

Supplementary Specification to API Recommended Practice 582 for Welding of Pressure Equipment and Piping

NOTE This version (S-705J) of the specification document provides the justification statements for each technical requirement, but is otherwise identical in content to S-705.

Revision history

VERSION	DATE	PURPOSE
2.0	November 2025	Second Edition
1.0	June 2020	First Edition

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

This second edition cancels and replaces the first edition published in June 2020. Due to technical writing requirements leading to extensive changes, this second edition should be treated as a new document.

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Introduction

The purpose of the IOGP S-705 specification documents is to define a minimum common set of requirements for the welding of pressure equipment and piping in accordance with API Recommended Practice 582, Fourth Edition, May 2023, Welding Guidelines for the Chemical, Oil, and Gas Industries for application in the petroleum and natural gas industries.

The IOGP S-705 specification documents follow a common structure (as shown below) comprising a specification, also known as a technical requirements specification (TRS), a procurement data sheet (PDS), an information requirements specification (IRS) and a quality requirements specification (QRS). These four specification documents, together with the purchase order, define the overall technical specification for procurement.



JIP33 Specification for Procurement Documents Supplementary Technical Requirements Specification (TRS)

This specification is to be applied in conjunction with the supporting PDS, IRS and QRS as follows.

IOGP S-705: Supplementary Specification to API Recommended Practice 582 for Welding of Pressure Equipment and Piping

This specification defines technical requirements for the supply of the equipment and is written as an overlay to API 582, following the API 582 clause structure. Clauses from API 582 not amended by this specification apply as written. Modifications to API 582 defined in this specification are introduced by a description that includes the type of modification (i.e. Add, Replace or Delete) and the position of the modification within the clause.

NOTE Lists, notes, tables, figures, equations, examples and warnings are not counted as paragraphs.

IOGP S-705D: Procurement Data Sheet for Welding of Pressure Equipment and Piping (API)

The PDS defines application-specific requirements. The PDS is applied during the procurement cycle only and does not replace the equipment data sheet. The PDS may also include fields for supplier-provided information required as part of the purchaser's technical evaluation. Additional purchaser-supplied documents may also be incorporated or referenced in the PDS to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-705L: Information Requirements for Welding of Pressure Equipment and Piping (API)

The IRS defines information requirements for the scope of supply. The IRS includes information content, format, timing and purpose to be provided by the supplier, and may also define specific conditions that invoke the information requirements.

IOGP S-705Q: Quality Requirements for Welding of Pressure Equipment and Piping (API)

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the PDS or in the purchase order.

The specification documents follow the editorial format of API 582 and, where appropriate, the drafting principles and rules of ISO/IEC Directives Part 2.

The PDS and IRS are published as editable documents for the purchaser to specify application-specific requirements. The TRS and QRS are fixed documents.

The order of precedence of documents applicable to the supply of the equipment, with the highest authority listed first, shall be as follows:

- a) regulatory requirements;
- b) contract documentation (e.g. purchase order);
- c) purchaser-defined requirements (e.g. PDS, IRS and QRS);
- d) this specification;
- e) API 582.

1 Scope

1.1

Add to first paragraph

This specification applies to the procurement of equipment packages.

Justification

This addition aligns with the scope defined in the framing proposal.

Delete "-retaining" from list item a)

Justification

The scope of the specification applies to pressure-retaining and pressure-containing parts of pressure equipment and component items.

Add to list item d)

(e.g. saddle, skirt, trunnion, braces, supports)

Justification

This addition provides examples of structural items covered by the term "attached and related" used in API 582.

1.3

Add new list item j)

j) weld buildup to restore base metal thickness and additive manufacturing.

Justification

Weld buildup to correct dimensional problems and additive weld manufacturing is not in the scope of the specification.

2 Normative References

Add to first paragraph

The following documents are referred to in this specification, the PDS (IOGP S-705D) or the IRS (IOGP S-705L) in such a way that some or all of their content constitutes requirements of these specification documents.

Add to section

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

ASME *Boiler and Pressure Vessel Code*, Section II:2023, Part C, Specifications for Welding Rods, Electrodes, and Filler Metals

ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1:2023, *Rules for Construction of Pressure Vessels*

ASME *Boiler and Pressure Vessel Code*, Section IX:2023, *Welding, Brazing, and Fusing Qualifications*

ASME B31.3:2024, *Process Piping*

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

ISO 8249, *Welding — Determination of Ferrite Number (FN) in austenitic and duplex ferritic-austenitic Cr-Ni stainless steel weld metals*

ISO 13703-3:2023, *Oil and gas industries including lower carbon energy — Piping systems on offshore production platforms and onshore plants — Part 3: Fabrication*

ISO 15614 (all parts), *Specification and qualification of welding procedures for metallic materials — Welding procedure test*

Delete from section

AWS A4.2M (ISO 8249:2000 MOD), *Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal*

3 Terms, Definitions, Acronyms, and Abbreviations

3.2 Acronyms and Abbreviations

Add to section

CRA corrosion-resistant alloy

CS carbon steel

CSWIP Certification Scheme for Welding Inspection Personnel

CWB Canadian Welding Bureau

CWI Certified Welding Inspector

ECA engineering critical assessment

HSC * hydrogen stress cracking

IWE International Welding Engineer

IWI-S International Welding Inspector Standard Level

LAS low-alloy steel

LNG liquefied natural gas

QL quality level

SMYS specified minimum yield strength

SSC * sulfide stress cracking

* Cited in IOGP S-705J only.

4 General Welding Requirements

4.1

Replace "D.1, D.6, and D.8 or may be qualified per ASME BPVC Section IX" with

AWS D1.1, AWS D1.6, and AWS D1.8 or may be qualified in accordance with ASME BPVC Section IX or ISO 15614 (all parts)

Justification

In the original requirement, "D.1, D.6, and D.8" editorially refers to Annex D sections. This replacement ensures that references are to the AWS standards. This replacement also includes the addition of ISO 15614 (all parts) which is the alternative ISO standard to ASME BPVC Section IX.

4.2

Add to first sentence after "ASME BPVC Section IX"

, or ISO 15609 and ISO 15614 (all parts),

Justification

ISO 15609 and ISO 15614 (all parts) are the alternative ISO standards to ASME BPVC Section IX.

4.6

Replace "plus any applicable API standard or recommended practice" with

and this specification

Justification

This replacement makes compliance with this specification mandatory and allows the use of codes and standards other than ASME.

4.7

Add after "ASME BPVC Section IX"

or ISO 15614-1

Justification

This alternative ISO standard describes how to measure instantaneous power and energy. ISO 15614-1:2017, 8.4.7 refers to ISO/TR 18491 which defines how to measure heat input.

4.9 Welder and Welding Operator Qualifications

4.9.2

Replace "ISO 9606" with

ISO 14732

Justification

The correct standard for the qualification of welding operators is ISO 14732.

Add new section

4.10

Welding shall be performed under a weld quality management system that complies with ISO 3834-2 or similar requirements in the specified fabrication code (e.g. ASME B31.3:2024, Appendix Q or ASME BPVC Section VIII, Division 1:2023, Appendix 10) or as specified.

Justification

Adequate quality assurance and quality control are important in all welded fabrications. At the elementary level, this requirement ensures that welding consumables are stored correctly and that the correct consumable is used in any given joint and, in the case of more critical fabrications, that arc energy restrictions, interpass temperature limits and overall thermal profile requirements are observed. Compliance with ISO 3834-2 can negatively impact procurement in the downstream and refinery sectors due to the limited number of pressure vessel fabricators certified to ISO 3834-2, so alternative welding quality management requirements can be specified.

Add new section

4.11 Welding Procedure Specification

4.11.1

WPSs shall include the applicable additional essential variables stated in this specification.

Justification

This requirement ensures adherence to this specification which provides additional process safety requirements. Changes outside these essential variables may change the properties of the weld to such an extent that the mechanical properties are no longer represented by the PQR.

NOTE If an existing WPS has previously been approved but does not contain the additional essential variables required by this specification, approval can be sought to allow the use of this WPS.

Justification

This note advises that the updating and reapproval of previously approved welding procedures are not always necessary, as they can have significant implications for project costs and schedules.

4.11.2

WPSs shall be accessible by the welder or welding operator at the welding station for the duration of the welding activity.

Justification

This requirement ensures that the welder and welding operator have direct access to the WPS while welding.

Add new section

4.12

Where there is a conflict between the requirements of this specification, the applicable design and fabrication code, and the welding code, the most stringent requirements shall apply.

Justification

Requirements can differ between the specification, the code and ASME BPVC Section IX (e.g. CVN). The application of the most stringent requirements results in an improvement in weld quality while ensuring code compliance.

Add new section

4.13

Test laboratories shall be certified to ISO/IEC 17025 or as specified.

Justification

This requirement ensures that test laboratories operate under a quality system.

Add new section

4.14

During welding, the weld shall be protected from unfavorable weather conditions (e.g. wind and rain).

Justification

Unfavorable weather conditions can negatively affect the quality of the weld if protection from exposure is not provided.

Add new section

4.15

Welding inspectors shall hold a current level 2 or equivalent certification from a recognized scheme such as AWS-CWI, CSWIP 3.1, CWB-Level 2 or IWI-S.

Justification

This requirement ensures that welding inspectors have the qualifications to demonstrate sufficient knowledge and skills to perform the inspections.

Add new section

4.16

When ISO 3834-2 is selected as the welding quality management system, welding coordinator qualification shall be at the comprehensive level specified in ISO 14731.

NOTE Welding coordinators holding IWE or equivalent certification are considered to satisfy the comprehensive level requirements of ISO 14731.

Justification

This requirement ensures that the welding coordinator has sufficient knowledge and skill to consistently control the various welding and welding-related operations and achieve the desired quality.

Add new section

4.17

If specified, autogenous, dissimilar and heterogeneous welding shall not be permitted.

Justification

Autogenous welding commonly causes insufficient deposition. Dissimilar and heterogeneous welding can cause a loss of mechanical properties in the transition zone and an anodic pair prone to corrosion.

Add new section

4.18

If impact testing of the transition zone on heterogeneous welds and dissimilar joints is specified, the transition zone (fusion line + 0.06 in. (1.5 mm)) shall be tested in addition to the HAZ and weld metal.

Justification

Codes only require impact testing to weld metal and HAZ, and not to the transition zone which has a different chemical composition.

5 Welding Processes

5.1 Acceptable Welding Processes

Delete list item 4) from list item c)

Justification

GMAW-G results in excessive weld spatter and uneven weld bead. On this basis, GMAW-G is not accepted for pressure equipment items.

5.2 Limitations of Fusion Welding Processes

5.2.1 General

Add to sentence

and in Table 8

Justification

Table 8 provides additional limitations on which of the processes listed in API 582, 5.1 are suitable for the associated weld layers (e.g. root pass). This ensures that the supplier does not use an unsuitable welding process for an application.

