

Standard for Repair and Remanufacture of Drill-through Equipment

API STANDARD 16AR
FIRST EDITION, APRIL 2017

ERRATA 1, AUGUST 2017

REAFFIRMED, MAY 2023



Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, remanufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to ensure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this standard should consult with the appropriate authorities having jurisdiction.

Users of this standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

Examples used in this standard are merely examples for illustration purposes only. [Each company should develop its own approach.] They are not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied for reliance on or any omissions from the information contained in this document.

Where applicable, authorities having jurisdiction should be consulted.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Washington, DC 20001.

Copyright © 2017 American Petroleum Institute

Foreword

This standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

Standards and specifications referenced herein may be replaced by other international or national standards or specifications that can be shown to meet or exceed the requirements of the referenced standard or specification. Manufacturers or remanufacturers electing to use another standards or specifications in lieu of a referenced standard or specification are responsible for documenting equivalency.

This standard is under the jurisdiction of the API Subcommittee on Drilling Well Control Systems.

This standard replaces the repair and remanufacture requirements from API 16A.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the standard.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the standard.

May: As used in a standard, “may” denotes a course of action permissible within the limits of a standard.

Can: As used in a standard, “can” denotes a statement of possibility or capability.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Washington, DC 20001, standards@api.org.

Contents

Page

1	Scope	1
2	Normative References	4
3	Terms, Definitions, Acronyms, and Abbreviations	6
3.1	Terms and Definitions	6
3.2	Acronyms and Abbreviations	15
4	Quality Control Requirements	17
4.1	General	17
4.2	Measuring and Testing Equipment	17
4.3	Quality Control Personnel Qualifications	18
4.4	Quality Control Requirements for Equipment and Parts	19
4.5	Quality Control Requirements for Specific Equipment and Parts	20
4.6	Quality Control Records	29
4.7	Repair and Remanufacture Service Levels	31
5	Quality Management System Requirements	33
5.1	General	33
5.2	Control of Documents	33
5.3	Training and Awareness	34
5.4	Control of Testing, Measuring, and Monitoring Equipment	34
5.5	Contract Review	35
5.6	Purchasing Control	35
5.7	Design and Development	35
5.8	Control of Nonconforming Product	37
6	Responsibilities	37
6.1	General	37
6.2	Manufacturer	37
6.3	Remanufacturer	38
6.4	Equipment Owner	38
7	Repair/Remanufacture Specification Level Minimum Requirements	38
7.1	General	38
7.2	Factory Acceptance Testing	39
7.3	Dimensional Check	43
7.4	NDE-Initial Inspection	44
7.5	Inspection on Closure Bolting (Pressure Retaining)	44
7.6	Visual Inspection at Disassembly	44
7.7	Replacement Parts	45
7.8	General Equipment Specifications	45
7.9	Documentation	45
7.10	Failure Reporting	45
8	Materials	45
8.1	General	45
8.2	Metallic Parts	46
8.3	Nonmetallic Parts	46
8.4	Base Metal Material Identification	47
8.5	Pressure-containing Members	48
9	Welding Requirements	53
9.1	General	53

Contents

	Page
9.2 Weldment Design and Configuration	53
9.3 Welding Controls	56
9.4 Welding Procedure and Performance Qualifications	58
9.5 Other Welding Qualification requirements	60
9.6 Other Requirements	66
9.7 Documentation Requirements	66
10 Marking Requirements	66
10.1 General	66
10.2 Low-stress Area Marking	68
10.3 High-stress Area Marking	68
10.4 Corrosion-resistant Overlay	68
10.5 Wellbore Nonmetallic Components	68
10.6 Non-wellbore Nonmetallic Components	68
10.7 Specific Codification Requirements of Equipment	68
11 Storing and Shipping	69
11.1 Storing Periods Greater than 30 Days	69
11.2 Shipping	69
12 Certification	70
12.1 General	70
12.2 Certificate of Conformance	70
12.3 Statement of Compatibility	70
12.4 Statement of Fact	70
12.5 Certificate of Service	70
Annex A (normative) General Equipment Specifications	71
Annex B (normative) Manufacturing Data Book Requirements	73
Annex C (normative) Product History File Requirements	75
Annex D (normative) Failure Reporting	77
Annex E (normative) Design Ownership	78
Annex F (normative) Minimum Requirements for Certificate of Conformance	79
Annex G (informative) Recommended Weld Preparation Design Dimensions	81
Annex H (normative) Qualification of Heat Treating Equipment	84
Annex I (normative) Equivalent Round Models	87
Annex J (normative) Remanufacture and Replacement Parts	89
Annex K (normative) Charpy V-notch Impact Tests Location for Weld Qualification	90
Annex L (normative) Minimum Requirements for Statement of Compatibility	92
Figures	
1 Simplified Example of Surface Drill-through Equipment	2
2 Simplified Example of Subsea Drill-through Equipment	3
3 Logic for Classification as Corrosion Resistant	55
4 Rockwell Hardness Test Locations	61

Contents

	Page
5 Vickers Hardness Test Locations	62
6 Hardness Test Locations for Weld Overlay	63
7 Typical Mechanical Specimen Removal for Welding Procedure Qualification	67
E.1 Design Ownership Flow Diagram	78
G.1 Typical Weld Grooves for Pipe Butt Joints.	81
G.2 Typical Attachment Welds	82
G.3 Typical Repair Welds.	83
G.4 Repairs	83
H.1 Thermocouple Locations—Rectangular Furnace (Working Zone).	85
H.2 Thermocouple Locations—Cylindrical Furnace (Working Zone)	86
I.1 Simple Geometric Equivalent Round Sections/Shapes Having Length L	87
I.2 Complex-shaped Components	87
I.3 Equivalent Round Models	88
J.1 Flow Diagram for Remanufactured and Replacement Parts.	89
K.1 Location of Charpy V-notch Impact Test.	91

Tables

1 Weld Inclusion Criteria	24
2 Minimum Hardness Requirement	26
3 Bolting Requirement	29
4 Quality Control Requirements	32
5 Material Property Requirements for Pressure-containing Members	49
6 Material Applications for Pressure-containing Members	49
7 Acceptance Criteria for Charpy V-notch Impact Tests	51
8 Chemical Composition of Austenitic or 300-series Stainless Steels	64
9 Chemical Composition of the Nickel-based Alloy UNS06625.	65

Standard for Repair and Remanufacture of Drill-through Equipment

1 Scope

This standard specifies requirements for repair and remanufacture of drill-through equipment built under API 16A. This standard also applies to repair and remanufacture of drill-through equipment manufactured to API 6A requirements and produced prior to the existence of API 16A.

