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Association  
of Oil & Gas  
Producers

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IOGP S-705

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

Public Review Draft

## Revision history

| VERSION | DATE      | PURPOSE                  |
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## 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).

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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-containing 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-containing 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-containing 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-containing 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-containing 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

Delete "-retaining" from list item a)

Add to list item d)

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

### 1.4

Delete section 1.4

## 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

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*

ASME B31.3:2022, *Process Piping*

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*

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                                  |
| 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 per ASME BPVC Section IX or ISO 15614 (all parts)

### 4.2

Add to first sentence after "ASME BPVC Section IX"

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

### 4.6

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

and this specification

### 4.7

Add after "ASME BPVC Section IX"

or ISO 15614-1

## 4.9 Welder and Welding Operator Qualifications

### 4.9.2

Replace "ISO 9606" with

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 B31.3:2022, Appendix Q or ASME BPVC Section VIII, Division 1, Appendix 10) or as specified.

Add new section

#### **4.11 Welding Procedure Specification**

##### **4.11.1**

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

##### **4.11.2**

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

##### **4.11.3**

WPSs shall be translated from the contract language to a language understood by the welder or welding operator and the welding inspector.

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.

Add new section

#### **4.13**

Test laboratories shall be certified to ISO/IEC 17025.

Add new section

#### **4.14**

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

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.

Add new section

#### **4.16 Welding Coordinator Qualification**

##### **4.16.1**

Welding coordination shall comply with ISO 14731.

##### **4.16.2**

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.

## 5 Welding Processes

### 5.1 Acceptable Welding Processes

*Delete list item 4) from list item c)*

### 5.2 Limitations of Fusion Welding Processes

#### 5.2.1 General

*Add to sentence*

, and in Table 8

*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 <sup>a</sup>    | x              | x              | x       | x         |
| Gas tungsten arc welding (GTAW and GTAW-P)   | x <sup>b</sup>    | x <sup>b</sup> | x <sup>b</sup> | x       | x         |
| Gas metal arc welding—spray (GMAW-Sp)  |                   | x              | x              | x       | x         |
| Gas metal arc welding—short circuiting (GMAW-S)  | x <sup>c</sup>    | x <sup>c</sup> | x <sup>c</sup> |         |           |
| Gas metal arc welding—pulsed (GMAW-P)  |                   | x              | x              | x       |           |
| Electrode gas welding (EGW)  | x <sup>d</sup>    | x <sup>d</sup> | x <sup>d</sup> |         |           |
| Submerged arc welding (SAW)  |                   | x              | x              | x       |           |
| Electroslag welding (ESW)  |                   |                |                | x       |           |
| Gas shielded flux-cored arc welding (FCAW-G)   | x <sup>a, e</sup> | x              | x              | x       | x         |
| Plasma arc welding (PAW)   | x                 | x              | x              | x       | x         |
| <b>Key</b>   |                   |                |                |         |           |
| x Acceptable   |                   |                |                |         |           |
| <p><sup>a</sup> See 5.3 for limitations on slag-forming welding processes in single-sided welded joints.</p> <p><sup>b</sup> See 5.2.2 and D.4.2.</p> <p><sup>c</sup> See 5.2.3 and F.2.</p> <p><sup>d</sup> See 5.2.6.</p> <p><sup>e</sup> See 5.2.5.</p> |                   |                |                |         |           |

*Replace section 5.2.2 title with*

#### 5.2.2 Gas Tungsten Arc Welding

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

shall

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

and 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

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

### 5.2.5 Flux-cored Arc Welding

#### 5.2.5.1

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

#### 5.2.5.2

Add to sentence

as permitted in Table 8

### 5.3 Single-sided Welded Joints

Add to section

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

## 6 Welding Consumables (Filler Metal and Flux)

### 6.1 General

#### 6.1.3

Delete fourth sentence (including list)

#### 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 or EN10204 Type 2.2 inspection document, or as specified.

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.

## 6.1.5

In first sentence, replace "should" with

shall

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

6.1.10

In second sentence, replace "should" with

shall

## 6.1.11

Delete section 6.1.11

**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

## 6.1.12

Delete NOTE

Add new section

## 6.1.13

Carbon steel and low-alloy steel welding consumables for sour service shall produce a deposit containing no more than 1 % Ni.

Add new section

## 6.1.14

Carbon steel and low-alloy steel consumables for sour service that produce welds with nickel content exceeding 1 % shall be tested in accordance with NACE MR0175/ISO 15156-2.

Add new section

## 6.1.15

For wetted carbon steel 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 6.1.15 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.

Add new section

**6.1.16 Lot classification**

**6.1.16.1**

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.

**6.1.16.2**

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.

**6.1.16.3**

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.