Add new Table 8

Table 8—Limitations of Fusion Welding Processes

Welding Processes	Root Pass	Second Pass	Fill/Cap	Overlay	Buttering
Shielded metal arc welding (SMAW)	x ^a	x	x	x ⁱ	x
Gas tungsten arc welding (GTAW and GTAW-P)	x ^b	x ^b	x ^b	x ⁱ	x
Gas metal arc welding—spray (GMAW-Sp)		x	x	x ⁱ	x
Gas metal arc welding—short-circuiting (GMAW-S)	x ^{a, c}	x ^c	x ^c		
Gas metal arc welding—pulsed (GMAW-P)		x ^g	x ^g	x ^{g, i}	
Electrode gas welding (EGW)	x ^{a, d}	x ^d	x ^d		
Submerged arc welding (SAW)	x ^{a, f}	x ^f	x ^f	x ^{f, i}	
Electroslag welding (ESW)				x ^{h, i}	
Gas shielded flux-cored arc welding (FCAW-G)	x ^{a, e}	x ^e	x ^e	x ^{e, i}	x ^e
Plasma arc welding (PAW)	x ^a	x	x	x ⁱ	
Key x Acceptable ^a See 5.3, 6.2.2, C.2 and D.4.2 for limitations in single-sided welded joints. ^b See 5.2.2 and D.4.2 for limitations on GTAW and GTAW-P. ^c See 5.2.3 and F.2 for limitations on GMAW-S. ^d See 5.2.6 for limitations on EGW. ^e See 5.2.5 for limitations on FCAW. ^f See 5.2.7 for limitations on SAW. ^g See 5.2.4 for limitations on GMAW-P. ^h See 5.1 f) for limitations on ESW. ⁱ See Annex B for limitations on weld overlay.					

Justification

This table provides a more detailed overview of the limitations of the welding processes listed in API 582, 5.1, providing information on the acceptable processes for the associated weld layers (e.g. root pass). This ensures that the supplier does not use an unsuitable welding process for an application.

Replace section 5.2.2 title with

5.2.2 Gas Tungsten Arc Welding

Justification

The section title "GTAW-P" in API 582, Third Edition was replaced with "GTAW" in IOGP S-705 Version 1.0. The title in API 582, Fourth Edition remains as GTAW-P. 5.2.2 b) applies to both GTAW and GTAW-P, so the title has been revised to cover both processes. In addition, 5.2.2 b) has been modified to make it applicable to GTAW and GTAW-P.

In first sentence of list section a), replace "should" with

shall

Justification

A change in make and model for both GTAW-P and GMAW-P (see 5.2.4) can affect the weld quality. Pulsed GTAW and GMAW equipment have different (proprietary) ways to control pulse and to define program settings that are generally not transferable across different makes and models.

Add to list section b) after "GTAW-P"

and GTAW

Justification

If a high-frequency starting device is not used, weld defects (arc strike) can be more likely. This applies to GTAW and GTAW-P, so the requirement has been expanded to cover GTAW.

5.2.3 Gas Metal Arc Welding—Short Circuiting

Add to list section a)

or welds where cyclic loading is a controlling design requirement

Justification

GMAW-S welds have an elevated risk of lack of fusion or incomplete penetration defects that are difficult to detect by NDE. If these defects are undetected and therefore not rectified, they can reduce the fatigue performance of the joints when fatigue is a controlling design requirement.

In first sentence of list section b), replace "where the backside of the weld is not accessible" with

in single-sided welds, provided that adapted/modified arc transfer mode is used

Justification

GMAW-S is susceptible to lack of fusion defects in the weld. Power sources with modified arc transfer are required to reduce the risk of such defects on the root pass of single-sided welds.

Add to list item b)

GMAW-S with adaptive/modified arc transfer mode shall be performed with the same equipment make, model and program settings used in the PQR.

Justification

The make, model, program and equipment settings, and pulse waveform in GMAW-S equipment with adaptive/modified arc transfer mode affect welding arc performance, especially sidewall fusion and out-of-position welding. Studies have shown considerable variation in arc characteristics when one make or model of the welding system is compared to another for adapted/modified arc transfer mode. This variation can lead to welding defects, some of which can be very difficult to detect.

5.2.5 Flux-cored Arc Welding

5.2.5.1

Delete "for carbon and low-alloy steel pressure-retaining welds"

Justification

Self-shielded FCAW is prone to defects, poor toughness, limitations to the properties developed and corrosion.

5.2.5.2

Add to sentence

as permitted in Table 8

Justification

Acceptable uses of FCAW-G are given in Table 8.

5.2.7.2

Delete section 5.2.7.2

Justification

This requirement is addressed in the welding codes, ASME BPVC Section IX:2023, QW-403.9 (essential variable for SMAW, GTAW, SAW, GMAW/FCAW) and ISO 15614-1:2017, Table 7. Both standards allow a +10 % margin on the qualified weld deposit thickness for single-pass exceeding ½ in. (13 mm) (ASME) or 12 mm (ISO).

5.3 Single-sided Welded Joints

Add to section

For single-sided welded joints, root pass welding of CS and low-alloy steel (LAS) pipe sizes below NPS 3 (DN 75) shall use GTAW or PAW.

Justification

Restricting the use of SMAW and FCAW-G for root passes in single-sided welds reduces the risk of defects in small-bore piping.

Add to section

If specified, the use of SMAW E6010 shall be permitted for root pass welding of single-sided welded joints for CS and LAS pipe sizes below NPS 3 (DN 75).

Justification

SMAW E6010 is frequently used in the industry without defects and restricting its use can lead to increased cost and complexity.

6 Welding Consumables (Filler Metal and Flux)

6.1 General

6.1.3

Delete fourth sentence (including list)

Justification

Cellulose-type SMAW electrodes significantly increase the risk of fabrication hydrogen cracking due to their characteristic of having higher diffusible hydrogen than is recommended. As such, they are not recommended for pressure-retaining welds and attachment welds to pressure equipment, particularly single-pass fillet welds as the HAZ hardness and the amount of diffusible hydrogen are likely to be higher without subsequent reheating from successive passes.

For piping (list item b), this requirement (no cellulose-type electrodes permitted) is aligned with ISO 13703-3:2023, 7.2.1.

6.1.4

Replace second sentence with

The welding consumable mechanical properties, including toughness, shall be certified by the filler metal manufacturer in accordance with ASME BPVC Section II, Part C/AWS or ISO filler metal specifications, minimum Schedule 2 or G with an ISO 10474 /EN 10204 Type 2.2 inspection document, or as specified.

Justification

This addition ensures that alternative consumable specifications to ISO are included to facilitate the global use of this specification. It also clarifies the minimum schedule for mechanical testing and minimum certification required for the mechanical properties of the welding consumable. An alternative testing schedule and type of certification for the welding consumable mechanical properties can be selected.

Add to section

If the welding consumable certification does not report the toughness of the weld metal, weld metal impact testing may be performed as part of the PQR qualification.

Justification

This requirement permits alternative testing to verify adequate toughness of the welding consumable when the consumable certification does not include impact testing results. This requirement also removes the need to re-qualify the PQR with impact testing for each consumable heat and lot (i.e. for each job).

6.1.5

In first sentence, replace "should" with

shall

Justification

The "G" classification of electrodes does not fully define the composition and properties of the consumable. This replacement makes testing of the consumable mandatory, or its use restricted to the brand and type of consumable (including the nominal composition) qualified in the PQR.

In first sentence, replace "per A/SFA 5.01" with

in accordance with ASME BPVC Section II:2023, Part C, SFA-5.01, minimum Sch. 3 or H or ISO 10474/EN 10204, minimum Type 3.1

Justification

This replacement ensures that both AWS/ASME and ISO/EN certification requirements are covered.

In second sentence, replace "should" with

shall

Justification

The "G" classification of electrodes does not fully define the composition and properties of the consumable. This replacement ensures that the nominal chemical composition of the specified brand and type of consumable is provided in the WPS.

6.1.10

Replace "including" with

for

Justification

This replacement ensures clarity and removes a potential conflict with 6.1.4 paragraph 1 sentence 2. The default certification for consumables is type 2.2 for mechanical tests and type 3.1 for chemical composition, except for SAW flux which is type 2.2 for chemical composition.

6.1.11

Delete section 6.1.11

Justification

Low-hydrogen welding consumables help to prevent delayed hydrogen-induced cracks in the weld metal and HAZs resulting from hydrogen charged into the metal during the welding process. These cracks are difficult to detect with the NDE procedures used in most fabrication shops (typically radiography, visual and other surface examinations). There is no justification for relaxing the limits for FCAW, except that some FCAW classifications are not always available to meet the hydrogen limits stated in Table 2 and require an alternative consumable to meet the specification.

Table 1—Diffusible Hydrogen Limits for Hydrogen-controlled FCAW Consumables for Carbon, Low-alloy, and 2.5–3.5 % Ni Alloy Steels

Delete Table 1

Justification

Low-hydrogen welding consumables help to prevent delayed hydrogen-induced cracks in the weld metal and HAZs, resulting from hydrogen charged into the metal during the welding process. These cracks are difficult to detect with the NDE procedures used in most fabrication shops (typically radiography, visual and other surface examinations). There is no justification for relaxing the limits for FCAW, except that some FCAW classifications are not always available to meet the hydrogen limits stated in Table 2 and require an alternative consumable to meet the specification.

6.1.12

Delete NOTE

Justification

This note takes exceptions from the hydrogen limits in Table 2. This can increase the risk of fabrication hydrogen cracking. This note also conflicts with the deletion of 6.1.3, paragraph 1, sentence 4 (including list).

Add new section

6.1.13

In sour service, CS and LAS welding consumables shall comply with the restrictions of ANSI/NACE MR0175/ISO 15156-2 or ANSI/NACE MR0103/ISO 17945.

Justification

This requirement ensures weld metal chemistry with resistance to sulfide stress cracking (SSC).

Add new section

6.1.14

For wetted CS in water injection systems in upstream service, consumables for the root and second pass shall have one of the following chemical compositions:

- a) 0.8 % to 1.0 % Ni;
- b) 0.4 % to 0.8 % Cu and 0.5 % to 1.0 % Ni.

NOTE For sweet inhibited hydrocarbon or produced water service, the chemical compositions specified in 6.1.14 can cause preferential weld corrosion. Limiting the composition to a maximum of 0.3 % Ni, 0.6 % Si, 0.5 % Mo has been found in some cases to reduce preferential weld corrosion but may require specific corrosion testing and validation as specified in ISO 21457.

Justification

This requirement prevents preferential weld corrosion. Alloyed (1 % Ni) weld metal suffers from preferential weld corrosion in corrosion-inhibited sweet hydrocarbon service. Research has shown that the effect is not limited to 1 % Ni additions and that silicon needs to be limited, ideally to less than 0.5 %. However, this is impractical for some processes. The research did not include molybdenum above 0.5 %, but the levels tested showed slightly lower performance than plain CS weld metal.