This standard also covers the testing, inspection, welding, marking, certification, handling, storing, and shipping of equipment repaired or remanufactured per this standard.

Repair and remanufacture under this standard includes all remanufacture and all repairs.

This standard is applicable to and establishes requirements for the repair and remanufacture of the following specific equipment:

- 1) ram blowout preventers (BOPs);
- 2) ram blocks, operators, packers, and top seals;
- 3) annular BOPs;
- 4) annular packing units;
- 5) hydraulic connectors;
- 6) drilling spools;
- 7) adapters;
- 8) loose connections;
- 9) clamps;
- 10) API 6A flanges;
- 11) other end connections (OECs).

Dimensional interchangeability is limited to end and outlet connections. Simplified examples of surface and subsea equipment defined by this standard are shown in Figures 1 and 2.

Maintenance activities are not governed by this document, but the documentation of those activities is included in the scope.

This standard defines various repair/remanufacture specification levels (RSLs) for the equipment identified below as well as the mandatory equipment traceability that is required to prove conformance.

Requirements for failure reporting are outlined in Annex D.

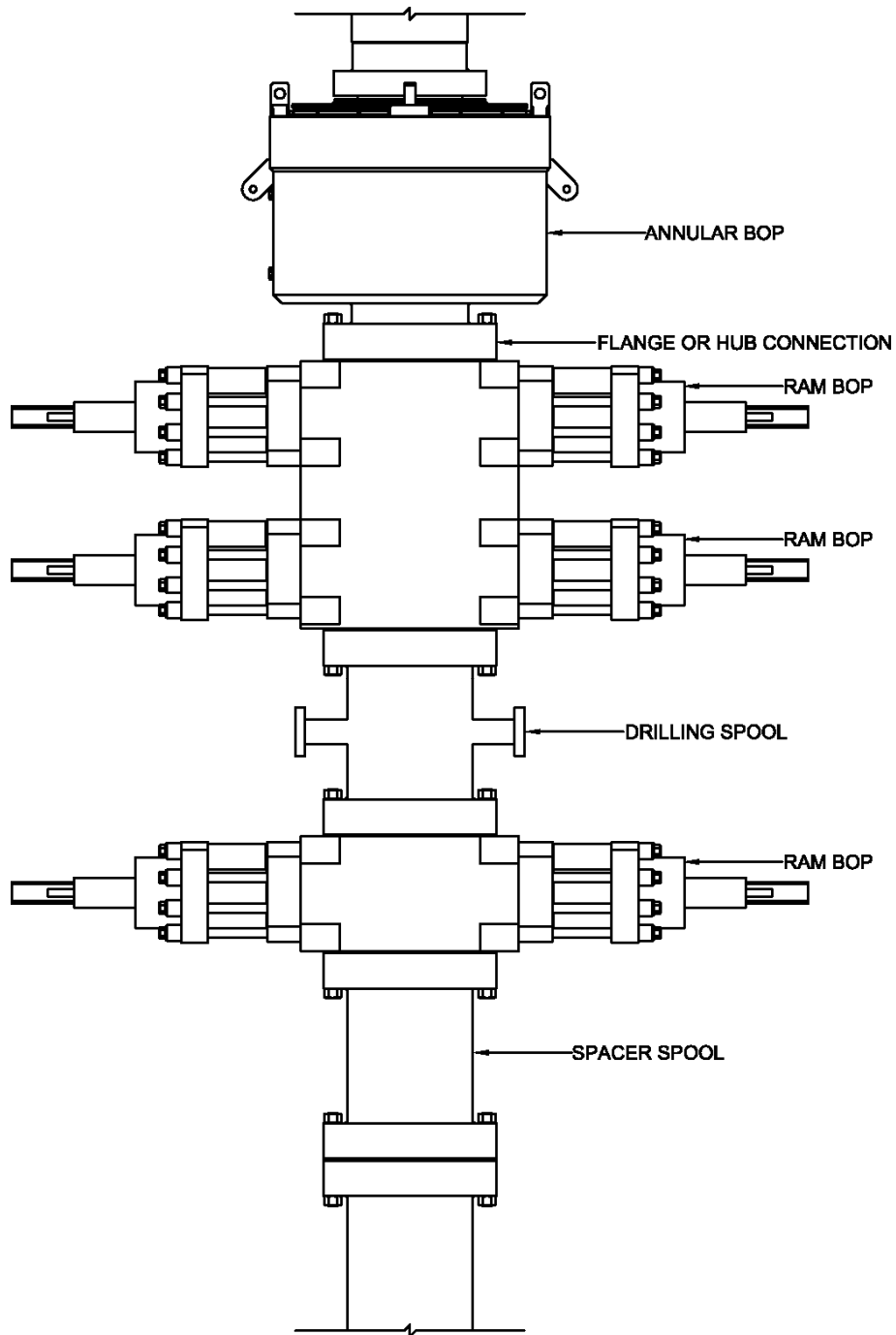


Figure 1—Simplified Example of Surface Drill-through Equipment

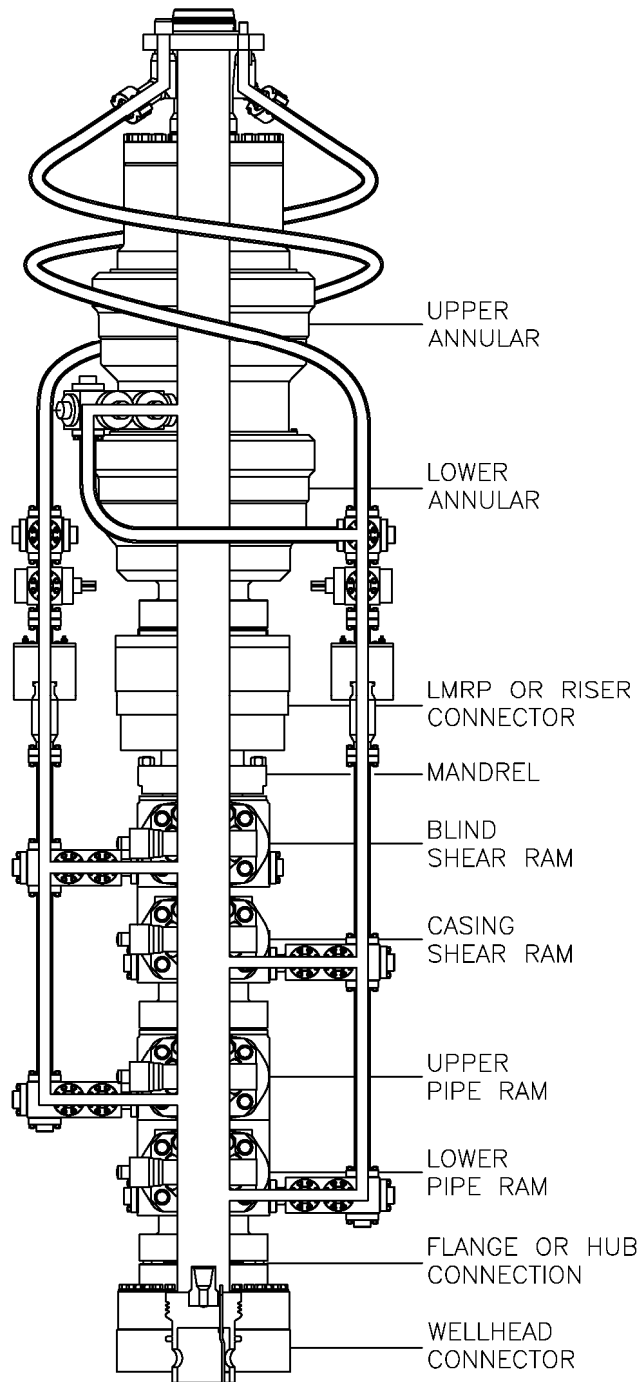


Figure 2—Simplified Example of Subsea Drill-through Equipment

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 5DP, *Specification for Drill Pipe*

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*

API Specification 16A, *Specification for Drill-through Equipment*

API Specification 16A, *Specification for Drill-through Equipment*, Third Edition, 2004 ¹

API Specification 20E, *Alloy and Carbon Steel Bolting for Use in the Petroleum and Natural Gas Industries*

API Specification 20F, *Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries*

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

ANSI ²/ASME B31.1 ³, *Power Piping*

ASME Boiler and Pressure Vessel Code (BPVC), Section V: Nondestructive Examination; Article: 5 Ultrasonic Examination Methods for Materials

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII: Rules for Construction of Pressure Vessels; Division 1

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII: Rules for Construction of Pressure Vessels; Division 1; Appendix 4: Rounded Indication Charts Acceptance Standard for Radiographically Determined Rounded Indications in Welds

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications; Article I: Welding General Requirements

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications; Article II: Welding Procedure Qualifications

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications; Article III: Welding Performance Qualifications

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications; Article IV: Welding Data

ASME Boiler and Pressure Vessel Code (BPVC), Section IX: Welding, Brazing, and Fusing Qualifications; QW-403.26

ASNT-SNT-TC-1A ⁴, *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 ⁵, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A388/A388M, *Standard Practice for Ultrasonic Examination of Steel Forgings*

¹ Use of API 16A, **Third Edition** applies only in two specific citations as identified in 4.5.20 and Table 4. All other references to API 16A require use of the most **current** version of the document.

² American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.

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

