) shall satisfy the applicable requirements of API 16A. If the results of the first tensile tests do not satisfy the applicable requirements, two additional tensile tests may be performed in an effort to qualify the material. The results of each of these additional tests shall be in conformance with the requirements of API 16A.

8.5.4.2 Impact Testing

If impact strength shall be reestablished for remanufacturing in order to meet RSL 2 requirements, a test coupon shall be removed from the part and must meet dimensions as described in 8.5.8.

Impact tests shall be performed in accordance with ASTM A370 using the Charpy V-notch technique.

In order to qualify material for an API 16A temperature rating T-0, T-20, or T-75, the impact tests shall be performed at or below the test temperature shown in Table 7.

Pressure-containing members for which the impact strength is unknown, and that only require RSL 1, shall not be given a classification higher than T-0.

NOTE 1 Exclusion for impact tests may apply to equipment manufactured before 1986 that may be in conformance with API 6A.

Equipment manufactured under API 6A and from which material traceability records do not contain impact test results shall be considered RSL 1 and shall reference API 6A, 13th Edition in the certification.

A minimum of three impact specimens shall be tested to qualify a part. The average of the impact property value shall be at least the minimum value shown in Table 7. In no case shall an individual impact value fall below 2/3 the required minimum average. No more than one of the three test results shall be below the required minimum average.

If a test fails, then one retest of three additional specimens (removed from the same part) may be made. The retest shall exhibit an impact value for each specimen equal to or exceeding the required minimum average.

The values listed in Table 7 are the minimum acceptable values for forgings and wrought products tested in the transverse direction and for castings and weld qualifications.

NOTE 2 Forgings and wrought products may be tested in the longitudinal direction instead of the transverse direction, in which case they shall exhibit 27 J (20 ft-lb) minimum average value.

Repairs for equipment rated for 20,000 psi and higher pressure, the Charpy V-notch impact values for weld forgings and wrought products shall meet the requirements of API 16A.

Table 7—Acceptance Criteria for Charpy V-notch Impact Tests

Temperature Rating	Test Temperature		Minimum Impact Value Required for Average of Each Set of Three Specimens		Minimum Impact Value Permitted for One Specimen Only per Set	
	°C	(°F)	J	(ft-lb)	J	(ft-lb)
T-0	–18	0	20	15	14	10
T-20	–29	–20	20	15	14	10
T-75	–59	–75	20	15	14	10

8.5.5 Qualification Test Coupons

QTCs used for reestablishing the material properties shall be removed from the part requiring weld repair.

NOTE A QTC may be taken from an equal size part from the same heat number as the part requiring weld repair to represent the impact and/or tensile properties, provided it satisfies the requirements of this standard.

The properties exhibited by the QTC shall represent the properties of the material comprising the equipment it qualifies.

When the QTC is a trepanned core or a prolongation removed from a production part, the QTC shall only qualify parts having the same or smaller equivalent round (ER).

A QTC should qualify material and parts produced from the same heat and subjected to the same remanufacturing heat cycles.

8.5.6 Equivalent Round

8.5.6.1 General

The dimensions of a QTC for a part shall be determined using the following ER method.

8.5.6.2 ER Methods

The ER of a part shall be determined using the actual dimensions of the part in the “as-heat-treated” condition (see Annex I for basic models for determining the ER of simple solid and hollowed parts and more complicated equipment).

8.5.6.3 Required Dimensions

The ER of the QTC shall be equal to or greater than the dimensions of the part it qualifies, except the size of the QTC is required not to exceed 125 mm (5 in.) ER.

8.5.7 Processing

8.5.7.1 Melting Practices

Processing the QTC shall not be permitted by using a melting practice cleaner than that of the material it qualifies.

EXAMPLE A QTC made from a remelt grade or vacuum-degassed material does not qualify material from the same primary melt that has not experienced the identical melting practice.

NOTE Remelt grade material removed from a single remelt ingot may be used to qualify other remelt grade material that has been processed in like manner and is from the same primary melt. No additional alloying is permitted on these individual remelt ingots.

8.5.7.2 Welding

Welding on the QTC shall be prohibited, except for attachment-type welds.