Add new section

6.1.15 Lot classification

6.1.15.1

The quantity of consumables in a single lot of covered electrodes shall be in accordance with lot class C3 defined in ASME BPVC Section II, Part C or ISO 14344, or as specified.

Justification

This requirement ensures that a consistent and representative quantity of consumables is selected when reporting the chemical analysis of a particular product.

6.1.15.2

The quantity of consumables in a single lot of solid consumables shall be in accordance with lot class S3 defined in ASME BPVC Section II, Part C or ISO 14344, or as specified.

Justification

This requirement ensures that a consistent and representative quantity of consumables is selected when reporting the chemical analysis of a particular product.

6.1.15.3

The quantity of consumables in a single lot of tubular cored electrodes and rods shall be in accordance with lot class T2 defined in ASME BPVC Section II, Part C or ISO 14344, or as specified.

Justification

This requirement ensures that a consistent and representative quantity of consumables is selected when reporting the chemical analysis of a particular product.

6.1.15.4

The quantity of consumables in a single lot of SAW and ESW fluxes shall be in accordance with lot class F2 defined in ASME BPVC Section II, Part C or ISO 14344, or as specified.

Justification

This requirement ensures that a consistent and representative quantity of consumables is selected when reporting the chemical analysis of a particular product.

6.2 Welding of Carbon Steel for Hydrofluoric Acid Service

6.2.5

Replace first sentence with

CS in HF acid service shall be PWHT'd.

Justification

PWHT is required to control hardness and prevent cracking in HF service.

6.9 Submerged Arc Welding

6.9.4

Delete "low-alloy steels" from first sentence

Justification

Alloying through flux additions is too variable and difficult to control, and can adversely affect the performance of the flux. This issue affects all alloys and is not restricted to LASs.

6.11 Consumable Storage and Handling

Add new section

6.11.6

The number of re-drying cycles for SMAW electrodes shall not exceed three redrying cycles or the manufacturer's recommendation, whichever is lower.

Justification

The number of re-drying cycles recommended by manufacturers differs and this requirement ensures that the manufacturer's recommendations are followed. Most reputable consumable manufacturers recommend a maximum of two or three re-drying cycles for low-hydrogen electrodes. Some moisture-resistant electrodes permit extended time between re-drying cycles. This requirement is aligned with the approach used in ISO 13703-3:2023, 7.1.7 a).

Add new section

6.11.7

The number of re-drying cycles of each SMAW electrode shall be traceable.

Justification

This requirement ensures that the number of re-drying cycles applied to each electrode is traceable to prevent repeated re-drying exceeding the manufacturer's recommendation. This can have a detrimental effect on the flux on the electrode and the weld quality.

6.12 Alloy Consumable Controls

Replace section with

Prior to production welding, alloy consumables shall be subject to PMI in accordance with the accepted procedure.

Justification

The extent of inspection, method and acceptance criteria for PMI are not sufficiently defined in this section and need to be detailed in a separate procedure together with other NDE requirements. The traceability of consumables is covered by 6.8.3.

7 Shielding and Purging Gases

7.4

Replace second sentence of first paragraph with

When back purging is used, the following requirements shall apply:

Justification

The original sentence in API 582 conflicts with 5.2.3, paragraph 1, sentence 1, list item e), sentences 1 and 2. Removal of back purging is not permitted, but it is a deviation requiring approval by the "owner/operator's engineer".

In list section b), replace "1/4 in. (6.5 mm)" with

the specified

Justification

The experience of end users is that 1/4 in. (6.5 mm) is not a sufficient thickness to guarantee acceptable levels of oxidation on the underside of the weld.

In list section c), replace "1/4 in. (6.5 mm) thick" with

the specified thickness

Justification

The experience of end users is that 1/4 in. (6.5 mm) is not sufficient thickness to guarantee acceptable levels of oxidation on the opposite side of the weld.

Add new list section d)

- d) The oxygen content of the purge gas for each production weld shall not exceed the value recorded during weld procedure qualification or 0.05 % (500 ppm) as measured in the back-purged volume during welding.

Justification

This requirement ensures that an acceptable, low level of oxidation is achieved on the inside of the weld to minimize negative effects on the corrosion resistance of the joint. It is also consistent with ISO 13703-3.

Add new list section e)

- e) When back purging is required by the WPS, back purging shall be used for tack welding when the tack weld is incorporated into the weld.

Justification

This requirement prevents oxidized tack from being incorporated into the final weld as this can increase the risk of defects in the weld root.

Add new list section f)

- f) Shielding and purging gas for duplex stainless steel and titanium welding shall not use hydrogen gas mixtures.

Justification

This requirement prevents delayed hydrogen cracking in duplex stainless steels, and hydride formation and cracking in titanium.

7.8 Verification of Shielding and Purging Gas Effectiveness

7.8.4

Add after "nickel alloy"

and stainless steel

Justification

This addition ensures that sufficient gas shielding is used during the welding of both stainless steel and nickel alloys. If not removed, unacceptable levels of oxidation can negatively affect corrosion resistance.

Replace Table 5 title with

Table 5—Maximum Oxidation Levels for Nickel Alloys and Stainless Steel

Justification

This replacement ensures that sufficient gas shielding has been used during welding of both stainless steel and nickel alloys. Unacceptable levels of oxidation can negatively affect corrosion resistance if not removed.

7.8.7

Add new NOTE

NOTE ISO 13703-3:2023, Annex A provides reference images of acceptable and unacceptable oxidation levels for stainless steels and titanium.

Justification

Unacceptable levels of oxidation can negatively affect corrosion resistance if not removed. This note provides a reference to ISO 13703-3:2023, Annex A which includes informative reference pictures with acceptable and unacceptable levels of oxidation of stainless steel and titanium as defined in Table 4 and Table 5.

8 Preheating and Interpass Temperature

8.2

Add to start of section

The preheat temperature shall be maintained during welding throughout the entire thickness of the weld and at least 3 in. (75 mm) on each side of the weld.

Justification

When required, maintenance of the preheat temperature through the entire thickness of the weld and parent material adjacent to the joint prevents fabrication hydrogen cracking.

Add to section

When welding Cr-Mo steels with different P-numbers, the minimum preheating and post-heating temperatures shall be those applicable to the steel with the highest chromium (Cr) content.

Justification

When two different Cr-Mo materials are allowed for usage, performing welding with the minimum preheating and post-heating temperatures of the steel with the highest chromium content can eliminate cracking (as the highest Cr content in Cr-Mo steel is the most sensitive to cracking).

Add to section

If DHT is required, it shall be performed at a minimum temperature of 570 °F (300 °C) for at least 1 hour.

Justification

This requirement ensures that the minimum parameters required to perform DHT are defined to prevent hydrogen fabrication cracking in susceptible materials.

8.4

Add to section

The minimum preheat temperature for welding dissimilar materials shall be the highest of the preheat temperatures for the materials to be welded.

Justification

This requirement prevents hydrogen fabrication cracking in the most susceptible materials of the dissimilar joint requiring preheating.

Add to section

The maximum interpass temperature for welding dissimilar materials shall be the lowest of the interpass temperatures for the materials to be welded.

Justification

This requirement ensures that the interpass temperature during the welding of dissimilar materials does not exceed the lowest specified value for all materials of the dissimilar joint. This prevents degradation in the material with the lowest specified interpass temperature.

8.6

Replace first sentence with

The interpass temperature shall be measured on the weld metal or on the immediately adjacent base metal.

Justification

The interpass temperature is higher on the weld metal and on the immediately adjacent parent material.

Add to section

The preheat temperature and preheat maintenance temperatures shall be measured at a distance of at least 3 in. (75 mm) on either side of the weld groove.

Justification

This requirement ensures a homogeneous temperature throughout the area around the weld, not only locally on the weld.

8.9 Welding Interruption

8.9.2

Replace section with

If welding is interrupted for more than 3 minutes without maintenance of preheat before 30 % of the total joint thickness is completed, surface NDE (MT or PT) shall be performed before welding is restarted.

Justification

If less than 30 % of the weld thickness has been welded, shrinkage stresses in the weld and adjacent base metal during cooling can result in cracking.

9 Post-weld Heat Treatment

9.2

In first paragraph, replace "should" with

shall

Justification

This recommendation is made mandatory since any change in these PWHT variables outside the qualified range can affect the mechanical properties of the weld.

9.4

In second paragraph, replace "13.6.1" with

13.6

Justification

This replacement corrects the section number referred to in this paragraph.

Delete third paragraph

Justification

The hardness testing limits defined in the specification also address reasons other than service-related conditions that conflict with this requirement (e.g. to ensure no brittle welds and adequate mechanical properties in the HAZ, regardless of the service).

9.6

Add to first sentence after "austenitic"

and ferritic

Justification

It is not common to perform PWHT of these materials as it can affect the mechanical and corrosion properties.

9.7

Replace second sentence with

PWHT holding temperatures, soaking time, and heating and cooling rates shall comply with the most stringent requirements of this specification, the design code, and the specifications and standards applicable to the intended material and service.

Justification

Some PWHT requirements in the code, applicable standards (e.g. ANSI/NACE MR0103/ISO 17945, NACE MR0175/ISO 15156 (all parts), NACE SP0472) and the material standard specification can conflict. This requirement ensures that in case of conflict, the most stringent requirement applies to safeguard the integrity of the welded equipment.

Table 7—Recommended Post-weld Heat Treatment Temperatures and Holding Times

Replace footnote a with

^a For quenched and tempered or normalized and tempered materials, see 9.22.

Justification

This replacement points to the requirement added in 9.22 which covers PWHT of quenched and tempered or normalized and tempered CS materials. If the PWHT temperature is greater than the tempering temperature, the strength of the material can be reduced below the specified minimum. This requirement is also included in ISO 13703-3:2023, Table 7, footnote a).

9.8

Add before "The ASME B31.3 PWHT thickness exemption for P-No. 1 materials"

For piping,

Justification

This addition clarifies that this requirement applies to piping to ASME B31.3 but not to pressure vessels.

Replace "1.5 in. (38 mm) unless accepted" with

0.75 in. (19 mm) or as specified

Justification

The changes introduced in ASME B31.3:2014 and maintained in ASME B31.3:2024 are not accepted by some operators due to possible safety implications in certain applications. The API clause extends the PWHT exception beyond ASME B31.3:2024, Table 331.1.3 requirement for P-No. 1 material, resulting in a non-compliance with the code. This is aligned with ISO 13703-3:2023, Table 7, footnote b.

Add new NOTE

NOTE Exemption from PWHT for greater thickness up to the limit permitted by the design code can either be supported by an item-specific ECA or generic industry guidance (e.g. EEMUA Publication 235), or be based on documented historical safe operation and a risk-based assessment.

Justification

The changes introduced in ASME B31.3:2014 and maintained in ASME B31.3:2024 are not accepted by some operators due to possible safety implications in certain applications. This note provides guidelines on alternative ways to support an exception to the requirement in 9.8.