⁴ American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.

⁵ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM A967/A967M, *Standard Specification for Chemical Passivation Treatments of Stainless Steel Parts*

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

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

ASTM D471, *Standard Test Method for Rubber Property—Effect of Liquids*

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

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

ASTM D2240, *Test Method for Rubber Property—Durometer Hardness*

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

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

ASTM E94, *Standard Guide for Radiographic Examination*

ASTM E110, *Standard Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers*

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/E165M, *Standard Practice for Liquid Penetrant Examination for General Industry*

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

ASTM E428, *Standard Practice for Fabrication and Control of Metal, Other than Aluminum, Reference Blocks Used in Ultrasonic Testing*

ASTM E569/E569M, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

AWS A4.2M⁶, *Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*

AWS QC1, *Standard for AWS Certification of Welding Inspectors*

CSWIP-WI-6-92⁷, *Requirements for the Certification of Visual Welding Inspectors (Level 1), Welding Inspectors (Level 2) and Senior Welding Inspectors (Level 3) (fusion welding) in accordance with the requirements of BS EN ISO 176371:2011*

ISO 6506-1⁸, *Metallic materials—Brinell hardness test—Part 1: Test method*

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

ISO 6508 (all parts), *Metallic materials—Hardness test—Rockwell test (scales A-B-C-D-E-F-G-H-K)*

⁶ American Welding Society, 8669 NW 36 Street, #130, Miami, Florida 33166-6672, www.aws.org.

⁷ TWI Certification Ltd., Granta Park, Great Abington, Cambridge CB21 6AL, United Kingdom, www.cswip.com.

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

ISO 6892, *Metallic materials—Tensile testing at ambient temperature*

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

ISO 18265, *Metallic materials—Conversion of hardness values*

NACE MR0175 ⁹/ISO 15156 (all parts), *Petroleum, petrochemical, and natural gas industries—Materials for use in H₂S-containing environments in oil and gas production*

SAE AMS 2750E ¹⁰, *Pyrometry*

SAE AMS-H-6875B, *Heat Treatment of Steel Raw Materials*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1

acceptance criteria

Defined limits placed on characteristics of materials, equipment, processes, or service.

3.1.2

adapter

Pressure-containing piece of equipment having end connections of different nominal size and/or pressure ratings, used to connect other pieces of equipment of different nominal sizes and/or pressure ratings.

3.1.3

annular blowout preventer

annual BOP

Blowout preventer that uses an annular shaped elastomeric sealing element to seal the space between the tubular and the wellbore or an open hole.

3.1.4

blind ram

Closing and sealing component in a ram BOP that seals the open wellbore.

3.1.5

blind-shear ram

Closing and sealing component in a ram BOP that first shears the tubular in the wellbore and then seals the bore or acts as a blind ram if there is no tubular in the wellbore.

3.1.6

blowout preventer

BOP

Equipment installed at the wellhead to contain wellbore pressure either in the annular space between the casing and the tubulars or in an open hole during drilling, completion, testing, or workover operations.