8.5.7.3 Heat Treating

All heat treatment operations shall be performed utilizing “production-type” equipment certified in accordance with the manufacturer or remanufacturer written specification. “Production-type” heat treatment equipment shall be considered equipment that is routinely used to process parts.

Qualification of heat treatment equipment shall be in conformance with Annex H.

The QTC shall experience the same specified heat treatment processing as the parts it qualifies.

The QTC shall be heat treated using the manufacturer or remanufacturer specified heat treatment procedures.

When the QTC is not heat treated as part of the same heat treatment load as the parts it qualifies, the austenitizing (or solution heat treat) temperatures for the QTC shall be within 14 °C (25 °F) of those for the parts.

The tempering temperature for the part shall be no lower than 14 °C (25 °F) below that of the QTC. The upper limit shall be no higher than permitted by the heat treatment procedure for that material. The cycle time of the QTC at each temperature shall not exceed that for the parts.

8.5.8 Tensile and Impact Testing

Removal of tensile and impact specimens from multiple QTCs shall be permitted as long as the multiple QTCs have been exposed to the same heat treatment cycle(s).

Standard-size specimens of cross-section 10 mm (0.39 in.) × 10 mm (0.39 in.) shall be used, except where there is insufficient material, in which case the next smaller standard-size specimen obtainable shall be used. When it is necessary to prepare sub-size specimens, the reduced dimension shall be in the direction parallel to the base of the V-notch.

Tensile and impact specimens shall be removed from the part such that their longitudinal centerline axis is wholly within the center core $0.25T$ envelope for a solid QTC or within 1 mm (0.039 in.) of the mid-thickness of the thickest section of a hollow QTC (see Annex I).

NOTE For QTCs larger than the dimensions specified in Annex I, the test specimens do not need be removed from a location farther from the QTC surface than that would be applicable if the specified QTC dimensions were used.

When a sacrificial production part is used as the QTC, the test specimens shall be removed from a section of the part satisfying the dimensional requirements of the QTC for that production part.

8.5.9 Hardness Testing

A hardness test shall be performed on the QTC after the final heat treatment cycle.

Hardness testing shall be performed in accordance with procedures specified in ASTM E10, ASTM E18, ASTM E110, ASTM E384, ISO 6506-1, ISO 6507-1 or ISO 6508-1, as appropriate.

9 Welding Requirements

9.1 General

The welding requirements of this standard shall be the minimum for joining, overlaying, and repairing pressure-containing and load-bearing parts by welding and for qualification of welding procedures.

All welding of components exposed to wellbore fluid shall conform to the welding requirements of NACE MR0175/ISO 15156 (all parts). Verification of conformance shall be established through implementation of the remanufacturer's written WPS and the supporting PQR.

When material specifications for pressure-containing and pressure-retaining components require impact testing, verification of conformance shall be established through implementation of the remanufacturer's WPS and supporting PQR.

Welding shall be performed in accordance with a WPS that has been written and qualified in accordance with ASME *BPVC* Section IX.

The WPS shall describe all the essential, nonessential, and supplementary essential variables in conformance with ASME *BPVC* Section IX.

The PQR shall record the essential, and supplementary essential (if required) variables of the weld procedure used for the qualification test(s). Both the WPS and PQR shall be maintained as records in accordance with the quality control record requirements from 4.6.3 and 4.6.4.

All pressure-containing welds shall undergo a hardness test after PWHT and shall meet the minimum hardness requirements of the base material per the CPD.

9.2 Weldment Design and Configuration

9.2.1 Pressure-containing Fabrication Weldments

NOTE Pressure-containing fabrication weldments contain and are wetted by wellbore fluid.

Only full-penetration welds fabricated in accordance with the remanufacturer's written specification shall be used. Figures G.1 through G.3 in Annex G are provided for reference.

Welding and completed welds shall meet the quality control requirements of 4.5.

9.2.2 Load-bearing Weldments

NOTE Load-bearing weldments are those subject to external loads and not exposed to wellbore fluids.

Joint design shall be in accordance with the remanufacturer's written procedures.