9.11

Replace "should" with

shall

Justification

This replacement ensures that the PWHT procedure includes appropriate measures to prevent distortion and collapse during heat treatment.

9.12

Replace "should" with

shall

Justification

This replacement ensures that all essential variables for PWHT are recorded. A change in these variables can alter the mechanical properties of the weld so that the qualification is no longer representative of the mechanical properties obtained after PWHT.

9.14

Add to section

Thermocouples shall be in contact with the external and, where practical, internal surfaces of the item receiving PWHT.

Justification

This requirement ensures that the temperature and thermal gradients of the whole work are within the required range and are documented. This requirement is also included in ISO 13703-3:2023, 9.2.10 d).

Add to section

Thermocouples shall be thermally and electrically insulated from the heat source.

Justification

This requirement ensures that the temperature and thermal gradients measured are those of the actual part receiving PWHT and not the temperature of the heat source. This requirement is also included in ISO 13703-3:2023, 9.2.9.

Add new section

9.19

When a production test is required by the design code, the test plate shall be PWHT'd with the actual item.

Justification

When test plates are required by the pressure vessel design codes, this requirement is essential to ensure that the mechanical properties of the test plates are representative of the welds in the production item.

Add new section

9.20

When PWHT is required, weld procedure qualification shall include simulated PWHT equivalent to the total soaking time of the specified number of PWHT cycles.

Justification

This requirement ensures that the properties of the weld are acceptable after PWHT in case a weld repair is necessary after the first PWHT. This requirement also addresses ASME interpretations IX-15-22 and IX-18-33.

Add new section

9.21

When hardness testing or impact testing is required, the PQR qualified with simulated PWHT shall be tested after one PWHT cycle and after the maximum number of PWHT cycles.

Justification

This requirement ensures that the hardness and impact properties of the weld are acceptable after the first PWHT cycle, which is representative of the production weld when no weld repair is performed after PWHT, and also after the maximum number of PWHT cycles in case any weld repair is necessary after the first PWHT. This requirement also addresses ASME interpretations IX-15-22 and IX-18-33.

Add new section

9.22

For quenched and tempered or normalized and tempered CS materials, the PWHT holding temperature shall be at least 20 °C (36 °F) below the tempering temperature of the base metal, unless the weld procedure qualification is tested on the production material and demonstrates acceptable material properties at a higher PWHT temperature.

Justification

Depending on the soaking time, PWHT at a temperature above the tempering temperature of the base metal can reduce the strength of the material below the specified minimum strength for the steel. This requirement is also included in ISO 13703-3:2023, Table 7, footnote a).

Add new section

9.23

For welds in service environments that promote stress corrosion cracking, the PWHT soak time shall be at least 1 hour.

Justification

PWHT for a minimum of 1 hour ensures effective stress relief when the minimum soaking time established by the relevant construction codes is shorter than 1 hour. This is consistent with the recommendations in Table 7 and ISO 13703-3:2023, Table 7.

Add new section

9.24

Code exemptions that allow a reduction of the PWHT temperature for an extended soaking time shall not exceed the temperature range qualified in the PQR.

Justification

Some design codes (e.g. ASME BPVC Section VIII, Division 1:2023, UCS-56.1) permit the use of PWHT temperatures lower than those specified if longer soaking times are used. This exemption can result in the use of PWHT below the temperature range qualified in the PQR. If the PWHT temperature is lower than the qualified temperature, the mechanical properties are no longer represented by the PQR qualification tests.

Add new section

9.25

PWHT by direct flame impingement on the equipment is not permitted, except as stated in 9.10.

Justification

Direct flame heating can cause local overheating, carburization or decarburization, oxidation, localized hardening or softening, and differential thermal stresses that can degrade the material properties. This requirement is also included in ISO 13703-3:2023, 9.2.5.

Add new section

9.26

Machined surfaces shall be protected from oxidation during PWHT.

Justification

This requirement prevents damage to the final machined surface due to oxidation during PWHT. This requirement is also included in ISO 13703-3:2023, 9.2.7.

Add new section

9.27

PWHT equipment, including measuring and recording equipment, shall be calibrated to a recognized standard at least every 12 months or more frequently when required by the equipment specification.

Justification

This requirement ensures that production heat treatment is carried out in accordance with the parameters specified in the PWHT procedure.

Add new section

9.28

Martensitic stainless steels shall be PWHT'd.

Justification

Heat treatment of martensitic stainless steels prevents failure due to high hardness and embrittlement of the welded material.

10 Repairing a Post-weld Heat Treatment Component Without Post-weld Heat Treatment

10.3

In both instances, replace "should" with

shall

Justification

To meet the code requirements, impact testing of the repair procedure and ASME BPVC Section IX:2023, Table QW-290, Column B are mandatory when the design code requires impact testing.

10.5

Replace "1.5 in. (38 mm) unless accepted" with

0.75 in. (19 mm) or as specified

Justification

The change introduced in ASME B31.3:2014 and maintained in ASME B31.3:2024 to relax the thickness limit for PWHT is not acceptable for certain applications/operators. This replacement aligns the requirement to the amended section 9.8. The amended requirement which has a threshold thickness of 19 mm (hard conversion from 0.75 in. to mm) is also included in ISO 13703-3:2023, Table 7, footnote b.

11 Cleaning and Surface Preparation

11.5

Delete "The purchaser should specify if" from third sentence

Justification

This deletion ensures that MT and PT are conducted, which is essential for the detection of cracks resulting from arc strikes.

11.7

In first sentence, replace "the backside" with

all sides

Justification

Slag remaining on stainless steel welds can reduce the corrosion resistance of stainless steels and act as a preferential site for the initiation of localized corrosion. This replacement also provides consistency with C.7.4.

11.8

Add to first sentence

of tanks and related structures only

Justification

This requirement permits the use of specific weld-through primers to tanks and related structures only where this is normal practice for site-erected tanks and subject to testing the PQR with the specific primer. This also prohibits their use for pressure equipment and piping where weld-through primers can lead to poorer weldability and porosity inclusions in the weld. Aluminum flake is unweldable with GTAW which is specified as one of the preferred methods for root runs in pressure equipment. Even the better thin, weldable primers (zinc silicate) only work well with SMAW.

In second sentence, replace "the WPS should" with

the WPS for welding tanks and related structures shall

Justification

This replacement permits the use of specific weld-through primers to tanks and related structures only where this is normal practice, subject to approval of the PQR with the specific primer type and brand name. Weld-through primers can lead to poorer weldability and porosity inclusions in the weld.

Replace third sentence with

The PQR for welding through primer on tanks and related structures shall be qualified on material coated with the same primer type and primer brand name, and following the same primer coating procedure applied to the production material.

Justification

Weld-through primers can lead to poorer weldability and porosity inclusions in the weld. Aluminum flake is unweldable with GTAW which is specified as one of the preferred methods for root runs. Even the best thin, weldable primers (zinc-silicate) only work well with SMAW.

Add new section

11.13

Cut edges affected (e.g. burnt or oxidized) by carbon-arc or thermal cutting shall be ground or machined to bright metal prior to welding.

Justification

While specific requirements for the removal of the burnt area and HAZ next to thermally cut edges of Ni-steel, 300-series austenitic stainless steel and DSS are defined in 11.10, Annex C and Annex D respectively, this requirement applies to all steels, CRAs and non-ferrous materials. This ensures that welding is done on sound weld metal that has not been affected by thermal cutting. This is also aligned with ISO 13703-3:2023, 6.3.16.

Add new section

11.14

Carbon-arc cutting or gouging shall not be used on CRAs, except as permitted in C.7.6 for 300-series austenitic stainless steel.

Justification

While specific requirements for Ni-steel, 300-series austenitic stainless steel and DSS are defined in 11.10, C.7.6 and D.3.3, respectively, this requirement applies to all other stainless steels, CRAs and non-ferrous materials. This ensures that welding is done on sound weld metal that has not been affected by the thermal cut. This is also aligned with ISO 13703-3:2023, 6.3.16. In addition, arc air on austenitic stainless steel can contaminate the area around the weld joint.

Add new section

11.15

Fabrication of CRAs shall be performed in areas dedicated for these materials.

Justification

While specific requirements for austenitic stainless steel and DSS are now defined in C.1 and D.3.1 respectively, this requirement applies to all CRA materials to ensure that cross-contamination is prevented. Cross-contamination can reduce the corrosion properties of the material and affect the weld quality. This is also aligned with ISO 13703-3:2023, 6.1.3.

Add new section

11.16

CRA materials shall not come into contact with CS or LAS.

Justification

While specific requirements for austenitic stainless steel and DSS are now defined in C.1 and D.3.2 respectively, this requirement applies to all CRA materials to ensure that cross-contamination is prevented. Cross-contamination can reduce the corrosion properties of the material. This is also aligned with ISO 13703-3:2023, 6.1.4.

Add new section

11.17

Surfaces of CRAs, including cladding, contaminated with iron during fabrication shall be pickled and passivated in accordance with the accepted procedure.

Justification

Iron contaminants on the surface can act as initiation points for corrosion.

12 Special Procedure Qualification Requirements/Testing

12.1 General

12.1.1

In first sentence of second paragraph, replace "should" with

shall

Justification

This requirement ensures that the PQR contains the necessary information to confirm that it is appropriately qualified and supports the proposed welding procedure.

12.2 Tube-to-Tubesheet Welding

Add new section

12.2.4

Tube-to-tubesheet strength welding shall use GTAW with filler material.

Justification

The use of GTAW, and particularly orbital GTAW with filler metal, ensures a high-quality weld with a low defect rate, minimizing potential leakage.

12.3 Macroscopic Examination

12.3.1

In first sentence, replace "the purchaser" with

the welding code and this specification

Justification

This replacement ensures that the requirements in the welding code and this specification for macroscopic examination are fulfilled and not waived by the purchaser.

In third sentence, replace "the purchaser" with

the welding code and this specification

Justification

This replacement ensures that the requirements of the welding code and this specification to carry out hardness surveys are fulfilled and not waived by the purchaser.

12.3.2

Replace "ASME BPVC, Section IX, QW 193.1.3, with a magnification between 10x and 20x" with

ASME BPVC, Section IX or ISO 15614 (all parts)

Justification

This requirement ensures that the weld is free from any cracks, lack of fusion or volumetric defects (e.g. slag, porosity). Macrographic examination is carried out at a magnification of < 50X. The magnification can vary depending on the type and size of the weld joint and the applicable code requirement.

Add new section

12.4 Essential Variables

If the additional essential variables in Table 9 are exceeded, the WPS shall be requalified.

NOTE If an existing WPS has previously been approved but does not contain the additional essential variables required by this specification, approval can be sought to allow the use of this WPS.

Justification

A change in these essential variables can affect the weld such that the original qualification is not representative of the properties of the weld.