3.1.7

body

Any portion of equipment between end connections, with or without internal parts, that contains wellbore pressure.

⁹ NACE International, 15835 Park Ten Place, Houston, Texas 77084, www.nace.org.

¹⁰ SAE International (formerly the Society of Automotive Engineers), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

3.1.8**bolting**

All threaded fasteners, tap-end studs, double-ended studs, headed bolts, cap screws, screws, and nuts.

3.1.9**calibration**

Comparison to a standard of known accuracy and making any needed adjustment(s).

3.1.10**casing-shear ram****(nonsealing shear ram)**

Closing component in a ram BOP capable of shearing certain tubulars, but does not provide a wellbore seal.

3.1.11**casting (noun)**

Object at or near finished shape obtained by solidification of a molten metal in a mold.

3.1.12**certificate of conformance****COC**

Document in which the manufacturer, remanufacturer, or technical authority certifies that the assembly or part is in conformance to the mentioned standard(s), specifications, and guidelines in accordance with the original or current product definition (CPD).

3.1.13**certificate of service****COS**

Document in which the equipment manufacturer, remanufacturer, technical authority/owner, or operator certifies that the equipment has been inspected and successfully tested in accordance with the applicable equipment owner's maintenance program and/or manufacturer's guidelines.

3.1.14**chemical analysis**

Determination of the chemical composition of material.

3.1.15**clamp (noun)**

Device with internal angled shoulders used to fasten mating sealing hubs.

3.1.16**closure bolting**

Bolting used to assemble or join wellbore pressure-containing parts including end and outlet connections.

NOTE Examples: flange bolting, bonnet bolting, bolting on end connection on BOPs, ram door bolting, hub clamp bolting.

3.1.17**conformance**

Satisfying all of the specified requirements of the referenced specification, specification section, or document.

3.1.18**corrosion-resistant ring groove**

Ring groove lined with metal resistant to metal-loss corrosion.

3.1.19**critical dimension**

Dimension(s) identified by the manufacturer as requiring verification and documentation.

3.1.20**current equipment manufacturer****CEM**

Design owner or remanufacturer of the traceable current assembled equipment, single equipment unit, or component part responsible for the CPD.

NOTE The original equipment manufacturer (OEM) can be the current equipment manufacturer (CEM) as long as they own the CPD that is active for the equipment.

3.1.21**current product definition****CPD**

Complete design verified and validated definition of the requirements for the current assembled product, single equipment unit, or component part, including specified limits, tolerances, health requirements, safety requirements, environmental requirements, limitations of use, customer-specific requirements, design acceptance criteria, materials of construction, materials processing requirements, physical properties, physical dimensions, requirements for manufacturing process controls, inspection, assembly, testing, marking, handling, storage, maintenance, service, and record requirements.

3.1.22**dehydrogenation heat treatment****DHT**

Activity carried out to diffuse hydrogen and minimize the risk of hydrogen cold cracking in completed or partially completed weld joints prior to the weld joint cooling to ambient temperature.

3.1.23**design status**

Status of a product managed under the requirements of this standard, with regard to changes to elements of the original product definition (OPD) as well as improvements to the OPD or obsolescence of the product.

3.1.24**drilling spool**

Pressure-containing piece of equipment having end connections with or without side outlet connections, used below or between drill-through equipment.

3.1.25**end connection**

Integral male or female thread, clamp hub end connector, studded or through-bolted flange, or any other means used to join together equipment that contains or controls pressure.

3.1.26**equipment**

Components or assemblies to which this specification is applicable.

3.1.27**equipment owner**

Owner of the equipment repaired or remanufactured in conformance with this document.

3.1.28**fabrication weld**

Weld that joins two or more parts.

3.1.29**ferrite number**

The measure of chrome and nickel equivalent in an austenitic stainless steel material.

3.1.30**flange**

Protruding rim, with holes to accept bolts and having a sealing mechanism, used to join pressure-containing equipment with dimensions specified in this standard.

3.1.31**forging (noun)**

Shaped metal part formed by the forging method.

3.1.32**full-penetration weld**

Weld that extends throughout the complete wall section of the parts joined.

3.1.33**heat**

Cast lot material originating from a final melt.

NOTE For remelted alloys, a heat is defined as the raw material originating from a single remelted ingot.

3.1.34**heat-affected zone****HAZ**

Portion of the base metal that has not been melted, but whose mechanical properties or microstructure has been altered by the heat of welding or cutting.

3.1.35**heat treatment****heat treating**

Specified, timed sequence of controlled heating and cooling of materials for the purpose of changing physical or mechanical properties.

3.1.36**heat treatment load**

For batch furnaces: material placed on loading or carry devices and moved as a batch through one heat treat cycle.

For continuous furnaces: group of pieces of material with the same nominal size that is moved sequentially through the heat treatment process using the same process parameters.

3.1.37**hot-work (verb)**

Deform metal plastically at a temperature above the recrystallization temperature.

3.1.38**hub**

Protruding rim with an external angled shoulder and a sealing mechanism used to join pressure-containing equipment.

3.1.39**hydraulic connector**

Hydraulically actuated drill-through equipment that locks and seals on end connections.

3.1.40**indication**

Visual sign of cracks, pits, or other abnormalities found during nondestructive examination (NDE).

3.1.41**integral (*adjective*)**

Parts joined by the forging, casting, or welding process.

3.1.42**intermediate stress relief****ISR**

Activity carried out to reduce residual stresses and diffuse hydrogen from completed highly stressed weld joints so that the risk of cracking is minimized upon the weld joint cooling to ambient temperature.

NOTE Intermediate stress relief (ISR) may be used to reduce the risk of decreasing the base material properties when multiple welding operations are performed on a component. For example, a flange may receive an ISR after the seal groove inlay, then receive the final PWHT after the flange has been circumferentially welded to its mating component.

3.1.43**leakage**

Visible passage of pressurized fluid from the inside to the outside of the pressure-containment area of the equipment being tested.

3.1.44**loose connection**

Flange (studded or open-face), hub connection, or OEC used to join together equipment, but not integral to the equipment.

3.1.45**maintenance**

Upkeep of well control equipment that is performed in accordance with the equipment owner's preventive maintenance (PM) program and the manufacturer's guidelines.

NOTE These procedures may include but are not limited to: inspections, cleaning, polishing, function testing, pressure testing, NDE, and change out of sealing parts and those parts defined in the PM program to be changed either periodically or on a cycle basis.