**6.1.16.4**

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.

**6.2 Welding of Carbon Steel for Hydrofluoric Acid Service**

**6.2.5**

Replace first sentence with

Carbon steel in HF acid service shall be PWHT'd.

**6.9 Submerged Arc Welding**

**6.9.4**

Delete "low-alloy steels" from first sentence

**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.

Add new section

**6.11.7**

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

**6.12 Alloy Consumable Controls**

Delete section 6.12

## 7 Shielding and Purging Gases

### 7.4

Replace second sentence of first paragraph with

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

In list section b), replace " $\frac{1}{4}$  in. (6.5 mm)" with

0.3 in. (8 mm)

Replace list section c) with

c) Back purging shall be maintained throughout the welding operation for seal and attachment welds on base materials with a thickness less than either of the following:

- 1) 0.3 in. (8 mm);
- 2)  $\frac{1}{4}$  in. (6.5 mm) where there is access for inspection and rectification.

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.

Add new list section e)

e) When back purging is specified for the weld, back purging shall be used for tack welding when the tack weld is incorporated into the weld.

Add new list section f)

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

### 7.5

Add to sentence

, except for welding of aluminum alloy series 5XXX for cryogenic service

## 7.8 Verification of Shielding and Purging Gas Effectiveness

### 7.8.4

Add after "nickel alloy"

and stainless steel

Replace Table 5 title with

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

### 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.

## 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.

### 8.4

Replace first sentence with

The interpass temperature shall not exceed the maximum value recorded on the PQR.

Replace second sentence with

The interpass temperature shall not exceed the limits specified in Table 6.

In third sentence, replace "recommended" with

maximum

Add to section

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

Add to section

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

Replace Table 6 title with

**Table 6—Maximum Interpass Temperatures**

### 8.6

Replace first sentence with

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

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.



## 8.9 Welding Interruption

### 8.9.2

Replace section with

If welding is interrupted for more than 3 minutes before 30 % of the total joint thickness is completed, surface NDE (MT or PT) shall be performed before welding is restarted.

## 9 Post-weld Heat Treatment

### 9.2

In first paragraph, replace "should" with

shall

### 9.4

In second paragraph, replace "13.6.1" with

13.6

Delete third paragraph

### 9.6

Add to first sentence after "austenitic"

, ferritic and martensitic

### 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.

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

Replace footnote <sup>a</sup> with

<sup>a</sup> For quenched and tempered or normalized and tempered materials, see 9.21.

### 9.8

Replace "1.5 in. (38 mm)" with

0.75 in. (19 mm)

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.

### 9.11

Replace "should" with

shall

### 9.12

Replace "should" with

shall

### 9.14

Add to section

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

Add to section

Thermocouples shall be insulated from the heat source.

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.

Add new section

### 9.20

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

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 three PWHT cycles.

Add new section

### 9.22

For quenched and tempered or normalized and tempered carbon steel 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.

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.

Add new section

### **9.24**

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

Add new section

### **9.25**

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

Add new section

### **9.26**

Machined surfaces shall be protected from oxidation during PWHT.

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

### **10.3**

In both instances, replace "should" with

shall

### **10.5**

Replace "1.5 in. (38 mm)" with

0.75 in. (19 mm)

## **11 Cleaning and Surface Preparation**

### **11.5**

Delete "The purchaser should specify if" from third sentence

### **11.7**

In first sentence, replace "the backside" with

all sides

### **11.8**

Add to first sentence

of tanks and related structures only

In second sentence, replace "the WPS should" with

the WPS for welding tanks and related structures shall

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.

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.

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.

Add new section

### **11.15**

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

Add new section

### **11.16**

CRA materials shall not come into contact with carbon or low-alloy steel.

Add new section

### **11.17**

Surfaces of corrosion resistant alloys, including cladding, contaminated with iron during fabrication shall be pickled and passivated in accordance with an accepted procedure.

## **12 Special Procedure Qualification Requirements/Testing**

### **12.1 General**

#### **12.1.1**

Replace first sentence of second paragraph with

PQRs shall include:

## **12.2 Tube-to-Tubesheet Welding**

Add new section

### **12.2.4**

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

## **12.3 Macroscopic Examination**

### **12.3.1**

In first sentence, replace "the purchaser" with

the welding code and this specification

In third sentence, replace "the purchaser" with

the welding code and this specification

### **12.3.2**

Replace ", QW 193.1.3, with a magnification between 10x and 20x" with

or ISO 15614 (all parts)