Add new Table 9

Table 9—Additional Essential Variables for Procedure Qualification per ASME *BPVC* Section IX or ISO 15614 (all parts)

Essential Variable	Description	Groove, Butt, and Fillet Welds in Specific Materials							Weld Overlay Cladding	Buttering
		CS/LAS	Austenitic Stainless Steel ^a	Ti	6Mo	DSS ^b	Ni-alloy	Cu-alloy		
Joints	A change from double-sided welding to single-sided welding ^c	x	x	x	x	^b	x	x		
Joints	When impact testing or corrosion testing is required, a decrease in the included angle of more than 10° where this results in an included angle that is less than 50° ^d	x	x	x	x	^b	x			
Joints	A deviation from the qualified included angle of more than ±2.5° if the qualified included angle is less than 30° (except for portions of compound bevels) ^d	x	x	x	x	^b	x			
Joints	A change in the nominal root gap tolerance of ±0.04 in. (±1 mm) for single-sided welding				x	^b				
Backing	For environmental crack-sensitive applications (e.g. sour service), a weld made without backing does not qualify a weld made with backing	x				^b				
Base material	For P-No. 1, an increase in CE of more than 0.03 than the value qualified in the PQR, when any of the following conditions apply: a) subject to sour service regardless of the wall thickness; b) wall thickness greater than 1.5 in. (38 mm), regardless of the service; c) subject to PWHT due to service, regardless of the wall thickness; d) pressure vessel components subject to impact toughness requirements; e) when either of the materials being welded is a forging and has a CE > 0.40; f) when the specified minimum yield strength (SMYS) > 52 ksi (360 MPa).	x							x	x
Base material	A change in the material grade ^e			x		^b				

Table 9 (continued)

Essential Variable	Description	Groove, Butt, and Fillet Welds in Specific Materials							Weld Overlay Cladding	Buttering
		CS/LAS	Austenitic Stainless Steel ^a	Ti	6Mo	DSS ^b	Ni-alloy	Cu-alloy		
Base material	A change in the UNS number for DSS					^b				
Base material	For P-No. 8, a change from another material to P-No. 8, Gr. 4		x		x					
Material thickness	A change in the thickness range for DSS					^b				
Consumable	A change in the brand name when impact testing is required, except for solid wire	x	x	x	x	^b	x		x	x
Consumable	For sour service, a change in the nominal composition even when it falls into the same classification (see 6.1.13)	x								
Electrode diameter	A change in the electrode nominal diameter (see B.1.17)								x	
Wire diameter	An increase in the diameter for FCAW-G	x	x	x	x	^b	x		x	x
Flux	A change in the brand name for SAW	x	x	x	x	^b	x		x	x
Welding progression	A change from vertical uphill to vertical downhill welding and vice versa	x	x	x	x	^b	x	x	x	x
Welding position	For mechanized and automated welding processes, a change in position exceeding ASME BPVC Section IX:2023, QW-461.9	x	x	x	x	^b	x	x	x	x
Welding position	For manual and semi-automatic welding, a change in position in accordance with ASME BPVC Section IX:2023, QW-461.9					^b				
Gas	Removal of backing gas except when permitted by 7.4	x	x	x	x	^b	x	x		
Gas	A change in the shielding or backing gas composition or a decrease in the purity level (e.g. a change from high purity to industrial purity argon) (see Section 7)			x		^b				
Gas	A change in the shielding system, including secondary shielding			x						

Table 9 (continued)

Essential Variable	Description	Groove, Butt, and Fillet Welds in Specific Materials							Weld Overlay Cladding	Buttering
		CS/LAS	Austenitic Stainless Steel ^a	Ti	6Mo	DSS ^b	Ni-alloy	Cu-alloy		
Heat input	When impact or corrosion testing is required, a change exceeding the maximum heat input (including the tolerance permitted by the specified welding code) or lower than 75 % of the minimum heat input measured during procedure qualification welding	x	x	x	x	^b	x	x	x	x
Heat input	For sour service or when hardness testing is required, a reduction of the minimum heat input for a weld zone used during procedure qualification welding	x								
Transfer mode	A change in transfer mode (e.g. dip/short circuit, globular, spray)	x	x	x	x	^b	x		x	x
Welding equipment	A change in the make, model and program settings for GTAW-P, GMAW-P, GMAW-S with adaptive/modified arc transfer and for automated welding processes	x	x	x	x	^b	x	x	x	x
Weaving	When impact testing is required, a change from stringer bead to weaving technique or vice versa	x				^b				
Welding process	A change between manual, semi-automatic, mechanized and automatic welding	x	x	x	x	^b	x	x	x	x
Key x Applicable ^a Austenitic stainless steels, P-No 8, Group 1. ^b Refer to D.6.3 and D.6.4 for DSS. ^c Single-sided welding with a backing strip is equivalent to double-sided welding. ^d The fabricator may deviate from this requirement by demonstrating their ability to meet the heat input requirement and by achieving mechanical properties with the altered geometry. ^e Not applicable for titanium grade 1, 2 and 3, provided that a grade 1 or 2 consumable is used in the qualification.										

Justification

- *Joints 1: This requirement is consistent with ISO 15614 (all parts). A single-sided weld is not represented by a double-sided weld since the mechanical properties of the root will not be tested.*
- *Joints 2: Reducing included angles often leads to difficulty applying the qualified welding parameters.*
- *Joints 3: Reducing included angles often leads to difficulty applying the qualified welding parameters.*
- *Joints 4: A change in the root gap exceeding this limit can greatly affect the heat input, degrading corrosion resistance and/or toughness, and the welder's ability to prevent incorrect penetration and lack of fusion.*
- *Backing: This guarantees the hardness and phase balance in the weld pass in contact with the service fluid.*
- *Base material 1: CE has a dramatic effect on hardenability, toughness and hydrogen cracking susceptibility. This requirement ensures that the PQR is representative of the production materials. This is only significant for higher CE material and therefore, universal boundary conditions have been defined.*
- *Base material 2: This ensures that the PQR is representative of the actual welds for the given materials where a change in material grade, even within the same P-No. and Group-No., can have a significant effect on the weld properties.*
- *Base material 3: Welding qualification on other austenitic materials (e.g. Type 316 stainless steel) does not qualify welding of 6Mo as the welding parameters and mechanical testing criteria are different and not representative of 6Mo. For instance, corrosion testing is not performed.*
- *Material thickness: Heat input and heat distribution can vary greatly with different thicknesses.*
- *Consumable 1: Different brand names may have different properties and compositions.*
- *Consumable 2: This reduces the risk that small differences in chemical composition can be detrimental to sulfide stress corrosion cracking resistance behavior.*
- *Electrode diameter: The diameter of the electrode can affect the dilution.*
- *Wire diameter: An increase in diameter can affect the behavior of the consumable.*
- *Flux: There can be a large variation in material properties and handling requirements depending on the flux composition.*
- *Welding progression: Due to the faster travel speeds when welding vertically down, weld defects like lack of fusion, porosity and inclusions or excessive hardness (untempered) in the root pass of LAS are considerably more likely than when welded vertically up.*
- *Welding position 2: See 5.2.2.*
- *Welding position 3: See D.6.3 g).*
- *Gas 1: Removal of backing gas may influence the welding parameters and root properties.*
- *Gas 2: Small additions of certain gases (e.g. oxygen and nitrogen) can significantly affect the properties of the weld in titanium and titanium alloys and duplex stainless steel.*
- *Gas 3: Inadequate shielding can lead to a permanent reduction in the properties and corrosion resistance of the material since titanium can readily absorb carbon, oxygen, nitrogen and hydrogen at high temperatures.*
- *Heat input 1: This ensures that welding procedures are not run with too high or low values. Changing the heat input can affect the properties of the weld. See D.6.3.*
- *Heat input 2: This reduces the risk of higher hardness on production welds.*
- *Transfer mode: The transfer mode can affect the tendency of lack of fusion defects, globular spatter and nitrogen ingress occurring to different degrees in each mode.*
- *Welding equipment: see 5.2.2, 5.2.3 and 5.2.4. The need to specify the make and model, program, equipment settings, and pulse waveform is based on the effects that these variables have on welding arc performance, especially sidewall fusion and out-of-position welding. Studies have shown considerable variation in arc characteristics when one make or model of the welding system is compared to another. This variation can lead to welding defects, some of which may be very difficult to detect by radiography.*
- *Weaving: This enables the welder to have control over heat input.*
- *Welding process: The important variables (e.g. sensitivity to root detail, degree of control provided by equipment, positional ability and adherence to welding parameters) differ.*

13 Other Items

13.1 Backing Materials

13.1.1

Delete "in the case of a permanent backing strip," from second sentence

Justification

Regardless of whether they are permanent or removed, metallic backing strips can fuse and result in weld metal dilution. If a dissimilar metal strip is used, this can affect the properties of the weld.

13.1.2

Replace section with

Permanent backing strips shall not be used.

Justification

Backing strips can obstruct weld inspection, preventing the identification of root weld defects and crevices resulting from their use, and are a site for preferential corrosion and fatigue.

Add new NOTE

NOTE In cryogenic LNG service, backing strips can be necessary for welding aluminum equipment and piping such as cold boxes and cryogenic heat exchangers.

Justification

Backing strips are used to reduce the potential for root weld defects in single-sided seal welds on some critical aluminum alloy equipment and piping in cryogenic LNG. Backing strips cannot be removed and are retained after welding.

13.1.3

In first sentence, replace "should" with

shall

Justification

Regardless of whether they are permanent or removed, metallic backing strips can fuse and result in weld metal dilution. If a dissimilar metal strip is used, this can affect the properties of the weld.

13.4 Temporary Attachments

13.4.3

Add after "alternative option"

for carbon and low alloy steels only

Justification

The adoption of this solution can negatively affect the parent material properties for materials such as highly alloyed stainless steels.

13.6 Hardness Testing—Weld Procedure Qualification and Production Testing

13.6.1

Replace first sentence with

When specified, production hardness testing shall be performed in accordance with the accepted procedure.

Justification

This replacement ensures that production hardness testing is performed to the accepted procedure. The requirement for hardness testing on the PQR is governed by the applicable welding code and specifications that are not necessarily ANSI/NACE MR0103/ISO 17945 or MR0175/ISO 15156 (all parts).

13.6.2

Replace section with

For sour service, PQR and production hardness testing results shall comply with the lowest values specified in Table 10 and one of the following standards:

- a) NACE MR0175/ISO 15156 (all parts);
- b) ANSI/NACE MR0103/ISO 17945.

Justification

This replacement reduces the risk for SSC or hydrogen stress cracking (HSC).

Add new section

13.6.3

When PQR qualification for non-sour services requires hardness testing, PQR hardness test results shall not exceed the values specified in Table 10.

Justification

This requirement ensures that the weld has acceptable hardness levels and does not contain brittle phases and/or microstructures susceptible to cracking in environments other than sour service.

Add new section

13.6.4

When the governing code does not define the hardness test locations, the PQR hardness survey shall comply with NACE MR0175/ISO 15156-2.