3.1.46**major repair weld**

Weld whose depth that is greater than 25 % of the original wall thickness or 25.4 mm (1 in.), whichever is less.

3.1.47**manufacturer**

OEM or CEM of the product or part.

3.1.48**manufacturing data book****MDB**

Composite file of records from a traceable API product, which includes all records associated with the original API product manufacturing, including certification records as required by this standard.

3.1.49**original equipment manufacturer****OEM**

Design owner or manufacturer of the traceable assembled equipment, single equipment unit, or component part.

3.1.50**original product definition****OPD**

Complete design verified and validated definition of the requirements for the original assembled product, single equipment unit, or component part, including specified limits, tolerances, health requirements, safety

requirements, environmental requirements, limitations of use, customer-specific requirements, design acceptance criteria, materials of construction, materials processing requirements, physical properties, physical dimensions, requirements for manufacturing process controls, inspection, assembly, testing, marking, handling, storage, maintenance, service, and records requirements.

3.1.51

other end connection

OEC

Connection that is not specified in an API specification or standard.

NOTE This includes API flanges and hubs with non-API gasket preparations and manufacturer's proprietary connections.

3.1.52

part

Individual piece used in the assembly of a single unit of equipment.

3.1.53

postweld heat treatment

PWHT

Controlled heat treatment subsequent to welding, including stress relief to obtain desired material properties.

3.1.54

pressure-containing part or member

Pressure-containing member or part exposed to wellbore fluids whose failure to function as intended would result in a release of wellbore fluid to the environment.

NOTE 1 Examples include bodies, bonnets, connecting rods, and replaceable seats within a pressure-containing member or part.

NOTE 2 In this document, the use of the word component and member are interchangeable.

3.1.55

pressure-containing weld

Weld whose absence or failure will reduce or compromise the pressure-containing integrity of the component.

3.1.56

pressure-controlling bolting

Bolting used to assemble or join pressure-controlling part(s).

NOTE Examples: bolting on ram, hydraulic operator cylinder bolting, hydraulic cylinder piston bolting, seat or seal retainer bolting, shear ram blade bolting.

3.1.57

pressure-controlling part

Parts intended to control or regulate the movement of wellbore fluids.

NOTE 1 Examples include packing elements, rams, and replaceable seats within a pressure-containing member or part.

NOTE 2 In this document, the use of the word component and member are interchangeable.

3.1.58

pressure-retaining bolting

Bolting used to assemble or join pressure-retaining parts whose failure would result in a release in wellbore fluid to the environment.

NOTE Examples: studs and nuts on top of housing hydraulic connector and clamp bolts.

3.1.59**pressure-retaining part or member**

Part not exposed to wellbore fluids whose failure to function as intended will result in a release of wellbore fluid to the environment.

NOTE Examples include closure bolts and clamps.

3.1.60**procedure qualification record****PQR**

Record of the welding data used to make the test weldment containing the actual values or ranges of the essential and supplementary essential variables used in preparing the test weldments, including the test results.

3.1.61**product history file****PHF**

Composite file of records from a traceable API product, which includes all records associated with the API product repair and remanufacture, including certification records required by this standard.

3.1.62**ram blowout preventer****ram BOP**

Blowout preventer that uses metal blocks assembled with elastomer seals to seal off pressure on a wellbore with or without tubulars in the bore.

3.1.63**rated working pressure**

Maximum internal pressure that the equipment is designed to contain and/or control.

3.1.64**record (*noun*)**

Document or dataset created and maintained that provides objective evidence of activities performed, results achieved, or statements made.

3.1.65**relevant indication**

Any indication [liquid penetrant (LP) or magnetic particle (MP) examination] with a major dimension greater than 1.6 mm (0.062 in.).

NOTE Inherent indications not associated with a surface rupture are considered nonrelevant indications.

3.1.66**remanufacture**

Process of disassembly, reassembly, and testing of drill-through equipment, with or without the replacement of parts, in which machining, welding, heat treatment, or other manufacturing operation is employed.

3.1.67**remanufacture specification level****RSL**

Level of traceability and/or conformance of parts or assemblies to API 16A.

3.1.68**remanufacturer**

Organization that performs the repair or remanufacture work.

3.1.69**repair**

Process of disassembly, inspection, reassembly, and testing of drill-through equipment, with or without the replacement of parts in order to correct failed or worn components.

NOTE Repair does not include machining, welding, heat treating, or other manufacturing operations of component parts.

3.1.70**repair weld**

Welding performed to correct a nonconformance.

3.1.71**serialization**

Assignment of a unique code to individual parts and/or pieces of equipment to maintain records.

3.1.72**skim cut**

Re-facing of a machined surface within allowable tolerances and surface finish of the CPD or API specification.

3.1.73**stabilized**

Pressure testing in a state in which the initial pressure-decline rate has decreased to within the remanufacturer's specified rate.

NOTE Pressure decline can be caused by such things as changes in temperature, setting of elastomer seals, or compression of air trapped in the equipment being tested.

3.1.74**statement of compatibility****SOC**

Document in which a manufacturer, remanufacturer, or technical authority states that an assembly or component part meets or exceeds the product performance requirements as defined in API 16A and is compatible with the assembly for which it is intended.

3.1.75**statement of fact****SOF**

Document in which the manufacturer, remanufacturer, or technical authority certifies that the repair or activity performed was made with in accordance with the scope defined by the owner.

NOTE A statement of fact (SOF) does not fulfil the requirements of a certificate of conformance (COC) or other documentation verifying product design.

3.1.76**stress relief**

Controlled heating of material to a predetermined temperature for the purpose of reducing any residual stresses.

3.1.77**technical authority**

Competent and technically qualified person or organization with evidence to demonstrate the expertise, skills, and experience regarding design, quality, and manufacturing processes necessary to perform the required verification(s).

3.1.78**trepan (verb)**

Produce a hole through a part by boring a narrow band or groove around the circumference of the hole and removing the solid central core of material.

3.1.79**utility bolting**

All bolting that is required to mount equipment and accessories to the drill-through equipment that is not closure bolting, pressure retaining, or pressure controlling.

NOTE Examples: bolting on lifting eye, pad eye (nonwelded), wear bushing, name plate, clamps for tubing, guards.