Add new section

## **12.4 Essential Variables**

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

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 |   |    |     |                  |          |          | Weld Overlay Cladding | Buttering |
|--------------------|---|-------------------------------|---|----|-----|------------------|----------|----------|-----------------------|-----------|
|                    |   | CS/LAS                        | Austenitic Stainless Steel <sup>a</sup> | Ti | 6Mo | DSS <sup>b</sup> | Ni-alloy | Cu-alloy |                       |           |
| Joints             | A change from double-sided welding to single-sided welding <sup>c</sup>   | 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° <sup>d</sup>  | 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) <sup>d</sup>   | 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 procedure qualification record, when any of the following conditions apply:<br>a) subject to sour service regardless of the wall thickness;<br>b) wall thickness greater than 1.5 in. (38 mm), regardless of the service;<br>c) subject to PWHT due to service, regardless of the wall thickness;<br>d) pressure vessel components subject to impact toughness requirements;<br>e) when either of the materials being welded is a forging and has a CE > 0.40;<br>f) when the SMYS > 52 ksi (360 MPa). | x                             |   |    |     |                  |          |          | x                     | x         |

Table 9 (continued)

| Essential Variable | Description   | Groove, Butt and Fillet Welds |   |    |     |                  |          |          | Weld Overlay Cladding | Buttering |
|--------------------|---|-------------------------------|---|----|-----|------------------|----------|----------|-----------------------|-----------|
|                    |   | CS/LAS                        | Austenitic Stainless Steel <sup>a</sup> | Ti | 6Mo | DSS <sup>b</sup> | Ni-alloy | Cu-alloy |                       |           |
| Base material      | A change in material grade <sup>e</sup>   |                               |   | x  |     | b                |          |          |                       |           |
| Base material      | A change in 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 thickness range for DSS   |                               |   |    |     | b                |          |          |                       |           |
| Consumable         | A change in 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 nominal composition even when it falls into the same classification             | x                             |   |    |     |                  |          |          |                       |           |
| Electrode diameter | A change in electrode nominal diameter (see B.1.17)   |                               |   |    |     |                  |          |          | x                     |           |
| Wire diameter      | An increase in diameter for FCAW-G  | x                             | x                                       | x  | x   | b                | x        |          | x                     | x         |
| Flux               | A change in brand name for SAW  | x                             | x                                       | x  | x   | b                | x        |          | x                     | x         |
| Welding position   | 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, 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, QW-461.9 |                               |   |    |     | b                |          |          |                       |           |

**Table 9** (continued)

| Essential Variable | Description  | Groove, Butt and Fillet Welds |   |    |     |                  |          |          | Weld Overlay Cladding | Buttering |
|--------------------|--|-------------------------------|---|----|-----|------------------|----------|----------|-----------------------|-----------|
|                    |  | CS/LAS                        | Austenitic Stainless Steel <sup>a</sup> | Ti | 6Mo | DSS <sup>b</sup> | Ni-alloy | Cu-alloy |                       |           |
| Gas                | Removal of backing gas except when permitted by 7.4  | x                             | x                                       | x  | x   | b                | x        | x        |                       |           |
| Gas                | A change in shielding or backing gas composition or a decrease in purity level (e.g. a change from high purity to industrial purity argon)   | x                             | x                                       | x  | x   | b                | x        | x        | x                     | x         |
| Gas                | A change in shielding system, including secondary shielding  |                               |   | x  |     |                  |          |          |                       |           |
| Heat input         | When impact or corrosion testing is required, a change exceeding the maximum heat input 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 make, model and program settings for GTAW-P or GMAW-P  | 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         |
| <b>Key</b>         |  |                               |   |    |     |                  |          |          |                       |           |
| x Applicable       |  |                               |   |    |     |                  |          |          |                       |           |



- <sup>a</sup> Austenitic stainless steels, P-No 8, Group 1.
- <sup>b</sup> Refer to D.6.3 and D.6.4 for DSS.
- <sup>c</sup> Single-sided welding with a backing strip is equivalent to double-sided welding.
- <sup>d</sup> 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.
- <sup>e</sup> Not applicable for titanium grade 1, 2 and 3, provided that a grade 1 or 2 consumable is used in the qualification.

## 13 Other Items

### 13.1 Backing Materials

#### 13.1.1

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

#### 13.1.2

Replace section with

Permanent backing strips shall not be used.

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.

#### 13.1.3

In first sentence, replace "should" with

shall

### 13.4 Temporary Attachments

#### 13.4.3

Add after "alternative option"

for carbon and low alloy steels only

### 13.6 Hardness Testing—Weld Procedure Qualification and Production Testing

#### 13.6.1

Replace first sentence with

Production hardness testing shall be performed in accordance with an accepted procedure.

#### 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;
- b) ANSI/NACE MR0103/ISO 17945.

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.

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.

Add new section

**13.6.5**

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

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.