Justification

This requirement ensures that the hardness indentations are taken at the locations defined by the code or standard specification or, if not defined, in the critical locations defined in NACE MR0175/ISO 15156-2.

Add new section

13.6.5

PQR hardness testing shall sample the welding position with the lowest heat input.

Justification

The lowest heat input position is typically associated with the highest hardness levels due to the fast cooling rate. This requirement ensures that the worst conditions (i.e. highest hardness) are recorded.

Add new section

13.6.6

The hardness of the weld metal and HAZ for titanium Grade 2 PQR testing shall not exceed the base material by more than 50 HV10.

Justification

A hardness difference of more than 50 HV is an indication of excessive uptake of N_2 or O_2 which forms nitrides/oxides that have a negative impact on the properties of the weld. This requirement is also absorbed (modified) in ISO 13703-3:2023, 8.5.3.

Add new Table 10

Table 10—Permitted Maximum Hardness Values (HV10) for Non-sour Service

Material Group	Maximum Hardness (HV10)
P-No. 1 (carbon steel)	350
P-No. 3 (0.5 Mo steel)	240
P-No. 4 (1-1/4 Cr-1 Mo)	235
P-No. 5A (2-1/4 Cr-1 Mo)	235
P-No. 5B (5 Cr-1/2 Mo)	250
P-No. 5B (9 Cr-1 Mo)	250
P-No. 9B (3.5 % Ni steel)	275
P-No. 11A (9 % Ni steel)	350
P-No. 15E (9Cr-1Mo-V)	290
P-No. 6 (martensitic stainless steel type 410)	248
P-No 10H (22Cr duplex)	^a
P-No 10H (25Cr duplex)	^a
P-No. 51, 52, 53 (titanium)	200
^a Refer to D.8 for duplex stainless steel hardness requirements.	

Justification

This table ensures that the weld has acceptable hardness levels and does not contain brittle phases or microstructures susceptible to embrittlement and cracking.

Add new section

13.6.7

When production hardness testing is specified, it shall be performed in the final heat-treated condition or following PWHT.

Justification

Hardness is a quality indicator for PWHT, confirming that residual stress has been relieved.

Add new section

13.11 Removable Bars, Cleats, and Bridge Pieces

Removable bars, cleat pieces and bridge pieces welded temporarily to the base material or inside the weld bevel shall comply with 13.4.1 and 13.4.2.

Justification

This requirement ensures that the removable material is compatible with the parent material and that mixing between the consumable and the base material in the weld pool of the tack weld does not degrade the properties of the parent material and weld.

Add new section

13.12 Repair Welding

13.12.1

Weld repair procedures shall contain the following information:

- a) method of defect removal;
- b) method for verification of defect removal (i.e. MT or PT);
- c) shape and size of the excavation prior to re-welding;
- d) WPS;
- e) PQR;
- f) PWHT procedure if applicable;
- g) type and extent of NDE after repair.

Justification

This requirement ensures that the repair is performed in a controlled manner and documented with the minimum information listed in this section.

13.12.2

Production WPSs and supporting PQRs may be used for weld repair if they comply with 13.12 and if the weld repair parameters are within the essential and additional essential variables of the supporting PQRs.

Justification

This requirement clarifies that a production WPS and supporting PQR may be used for weld repair provided that they comply with the requirements of 13.12, and that the repair is within the essential and additional essential variables defined in the specification.

13.12.3

For 6Mo and titanium, only one repair attempt shall be allowed in the same area.

Justification

6Mo and titanium are sensitive to heat input, and more than one repair can result in degradation of the HAZ and weld deposit.

13.12.4

For duplex stainless steel, repair attempts shall comply with D.3.5.

Justification

25Cr duplex, 6Mo and titanium are sensitive to heat input, and more than one repair can result in degradation of the HAZ and weld deposit.

13.12.5

For materials not covered by 13.12.3 and 13.12.4, a maximum of two repair attempts shall be allowed in the same area.

Justification

Repeated attempts at repair in the same area can result in degradation of the HAZ and weld deposit. For PWHT material, this is consistent with 9.20 which requires the simulation of three PWHT cycles in the PQR to include the initial PWHT cycle and up to two additional repair PWHT cycles.

13.12.6

Weld cut-out shall remove the original weld metal and HAZ.

Justification

This requirement ensures that the original weld is cut out and the new weld is made on unaffected base material.

13.12.7

Back purging for repair welding shall comply with Section 7.

Justification

This requirement ensures acceptable or no oxidation on the inside of the weld that can negatively affect the corrosion resistance of the weld.

13.12.8

Weld repair of tube-to-tubesheet welds shall comply with 12.2.

Justification

This requirement ensures that the repair welds of tube-to-tubesheet welds meet the quality of the original weld to prevent leaks.

13.12.9

Hardness testing of the repair weld shall comply with 13.6.

Justification

This requirement ensures that the mechanical testing samples the properties of the actual repaired weld.

13.12.10

Weld repair PQRs shall include macroscopic examination in accordance with 12.3.

Justification

Macroscopic examination is required to verify the accuracy of the repair. This requirement ensures that the testing samples properties of the actual repaired weld.

13.12.11

DSS repair PQRs shall be qualified in accordance with D.10.

Justification

This requirement ensures that the qualification of PQRs for weld repair of DSS is performed in accordance with D.10.

13.12.12

The repaired welded joint shall be subjected to at least the same NDE as specified for the original weld.

Justification

Design codes are not prescriptive regarding the NDE required for repair welds. This requirement clarifies that repair welds are to be examined to the same NDE requirements prescribed by the design code for all welds.

Add new section

13.13 Monitoring of Production Welding

13.13.1

Production welding parameters shall be recorded as specified.

Justification

This requirement ensures that the actual welding conditions are monitored and recorded for identification, traceability and remediation of welding issues.

13.13.2

Production welding records shall be endorsed by the welding coordinator or welding inspector.

Justification

This requirement ensures that the actual production welding parameters are logged.

13.13.3

Repair rates of individual welders and welding operators shall be recorded.

Justification

This requirement ensures that the fabricator has traceability of repairs and can act if the repair rate is unusually high (e.g. for a specific welding process, material or individual welder).

Annex A (informative)

Welding Consumables for Shielded Metal Arc Welding

Table A.1—Filler Metals for Carbon and Low-alloy Steel

In row "Carbon steel", column "Carbon Steel", replace "AB" with

A

Justification

This deletion removes the option to use cellulose-type electrode E6010 for the root pass, consistent with 6.1.3 (amended). This prevents fabrication hydrogen cracking. The use of cellulose-type electrodes requires the purchaser's approval in accordance with Table A.1, NOTE 3.

Annex B (normative)

Weld Overlay and Clad Restoration (Back Cladding)

B.1 General

B.1.1

Add to sentence

or ISO 15614-7, and this specification

Justification

This specification includes additional essential variables to ASME BPVC Section IX. The addition of ISO 15614-7 facilitates the global use of this specification.

B.1.5

Add to list item a) after "ASME BPVC, Section II, QW-382.1 (b)"

or ISO 15614-7

Justification

The addition of ISO 15614-7 facilitates the global use of this specification and an alternative method to ASME for metallographic examination.

B.1.7

Add after "ASME BPVC, Section II, Part C/AWS"

or ISO

Justification

The addition of ISO consumables facilitates the global use of the specification.

B.1.10

Replace second sentence with

The PQR chemical analysis shall meet the acceptance criteria at a depth greater than or equal to 0.0625 in. (1.5 mm) below the minimum specified overlay thickness.

Justification

For production welds, this is addressed in B.1.10, sentence 1. For PQR qualifications, this requirement reduces variation by defining a minimum standardized depth for composition measurements of corrosion-resistant weld overlay. This ensures that weld overlays have consistent corrosion properties.

B.1.14

In second sentence, replace "should" with

shall

Justification

The use of an alternative consumable not included in Table B.1 is a deviation requiring purchaser approval.

B.1.17

Add after "ASME/AWS"

or ISO

Justification

The addition of ISO consumables facilitates the global use of this specification.

B.1.19

Replace "Practice (e.g. Practice A, Practice C, etc.) specified by the purchaser" with

Practice C

Justification

ASTM A262 Practice C specifies intergranular corrosion testing requirements, while Practice A is only for screening.

B.3 Austenitic (300 Series) Stainless Steel Overlay

B.3.5

Add to section

or ISO 8249

Justification

This addition provides the alternative ISO standard for the calibration of instruments for FN measurement.

Annex C (normative)

Additional Considerations for Welding Austenitic Stainless Steel Alloys

C.2 Welding Processes

Replace "should" with

shall

Justification

This requirement has been modified for consistency with 5.3 in which this requirement is mandatory rather than a recommendation.

C.4 Austenitic Stainless Steel Welding

C.4.2 General

C.4.2.2

Add to first sentence of NOTE

or ISO 8249

Justification

This addition provides the alternative ISO standard for FN measurement in welds to facilitate the global use of this specification.

Delete third sentence from NOTE

Justification

While WRC 1992 diagram can be used for weld planning and set up to predict the final microstructure based on the selected consumable and dilution (welding process), it cannot be used as a replacement for the actual FN measurements.

Add new section

C.4.2.6

Where ferrite control is required by C.4.2.2 and C.4.2.3, the frequency and extent of FN measurements for procedure qualification and production welding shall be in accordance with D.7.2 and D.7.3.

Justification

Ferrite control ensures that the weld has adequate properties for critical service. This requirement defines the minimum extent of FN measurement for PQR and production welds.

C.5 Preheating and Interpass Temperature

C.5.2

In first sentence, replace "on the weld metal or on the immediately adjacent base metal" with

in accordance with 8.6

Justification

This replacement ensures consistency with the requirement in 8.6 covering preheating and interpass temperature. Interpass temperature is higher in the weld metal and immediately adjacent parent material. However, to ensure a uniform preheating temperature across the entire joint including HAZ and adjacent parent metal, the temperature needs to be measured further away from the weld.

C.6 Post-weld Heat Treatment

C.6.5

Add to third sentence

or ISO 15614 (all parts)

Justification

This addition ensures that the repair PQR meets the alternative ISO welding standard, which facilitates the global use of this specification.

C.7 Cleaning and Surface Preparation

C.7.6

Add before "austenitic stainless steels"

300 series

Justification

The use of carbon-arc cutting is acceptable only for 300 series austenitic stainless steels and not for higher alloy stainless steels such as 6Mo stainless steel, as this can cause intermetallic phase precipitation. This is also aligned with ISO 13703-3:2023, 6.3.16.

C.8 Quality of Final Surface Finish

C.8.1

In second sentence of first paragraph, replace "should be specified by the owner/operator" with

shall be in accordance with 7.8

Justification

7.8 already defines the acceptable and unacceptable levels of oxidation and remedial actions for stainless steels.