3.1.80**variable-bore ram****VBR**

Closing and sealing component in a ram BOP that is capable of sealing on a range of tubular sizes.

3.1.81**visual examination**

Examination of parts and equipment for visible defects in material and workmanship.

3.1.82**volumetric nondestructive examination**

Examination for internal material defects by radiography, acoustic emission (AE), or ultrasonic testing (UT).

3.1.83**weld (verb)**

Act of fusing materials, with or without the addition of filler materials.

3.1.84**weld groove (weld prep)**

Area between two metals to be joined that has been prepared to receive weld filler metal, also known as weld prep.

3.1.85**welding**

Application of any one of a group of welding processes, which applies heat energy sufficient to melt and join one or more pieces of metal through localized fusion and coalescence.

3.1.86**welding procedure specification****WPS**

Written welding procedure that is qualified to provide direction for welding in accordance with requirements of this standard and describing the specific essential, nonessential, and supplementary essential variables required for each welding process.

NOTE These variables and their meanings are defined in ASME BPVC Section IX, Article II and Article IV.

3.1.87**weldment**

Portion or area of a component on which welding has been performed.

NOTE A weldment includes the weld metal, the heat-affected zone (HAZ), and the base metal unaffected by the heat of welding.

3.1.88**yield strength****YS**

Stress level, measured at room temperature, at which material plastically deforms and will not return to its original dimensions when the stress is released.

NOTE 1 The term is expressed in Newton's per square millimeter (pounds per square inch) of loaded area.

NOTE 2 All yield strength (YS) specified in this standard are considered as being the 0.2 % yield offset strength in accordance with ISO 6892 or ASTM A370.

3.2 Acronyms and Abbreviations

AE	acoustic emission
AWS	American Welding Society/Specification Filler Number
BOP	blowout preventer
CE	carbon equivalent
CEM	current equipment manufacturer
COC	certificate of conformance
COS	certificate of service
CPD	current product definition
CRA	corrosion-resistant alloy
CSWIP	certification scheme for welding and inspection personnel
DAC	distance amplitude curve
DHT	dehydrogenation heat treatment
DPI	dye penetrant inspection
EP	equivalent P-number
ER	equivalent round
FAT	factory acceptance test
FCAW	flux-cored arc welding
Fe	iron
FN	ferrite number
HAZ	heat-affected zone
HBW	hardness Brinell
ID	inside diameter
ITP	inspection test plan
LP	liquid penetrant

MDB	manufacturing data book
MP	magnetic particle
MPI	magnetic particle inspection
MT	magnetic test
MTR	material test record
NDE	nondestructive examination
OD	outside diameter
OEC	other end connection
OEM	original equipment manufacturer
OPD	original product definition
PHF	product history file
PM	preventive maintenance
PMI	positive material identification
PQR	procedure qualification record
PT	penetrant test
PWHT	postweld heat treatment
QMS	quality management system
Q&T	quenched and tempered
QTC	qualification test coupon
RSL	remanufacture specification level
SAW	submerged-arc welding
SMAW	shielded metal arc welding
SOC	statement of compatibility
SOF	statement of fact
SSC	sulfide stress cracking
SST	stainless steel
TPI	third-party inspection
UNS	unified numbering system
UT	ultrasonic testing
UTS	ultimate tensile strength
VBR	variable-bore ram

WPS	welding procedure specification
YS	yield strength

4 Quality Control Requirements

4.1 General

Equipment repaired and remanufactured to this standard shall meet the quality control requirements specified by this section.

4.2 Measuring and Testing Equipment

4.2.1 General

Equipment used to inspect, test, or examine material or other equipment shall be identified, controlled, calibrated and adjusted at specified intervals in accordance with documented manufacturer requirements, and consistent with recognized standards specified by the manufacturer/remanufacturer, to maintain the accuracy required by this standard.

4.2.2 Pressure-measuring Devices

4.2.2.1 Type and Accuracy

Test pressure-measuring devices shall be accurate in accordance with 16A.

Test pressure-measuring devices shall be either pressure gauges or pressure transducers and shall be accurate to at least ± 1.0 % of full-scale range.

If pressure gauges are used in lieu of pressure transducers, they shall be selected such that the test pressure is indicated within 20 % and 80 % of the full-scale value.

Pressure tests shall be documented in a chart (linear or circular) in the product history file (PHF) and manufacturing data book (MDB).

The record shall identify the recording device and calibration due date and shall be dated and signed.

4.2.2.2 Calibration Procedure

Pressure-measuring devices shall be periodically recalibrated with a master pressure-measuring device or a deadweight tester to at least three equidistant points of full scale (excluding zero and full scale as required points of calibration).

4.2.2.3 Calibration Intervals

Intervals shall be established for calibrations based on repeatability and degree of usage.

Calibration intervals shall be a maximum of 3 months until recorded calibration history can be established by the manufacturer/remanufacturer and new intervals established demonstrating the ability to retain accuracy after a period of time and after repeated use.

The increased calibration intervals shall not exceed 1 year.

NOTE The date of the last test may be noted on the front of the gauge.

4.3 Quality Control Personnel Qualifications

4.3.1 NDE Personnel

Personnel performing NDE shall be qualified in accordance with the manufacturer's or remanufacturer's documented training program that conforms to the requirements specified in ISO 9712 or ASNT SNT-TC-1A.

4.3.2 Visual and Dimensional Examination Personnel

Personnel performing visual and dimensional examinations, including welders, shall take and pass an annual vision examination in accordance with the manufacturer's or remanufacturer's documented procedures that conforms to the applicable requirements of ISO 9712 or ASNT SNT-TC-1A.

4.3.3 Welding Inspectors

Personnel performing visual inspection of welding operations and completed welds shall be qualified to one of the following:

- AWS Senior Certified Welding Inspector (SCWI) in conformance with the provisions of AWS QC1;
- AWS Certified Welding Inspector (CWI) in conformance with the provisions of AWS QC1;
- AWS Certified Associate Welding Inspector (CAWI) in conformance with the provisions of AWS QC1 and under the supervision of an AWS SCWI or AWS CWI.
- CSWIP Certified Visual Welding Inspectors (Level 1);
- CSWIP Certified Welding Inspectors (Level 2);
- CSWIP Certified Senior Welding Inspectors (Level 3);
- welding inspector certified by the manufacturer's or remanufacturer's documented training program.

The manufacturer or remanufacturer shall have written procedures:

- defining the in-house welding inspector certification program including training syllabus, instructor qualification requirements, length of certification, and renewal requirements;
- defining the roles, responsibilities, authority, and accountability of a welding inspector;
- defining essential welding variables and equipment monitoring;
- defining welding, weld NDE, and postweld heat treatment (PWHT) audits. Internal audits shall be performed at least annually, covering all on-site areas and shifts. Supplier audits shall be performed in accordance with the manufacturer's or remanufacturer's written procedure for validation of supplier processes.

4.3.4 Third-party Inspection

If third-party inspection (TPI) is used, the following shall apply.

- Third-party inspectors shall be competent based on the appropriate education, training, skills, and experience needed to perform the inspection service and certification related product requirements defined in the inspection scope.

- Evidence of the determination of competence of TPI personnel shall be recorded and maintained by the TPI company in accordance with their quality management system (QMS) documented procedures and requirements for competence.
- The TPI scope shall be clearly defined in the purchase order by the equipment owner.
- The TPI requirements defined in the purchase order shall be included in the inspection test plan (ITP) for the product.

4.3.5 Equipment Certification

Equipment certification shall be approved by a technical authority.

4.3.6 Other Personnel

All other personnel performing measurements, inspections, tests, or other quality control activities for acceptance shall be qualified and competent in accordance with the manufacturer's QMS documented procedures and requirements that meet the requirements of API Q1 or equivalent internationally recognized standard.

4.4 Quality Control Requirements for Equipment and Parts

4.4.1 General

All pressure-containing and pressure-controlling parts exposed to wellbore fluid shall be in conformance with the requirements of NACE MR0175/ISO 15156 (all parts).

All equipment and parts that are to be repaired/remanufactured under this standard shall be reviewed and confirmed to meet the requirements in this standard.

The MDB and PHF shall be updated in accordance to these requirements.

4.4.2 Material Requirements

Material used for parts or members shall conform to the requirements of API 16A with the exceptions noted in 4.7.

4.4.3 Quality Control Instructions

All quality control work shall be controlled by the remanufacturer's documented instructions, which includes an appropriate ITP or other methodology that provides an auditable tracking document with quantitative and qualitative acceptance criteria.

4.4.4 Nondestructive Examination

4.4.4.1 NDE Instructions

NDE instructions shall be detailed regarding the requirements of this standard and those of all applicable nationally or internationally recognized standards specified by the manufacturer or remanufacturer. All NDE instructions shall be approved by a NDE Level III examiner.

4.4.4.2 NDE Qualification Levels

NDE personnel shall be qualified in accordance with requirements specified in ISO 9712 or ASNT SNT-TC-1A.

4.4.5 Acceptance Status

The acceptance status of all equipment, parts, and materials shall be indicated either on the equipment, parts, or materials or in the records traceable to the equipment, parts, or materials.

4.5 Quality Control Requirements for Specific Equipment and Parts

4.5.1 General

Unless specified differently in this standard, quality control requirements for specific equipment and parts under this standard shall be in conformance with API 16A.

All new manufactured or replacement parts shall be in full conformance to API 16A requirements, including design verification and validation.

All new manufactured, remanufactured or replacement parts shall be in conformance with an actual product definition (OPD or CPD).

Quality control records and marking for specific equipment and parts shall be in conformance with API 16A.

4.5.2 Hardness Testing

Hardness testing requirements shall meet the following.

- Hardness testing methods shall be in accordance with ASTM E10, ASTM E18, ASTM E110, ASTM E384, ISO 6506-1, ISO 6507-1, or ISO 6508-1, as appropriate.
- Only Vickers hardness testing shall be used in weld qualification.
- At least one hardness test (consisting of at least two indentations) shall be performed on each part tested, at a location determined by the manufacturer's or remanufacturer's specifications.
- When equipment is a weldment composed of different material designations, hardness testing shall be performed on each component part of the weldment after the final heat treatment (including stress relieving). The results of these hardness tests shall satisfy the hardness value requirements for each respective part.
- The hardness testing used to qualify each part shall be performed after the last heat treatment cycle (including all stress-relieving heat treatment cycles) and after all exterior machining operations.
- In no case shall an individual hardness value fall below 95 % of the required minimum in the Brinell hardness scale.
- The average value of the hardness test shall be stamped on the part adjacent to the test location. It is permissible for the hardness marking to be covered by other components after assembly.
- Hardness measurements on wellbore-wetted parts manufactured from carbon low-alloy and martensitic stainless type steels shall exhibit maximum values in accordance with NACE MR0175/ISO 15156 (all parts) and minimum values equal to or greater than those specified in API 16A.
- Hardness measurement results shall be added to the MDB and PHF.

4.5.3 Critical Dimensions

Critical dimension requirements shall meet the following.

- Critical dimensions, as defined by the CEM, shall be documented and recorded for each part, and such documentation shall be retained by the CEM in accordance with the quality control requirements of Section 4.
- Critical dimensions, as defined by the CEM, shall be within acceptable tolerances per the CPD.
- The CEM shall define and document the extent to which dimensions shall be verified and recorded.
- All API 6A ring grooves shall meet the requirements of API 6A before final factory acceptance testing (FAT).

NOTE Previously tested API 6A and API 16A ring grooves may not meet as-new machined surface dimensions and surface finish. Ring groove sealing surfaces showing radial coining without scars across that surface but sealing when reassembled and pressure tested after makeup have been successfully returned into service without re-machining.

4.5.4 Traceability

Traceability requirements shall meet the following.

- Parts and material shall be traceable in accordance with 4.7.
- Identification shall be maintained on materials and parts, to facilitate traceability, as required by documented manufacturer requirements.
- Manufacturer documented traceability requirements shall include provisions for maintenance or replacement of identification marks and identification control records.
- Welds without sufficient documentation/traceability in the PHF to meet the design specification of the manufacturer or the required RSL of the product shall be removed.

4.5.5 Chemical Analysis

Chemical analysis shall be required for remanufactured pressure-controlling, pressure-containing, and pressure-retaining parts/members, base metal, and filler material.

- Chemical analysis shall be performed when a material test record is not available.
- Chemical analysis shall be performed in accordance with the remanufacturer's written procedure.
- The chemical composition shall be in conformance with the requirements of API 16A.

4.5.6 Visual Examination

Visual examination requirements shall meet the following.