Add to first sentence of second paragraph after "charts"

and ISO 13703-3:2023, Annex A reference images

Justification

This addition ensures consistency with Table 5, 7.8.4 and 7.8.7 NOTE where the acceptable levels of oxidation for stainless steels are defined based on ISO 13703-3:2023, Annex A reference images.

Delete third paragraph

Justification

The acceptance criteria for the level of oxidation are defined in Table 5, 7.8.4 and 7.8.7 NOTE.

Delete fourth paragraph

Justification

The acceptance criteria for the level of oxidation are defined in Table 5, 7.8.4 and 7.8.7 NOTE.

C.8.3

Replace "should" with

shall

Justification

This replacement ensures that the mandatory code acceptance criteria for inspection are applied.

C.9 Other Items

Add new section

C.9.3 Autogenous Welding of 6Mo Austenitic Stainless Steel

Autogenous welding, including autogenous tack welding, shall not be utilized on 6Mo austenitic stainless steel.

Justification

Autogenous welding of 6Mo stainless steel can result in an unfavorable weld microstructure and depletion of nitrogen in the weld metal. This can favor intermetallic phase precipitation and a reduction of the corrosion properties of the weld.

Annex D (normative)

Welding Guidelines for Duplex Stainless Steel

D.3 Cleaning and Surface and Weld Preparation

D.3.1

Replace "should" with

shall

Justification

This replacement prevents contamination of DSS and CRAs which can degrade the properties of the material and result in premature corrosion.

D.3.2

In first sentence, replace "should" with

shall

Justification

This replacement prevents contamination of DSS and CRAs which can degrade the properties of the material and result in premature corrosion.

In second sentence, replace "should" with

shall

Justification

This requirement prevents contamination of DSS and CRAs which can degrade the properties of the material and result in premature corrosion.

In sixth sentence, replace "should" with

shall

Justification

This replacement prevents contamination of DSS and CRAs which can degrade the properties of the material and result in premature corrosion.

D.3.3

Delete "unless subsequently grinding to white metal on the arc-affected surface and where dross is found"

Justification

In addition to the justification in D.3.3 NOTE, carbon-arc cutting and gouging on duplex, and particularly super-duplex stainless steel, can result in intermetallic phase precipitation in the parent metal away from the weld joint due to the high heat input involved in the process.

D.3.5

Delete ", unless approved by the purchaser" from first sentence

Justification

Duplex stainless steels, particularly super duplex, are sensitive to heat input. Localized repair of the bevel can result in degradation of the parent material adjacent to the bevel and mask parent material defects such as laminations which can be exacerbated by subsequent welding of the joint.

In second sentence, replace "If approved for" with

For welds in

Justification

25Cr duplex is sensitive to heat input, and more than one repair can result in degradation of the HAZ and weld deposit.

Add to section

For 22Cr DSS, a maximum of two weld repair attempts shall be allowed in the same weld area.

Justification

22Cr DSS is sensitive to heat input, and more than two weld repairs can result in degradation of the HAZ and weld deposit.

D.4 Welding Processes

D.4.1

Add to second sentence

, cosmetic repairs and dressing of the weld

Justification

Autogenous cosmetic repair and dressing can impair the properties of the weld, reducing the corrosion resistance and toughness. This is consistent with ISO 13703-3:2023, 7.5.1.

D.5 Chemical Composition Requirements of Consumables and As-welded Deposits

D.5.1

Replace first paragraph with

DSS consumables shall comply with Table D.1 or the equivalent ISO consumable classification, and Table D.6.

Justification

Compliance with Table D.1 and the additional restrictions of new Table D.6 ensures that the filler metal is compatible with the parent material. Allowing the use of the equivalent ISO consumable facilitates the global use of this specification.

Table D.1—Welding Consumables for Duplex Stainless Steels ^a

Add reference to footnote ^d to column heading "Standard DSS"

Justification

This amendment ensures that consumables can produce a weld with corrosion resistance compatible with the parent material.

Replace footnote ^d with

^d The chemical composition and PREN of the consumable and undiluted weld metal shall comply with Table D.6.

Justification

This amendment ensures that consumables can produce a weld with corrosion resistance compatible with the parent material.

Add to section

Super DSS consumables may be used for standard DSS but not vice versa.

Justification

This requirement permits the use of super DSS consumables for welding standard DSS. This combination is often used to produce a weld with corrosion resistance overmatching the parent material.

Add new Table D.6

Table D.6—Additional Chemical Requirements for Standard Duplex and Super Duplex Stainless Steel Consumables and As-welded Deposit

Element	Chemical Composition	
	Standard DSS	Super DSS
Nitrogen	0.14 % (by mass) minimum	0.22 % (by mass) minimum
Nickel	8.0 % (by mass) minimum	9.0 % (by mass) minimum
Molybdenum	3.0 % (by mass) minimum	3.5 % (by mass) minimum
Sulphur	0.015 % (by mass) maximum	0.015 % (by mass) maximum
PREN	34.0 minimum	40.0 minimum

Justification

This table ensures that consumables can produce a weld with corrosion resistance and properties compatible with the parent material.

D.6 Procedure Specification and Qualification Requirements

D.6.1

Delete list item c)

Justification

This requirement is unnecessary duplication, and conflicts with D.6.3 b) which details restrictions and exceptions on the UNS number (additional essential variable) for the procedure qualification.

In list section d), replace "For SAW and FCAW welding process" with

Except for solid wire with the same AWS or ISO grouping and nominal chemical composition

Justification

This amendment ensures that PQR tests are representative of the production weld properties in DSS. Except for solid wire with the same grouping and composition, changes in the consumable tradename used can have significant impact on the weld properties in DSS.

Delete list section h)

Justification

This requirement conflicts with D.6.3, list item g), subitem 3). A change in position outside the qualified range can result in different weld properties.

D.6.2

Add to first sentence

, or ISO 15609 and the following

Justification

This addition facilitates the global use of this specification by allowing the use of WPSs prepared to ISO.

D.6.3

Add to first sentence

or ISO 15614 (all parts) essential variables and those listed below

Justification

This addition facilitates the global use of this specification by allowing the use of WPSs prepared to ISO.

Add new list item 4) to list item a)

- 4) A change in nominal root gap tolerance exceeding ± 0.04 in. (± 1 mm) for single-sided welding.

Justification

This addition ensures that the root gap is maintained within tolerances representative of the procedure qualification. An excessive increase in the root-gap from the PQR can require weaving which increases the risk of weld defects and precipitation of deleterious phases in the weld and HAZ. This is also absorbed in ISO 13703-3:2023, Table 5.

In list item b), replace "except that dual certified UNS S31803/UNS S32205 are interchangeable" with

except for the following:

- 1) UNS S31803 and UNS S32205 which are interchangeable;
- 2) UNS S32760, UNS S32750 and UNS S32550 which are interchangeable.

Justification

The experience of end users is that these parent material UNS numbers can also be changed with no deleterious effect, provided that all other essential and additional essential variables are complied with. This is also aligned with ISO 13703-3:2023, 8.3.1.

Delete "when impact testing is required" from list item d)

Justification

This deletion removes conflicts with the requirements in D.6.1, D.6.2 and D.6.5. Impact testing is always required for DSS PQRs (see D.6.5.1).

Replace list item f) with

- f) A change in flux brand name for SAW.

Justification

This replacement resolves a conflict with list item d) and D.6.1, paragraph 1, sentence 1 which requires requalification when the consumable brand name is changed, except for solid wire.

Delete "When impact testing is required," from list item m)

Justification

This deletion removes a conflict with D.6.5.1.1 which always requires impact testing for DSS procedure qualification.

D.6.4 Thickness Qualified

Replace section (including list) with

The qualified thickness shall comply with Table D.7.

Justification

This requirement clarifies the qualification range for both parent material and deposited weld metal, including for multi-process qualifications, resolving conflicts with welding codes. This requirement and Table D.7 limit the qualified range to ensure optimum microstructure and properties of the weld.

Add new Table D.7

Table D.7—Range of Qualification for Parent Material Thickness and Deposited Metal Thickness

Thickness of Test Piece ^a t	Range of Qualification		
	Parent Material Thickness T		Deposited Weld Metal Thickness for Each Process ^b s
	Minimum	Maximum	Maximum
$t \leq \frac{5}{8}$ in. (16 mm)	t	$2t$ Maximum $\frac{5}{8}$ in. (16 mm)	$2s$ Maximum $\frac{5}{8}$ in. (16 mm)
$\frac{5}{8}$ in. (16 mm) < t < $1\frac{1}{8}$ in. (29 mm)	$\frac{5}{8}$ in. (16 mm)	$1\frac{1}{8}$ in. (29 mm)	$2s$ Maximum $1\frac{1}{8}$ in. (29 mm)
$t \geq 1\frac{1}{8}$ in. (29 mm)	t	$1.2t$	$2s$ Maximum $1\frac{1}{8}$ in. (29 mm) when $s < 1\frac{1}{8}$ in. (29 mm) $1.2t$ when $s \geq 1\frac{1}{8}$ in. (29 mm)
^a For weld joints with dissimilar parent material thicknesses, both parent material thicknesses shall be within the range of qualification. ^b The range of qualification applies separately to each process.			

Justification

This table limits the qualified range to ensure optimum microstructure and properties of duplex stainless steel weld joints. The table replaces D.6.4 items a), b) and c), clarifying the qualification range for both parent material and deposited weld metal, including for multi-process qualifications and dissimilar parent material thicknesses. The table resolves conflicts between D.6.4 and the welding codes.

D.6.5 Mechanical, Corrosion, Ferrite, and Microstructural Testing and Requirements

D.6.5.1

D.6.5.1.1

Add to first sentence

or as specified

Justification

This addition ensures adequate toughness in the weldment and compliance with the applicable design code requirements.

Add new NOTE

NOTE QLI is aligned with the acceptance level applied to the type 22Cr and 25Cr DSS grades for most oil and gas applications. QLI is intended for special applications and satisfies the requirements for high-pressure service in ASME B31.3:2024, Table K323.3.5 and EN 13445-2:2021+A1:2023, Table B.2-14.

In second sentence, replace "per ASTM A923 are also acceptable" with

to a standard accepted by the purchaser do not require re-testing

Justification

This replacement ensures that existing WPSs qualified to an acceptable standard accepted by the purchaser can be used without requalification.

Add new section

D.6.5.1.4

The lateral expansion of impact test specimens shall comply with the design code.

Justification

This is required for procedures qualified to ASME when lateral expansion is used as a criterion for acceptance of impact testing.

D.6.6 Preheat, Interpass Temperature, Heat Input, and Post-weld Heat Treatment

D.6.6.3

Replace "are" with

shall not exceed the limits

Justification

Higher interpass temperatures can result in secondary phase precipitation and degradation of the weld properties.

Replace Table D.2 title with

Table D.2—Maximum Interpass Temperatures for Duplex Stainless Steels

Justification

Exceeding the interpass temperatures specified in Table D.2 can degrade the mechanical and corrosion properties of the as-welded weld metal and the HAZ.