- Each part shall be visually examined.
- Visual examination of castings and forgings shall be performed in accordance with the manufacturer's or remanufacturer's written specification.
- Acceptance criteria shall be in accordance with manufacturer's written specifications.
- Non-well-fluid-wetted and nonsealing surfaces shall be examined in accordance with manufacturer's written specifications.

4.5.7 Surface NDE

Surface NDE requirements shall meet the following.

- For surface NDE of ferromagnetic materials, all accessible well-fluid-wetted surfaces and all accessible sealing surfaces of each finished part shall be inspected after final heat treatment and final machining operations by either MP or LP methods.
- For surface NDE of nonferromagnetic materials, all accessible well-fluid-wetted surfaces of each finished part shall be inspected after final heat treatment and after final machining operations by the LP method.
- LP examination shall be in accordance with procedures specified in ASTM E165/E165M.
- MP examination shall be in accordance with procedures specified in ASTM E709. Prods are not permitted on well-fluid-wetted surfaces or sealing surfaces.

4.5.8 Acceptance Criteria for MP and LP

4.5.8.1 General

NOTE Inherent indications not associated with a surface rupture (i.e. magnetic permeability variations, nonmetallic stringer, etc.) are not considered relevant indications.

4.5.8.2 Acceptance Criteria for Surfaces Other than Pressure Contact (Metal-to-Metal) Sealing Surfaces

Acceptance criteria for surfaces other than pressure contact (metal-to-metal) sealing surfaces shall meet the following:

- No relevant indication with a major dimension equal to or greater than 5 mm (0.2 in.).
- No more than 10 relevant indications in any continuous 10 cm² (2.5 in.²) area.
- Four or more relevant indications in a line separated by less than 1.6 mm (0.062 in.) (edge to edge) are unacceptable.

4.5.8.3 Acceptance Criteria for Pressure Contact (Metal-to-Metal) Sealing Surfaces

There shall be no relevant indications in the pressure-contact (metal-to-metal) sealing surfaces.

4.5.9 Weld NDE

All welds shall be surface NDE and visual inspected.

Weld NDE requirements shall meet the following.

- Essential welding variables and equipment shall be monitored, and completed weldments and the entire accessible weld shall be examined in accordance with the methods and acceptance criteria of this standard.
- 100 % of all surfaces prepared for welding shall be visually examined prior to initiating welding.
- Examinations shall include a minimum of 13 mm (0.5 in.) of adjacent base metal on both sides of the weld.

- Weld NDE surface preparation acceptance shall be in accordance with the remanufacturer's written specification.
- All welds shall be examined according to remanufacturer's written specification.
- Any undercut detected by visual examination shall be evaluated in accordance with the remanufacturer's written specification.
- Surface porosity and exposed slag are not permitted on or within 3 mm (0.125 in.) of sealing surfaces.

4.5.10 Weld NDE—Surface Examination (Other Than Visual)

Weld NDE surface examination requirements shall meet the following:

- 100 % of all pressure-containing repair welds, weld metal overlay welds, and repaired fabrication welds shall be examined by either MP or LP methods after all welding, PWHT, and machining operations are completed;
- the examination shall include 13 mm (0.5 in.) of adjacent base material on both sides of the weld;
- acceptance criteria for MP and LP shall be in conformance with API 16A.

4.5.11 Repair Welds

Repair weld requirements shall meet the following:

- all repair welds shall be examined using the same methods and acceptance criteria used in examining the base metal;
- the examination shall include 13 mm (0.5 in.) of adjacent base material on both sides of the weld;
- surfaces of ground-out areas for repair welds shall be examined prior to welding to ensure defect removal using the acceptance criteria for fabrication welds.

4.5.12 Weld NDE—Volumetric Examination of Weld

4.5.12.1 Sampling

Sampling requirements shall meet the following:

- 100 % of all pressure-containing welds and 100 % of the weld volume shall be examined by either radiography, ultrasonic, or AE methods after all welding and PWHT;
- all repair welds for which the repair is greater than 25 % of the original wall thickness or 25.4 mm (1 in.) (whichever is less) shall be examined by either radiography, ultrasonic, or AE methods after all welding and PWHT;
- examinations shall include at least 12.7 mm (0.5 in.) of adjacent base metal on all sides of the weld;
- equipment with untraceable pressure-containing welds that are not subjected to 100 % volumetric NDE are classified as RSL 1 product.

4.5.12.2 Radiography Examination

Radiography examination requirements shall meet the following:

- radiographic examinations shall be performed in accordance with procedures specified in ASTM E94, to a minimum equivalent sensitivity of 2 % and a 2-2T quality level;
- both X-ray and gamma ray radiation sources are acceptable within the inherent thickness range limitation of each;
- real-time imaging and recording/enhancement methods may be used when the manufacturer or remanufacturer has documented proof that the methods will result in a minimum equivalent sensitivity of 2 % and a 2-2T quality level;
- wire-type image quality indicators are acceptable for use in accordance with ASTM E747.

4.5.12.3 Radiography Examination Acceptance Criteria

The following shall not be accepted:

- any type of crack, zone of incomplete fusion or penetration;
- any elongated slag inclusion that has a length equal to or greater than specified in Table 1;
- any group of slag inclusions in a line having an aggregate length greater than the weld thickness, t , in any total weld length $12t$, except when the distance between successive inclusions exceeds six times the length of the longest inclusion;
- any rounded indications in excess of that specified in ASME *BPVC* Section VIII, Division 1.

4.5.12.4 Ultrasonic Examination

Ultrasonic examinations shall be performed in accordance with procedures specified in ASME *BPVC* Section V.

Table 1—Weld Inclusion Criteria

Weld Thickness t		Inclusion Length	
mm	(in.)	mm	(in.)
<19	<0.76	6.4	0.25
$19 \leq t \leq 57$	$0.76 \leq t \leq 2.25$	$0.33t$	$0.33t$
>57	>2.25	19.0	0.75

4.5.12.5 Ultrasonic Examination Acceptance Criteria

The following shall not be accepted:

- any indication whose signal amplitude exceeds the reference level;
- any linear indication interpreted as a crack, incomplete joint penetration, or incomplete fusion;
- any slag indication with amplitude exceeding the reference level whose length exceeds that specified in Table 1.

NOTE If a weld joins two members having different thicknesses at the weld, t is taken as the thinner of the two thicknesses.