D.6.6.4

Add to second paragraph after "Appendix H"

or ISO 15614 (all parts)

Justification

This addition provides the alternative ISO standard to facilitate the global use of this specification.

In second sentence of NOTE, replace "should" with

shall

Justification

This amendment ensures compliance with the mandatory code requirement and D.6.3, item j).

D.6.7 Requirements for Shielding and Back Purging Gases

In second sentence of list section c), replace "0.25 in. (6 mm)" with

0.3 in. (8 mm)

Justification

The experience of end users is that 0.25 in. (6 mm) is not sufficient thickness to prevent unacceptable levels of oxidation on the underside of the weld.

In list section d), replace "0.10 % (1000 ppm)" with

0.05 % (500 ppm)

Justification

This replacement ensures that an acceptable, low level of oxidation is achieved on the inside of the weld to minimize negative effects on the corrosion resistance of the joint. This is consistent with ISO 13703-3.

D.7

D.7.1

Replace first sentence with

Production test coupons shall comply with the design code.

Justification

This replacement facilitates the global adoption and use of design code requirements other than ASME.

Delete second sentence

Justification

This deletion facilitates the global adoption and use of design code requirements other than ASME.

Delete third sentence

Justification

This deletion facilitates the global adoption and use of design code requirements other than ASME.

Add to section

The lateral expansion of impact test specimens shall comply with the design code.

Justification

This requirement ensures that the impact testing acceptance criteria code requirements are satisfied.

D.7.2

Add to first sentence after "AWS A4.2M"

or ISO 8249

Justification

This addition provides the alternative ISO standard for calibration of ferrite scope instruments.

D.7.3

Delete "main" from first sentence of list item b)

Justification

The term "main" is undefined and its use could result in ambiguity regarding which welds it is intended to apply to. Applying this requirement to all pressure-containing welds ensures that the correct level of ferrite is achieved in production welds for optimum weld properties.

Replace section D.8 title with

D.8 Additional Requirements

Justification

Hardness testing is mandatory for all DSS, not only for sour and H-charging services (e.g. when specified by the welding code ISO 15614 (all parts)).

Replace first paragraph with

DSS hardness shall comply with the following requirements.

Justification

This replacement ensures that the presence of hard microstructures promoted by sigma and other intermetallic phases is detected.

Delete list item 1) from list item a)

Justification

List item 1) requires an additional section for microstructural examination as part of PQR hardness testing, which is unnecessary. Microstructural examination is already addressed in D.6.5.1.

In first sentence of list item 2) of list item a), replace "HV5" with

HV10

Justification

This replacement ensures consistency with the acceptance criteria in D.8, list item b).

Delete second paragraph

Justification

This deletion ensures that the presence of hard microstructures promoted by sigma and other intermetallic phases for all services, not only sour service, is checked.

D.9 Special Requirements

D.9.1

Add to list section a) after "QW-193"

or ISO 15614-8

Justification

The addition of the alternative ISO standard facilitates the global use of this specification.

In first sentence of list section c), replace "HV5" with

HV10

Justification

This replacement ensures consistency with the acceptance criteria given in D.8, list item b) which specifies HV10.

Delete "when required by the purchaser" from first sentence of list item d)

Justification

This deletion ensures that the tube-to-tubesheet weld has appropriate corrosion resistance.

Add new section

D.10 DSS Weld Repair Procedure Qualification Methodology

D.10.1

Figure D.2 illustrates the repair procedure qualification methodology for DSS.

Justification

Reheating during repair can have a detrimental effect on ferrite balance and favor precipitation of secondary phases in the reheated weld and HAZ with deleterious effects on properties.

D.10.2

When the remaining ligament beneath the excavation is $\frac{1}{4}$ in. (6 mm) or thicker and the partial penetration repair welding variables comply with D.6.3, partial penetration repair welding of DSS shall be qualified by the production PQR.

Justification

Reheating during repair can have a detrimental effect on the properties of the original weld metal and HAZ remaining after excavation. This deleterious effect is more pronounced when the remaining ligament is thinner. This requirement is also absorbed in ISO 13703-3:2023, 12.10.4 c) and Table 22.

D.10.3

When the remaining ligament beneath the excavation is less than $\frac{1}{4}$ in. (6 mm) thick, welding of DSS shall be qualified with a separate PQR carried out on a section of weld deposited in accordance with the production WPS, and excavated to or below the minimum remaining ligament and re-welded.

Justification

Reheating during repair can have a detrimental effect on the properties of the original weld metal and HAZ remaining after excavation. This deleterious effect is more pronounced when the remaining ligament is thin. This requirement is also absorbed in ISO 13703-3:2023, 12.10.4 c) and Table 22.

D.10.4

Testing of the DSS repair PQR shall include ferrite testing and corrosion testing in accordance with D.6.5.

Justification

Reheating during repair can have a detrimental effect on the properties of the original weld metal and the HAZ remaining after excavation. Testing of the repair PQR verifies that the repaired joint has satisfactory properties. This requirement is absorbed in ISO 13703-3:2023, 12.10.4 c) and Table 22.

D.10.5

Partial penetration repair of DSS welding with remaining ligament beneath the excavation of thickness less than 0.118 in. (3 mm) shall be by weld cut-out or by using a repair procedure qualified in accordance with D.10.3 and D.10.4.

Justification

Reheating during repair can have a detrimental effect on the properties of the original weld metal and the HAZ remaining after excavation. This effect is more pronounced when the remaining ligament is thin. Removal of the original weld and HAZ by weld cut-out ensures that the repair weld is performed on unaffected material. This requirement is also absorbed in ISO 13703-3:2023, 12.10.4 c) and Table 22 for weld cut-out in piping.

D.10.6

Full penetration repair of DSS welding shall be by weld cut-out or by using a full penetration repair procedure qualified in accordance with D.10.3 and D.10.4.

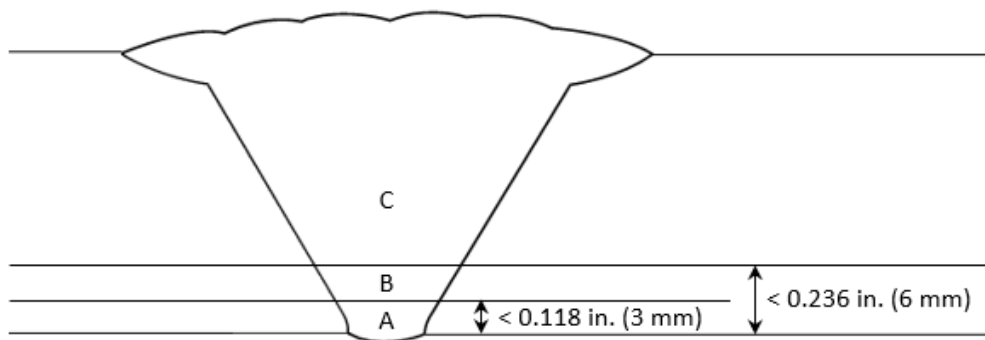
Justification

Reheating during repair can have a detrimental effect on the properties of the original weld metal and the HAZ remaining after excavation. This effect is more pronounced when the remaining ligament is thin. Removal of the original weld and HAZ by weld cut-out ensures that the repair weld is performed on unaffected material. Complete removal cannot be practicable in some cases, particularly for equipment items. This requirement is also absorbed in ISO 13703-3:2023, 12.10.4 c) and Table 22 for weld cut-out in piping.

Add new NOTE

NOTE Full penetration repair by weld cut-out is typically restricted to piping. Complete removal by weld cut-out cannot be practicable in some cases, particularly for equipment or component items.

Add new Figure D.2



Key

- A Remaining weld ligament after excavation—Weld zone A: cut out or repair as per D.10.3
- B Remaining weld ligament after excavation—Weld zone B: see D.10.3
- C Remaining weld ligament after excavation—Weld zone C: repair qualified by the original PQR, within the essential variables and additional essential variables defined in D.6.3

Figure D.2—Repair Methodology for Duplex Stainless Steel

Justification

This figure illustrates the acceptable repair methodology when repairing DSS.

Annex E **(normative)**

Welding of High-temperature Heat-resistant Alloys

E.3 Welding Procedures and Performance Qualifications

E.3.1

Add to first sentence after "ASME BPVC Section IX"

or ISO 15614 (all parts) and ISO 9606 or ISO 14732

Justification

The addition of alternative ISO standards to ASME BPVC, Section IX facilitates the global use of this specification.

In second sentence, replace "are shown in" with

shall be in accordance with

Justification

Table E.2 defines mandatory qualified ranges for parent materials with unassigned P-numbers and combinations thereof.

Annex F **(normative)**

Welding Guidelines for P91 (9Cr-1Mo-V) Steels

F.4 Composition and Mechanical Requirements of Consumables and Weld Deposits

Replace second sentence of second list section a) with

Impact energy acceptance criteria shall be in accordance with the applicable design code, and no less than 27 J (20 ft-lb) average and 21 J (16 ft-lb) single.

Justification

This replacement ensures the integrity of the weld. Some design codes require minimum impact test energy higher than 27 J / 21 J for type P91 material.

F.6 Preheating and Interpass Temperature

F.6.3

Replace "should" with

shall

Justification

This replacement ensures a complete transformation of the microstructure to martensite and minimal residual austenite prior to PWHT. This replacement also provides consistency with F.8.

Bibliography

Add to start of Bibliography

The following documents are informatively cited in the text of this specification, API 582, the PDS (IOGP S-705D) or the IRS (IOGP S-705L).

Add to Bibliography

- [3] API Specification Q1, *Quality Management System Requirements for Organizations Providing Products for the Petroleum and Natural Gas Industry*
- [4] API Specification Q2, *Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries*
- [5] ASME B31.3:2014 *, *Process Piping*
- [6] ASTM E415-14, *Standard Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry*
- [7] ASTM E1086-14, *Standard Test Method for Analysis of Austenitic Stainless Steel by Spark Atomic Emission Spectrometry*
- [8] EEMUA Publication 235, *Guidance on PWHT for P1 CMn steels*
- [9] EN 13445-2:2021+A1:2023, *Unfired pressure vessels - Part 2: Materials*
- [10] ISO 10005, *Quality management — Guidelines for quality plans*
- [11] ISO 21457, *Petroleum, petrochemical and natural gas industries — Materials selection and corrosion control for oil and gas production systems*
- [12] ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*
- [13] ISO/IEC Directives, Part 2, *Principles and rules for the structure and drafting of ISO and IEC documents*
- [14] ISO/TR 18491 *, *Welding and allied processes — Guidelines for measurement of welding energies*

* Cited in IOGP S-705J only.



IOGP Headquarters

Level 6, 3 Moorgate Place, London, EC2R 6EA, United Kingdom
T: +44 20 4570 6879
E: reception@iogp.org

IOGP Europe

T: +32 2 882 16 53
E: reception-europe@iogp.org

www.iogp.org