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)  | 250                     |
| 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 410)                                   | 248                     |
| P-No 10H (22Cr duplex)  | a                       |
| P-No 10H (25Cr duplex)  | a                       |
| P-No. 51, 52, 53 (titanium)   | 200                     |
| <sup>a</sup> Refer to D.8 for duplex stainless steel hardness requirements. |                         |

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.

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;
- c) shape and size of the excavation prior to re-welding;
- d) repair WPS;
- e) repair PQR;
- f) PWHT procedure if applicable;
- g) type and extent of NDE after repair.

#### **13.12.2**

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

#### **13.12.3**

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

#### **13.12.4**

For materials not covered by 13.12.2 and 13.12.3, a maximum of two repair attempts shall be allowed in the same area.

#### **13.12.5**

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

#### **13.12.6**

Back purging for repair welding shall comply with Section 7.

#### **13.12.7**

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

#### **13.12.8**

Hardness testing of the repair weld shall comply with 13.6.

### **13.12.9**

Qualification of the repair PQR shall include macroscopic examination in accordance with 12.3.

*Add new section*

## **13.13 Monitoring of Production Welding**

### **13.13.1**

Production welding parameters shall be recorded as specified.

### **13.13.2**

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

### **13.13.3**

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

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## 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

##### B.1.5

Add to list item a) after "QW-382.1 (b)"

or ISO 15614-7

##### B.1.7

Add after "Part C/AWS"

or ISO

##### 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.

##### B.1.14

In second sentence, replace "should" with

shall

##### B.1.17

Add after "ASME/AWS"

or ISO

##### B.1.19

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

Practice C

### **B.3 Austenitic (300 Series) Stainless Steel Overlay**

#### **B.3.5**

Add to section

or ISO 8249

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## Annex C (normative)

### Additional Considerations for Welding Austenitic Stainless Steel Alloys

#### C.2 Welding Processes

Replace "should" with

shall

#### C.4 Austenitic Stainless Steel Welding

##### C.4.2 General

##### C.4.2.2

Add to first sentence of NOTE

or ISO 8249

Delete third sentence from NOTE

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.

#### 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

#### C.6 Post-weld Heat Treatment

##### C.6.5

Add to third sentence

or ISO 15614 (all parts)

#### C.7 Cleaning and Surface Preparation

##### C.7.6

Add before "austenitic stainless steels"

300-series



## **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

Add to first sentence of second paragraph after "charts"

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

Delete third paragraph

Delete fourth paragraph

### **C.8.3**

Replace "should" with

shall

## **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.

## Annex D (normative)

### Welding Guidelines for Duplex Stainless Steel

#### D.3 Cleaning and Surface and Weld Preparation

##### D.3.1

Replace "should" with

shall

##### D.3.2

In first sentence, replace "should" with

shall

In second sentence, replace "should" with

shall

In sixth sentence, replace "should" with

shall

##### D.3.3

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

##### D.3.5

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

Delete "If approved" from second sentence

Add to section

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

#### D.4 Welding Processes

##### D.4.1

Add to second sentence

, cosmetic repairs and dressing of the weld

## 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.

**Table D.1—Welding Consumables for Duplex Stainless Steels**

*Add reference to footnote <sup>d</sup> to column heading "Standard DSS"*

*Replace footnote <sup>d</sup> with*

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

*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              |

## D.6 Procedure Specification and Qualification Requirements

### D.6.1

*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

*Delete list section h)*

### D.6.2

*Add to first sentence*

or ISO 15609 and the following

### D.6.3

*Add to first sentence*

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

Add new list item 4) to list item a)

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

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.

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

Replace list item f) with

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

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

## **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

Add new NOTE

NOTE QL II is aligned with the acceptance level applied to the type 22Cr and 25Cr DSS grades for most oil and gas applications. QL I is intended for special applications and satisfies the requirements for high pressure service in ASME B31.3:2022, Chapter IX, 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

Add new section

#### **D.6.5.1.4**

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

## **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

Replace Table D.2 title with

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

#### **D.6.6.4**

Add to second paragraph after "Appendix H"

or ISO 15614 (all parts)

In second sentence of NOTE, replace "should" with

shall

#### **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)

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

0.05 % (500 ppm)

#### **D.7**

##### **D.7.1**

Replace first sentence with

Production test coupons shall comply with the design code.

Delete second sentence

Delete third sentence

Add to section

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

##### **D.7.2**

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

or ISO 8249

##### **D.7.3**

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

Replace section D.8 title with

#### **D.8 Additional Requirements**

Replace first paragraph with

DSS hardness shall comply with the following requirements.

Delete list item 1) from list item a)

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

HV10

Delete second paragraph

## **D.9 Special Requirements**

### **D.9.1**

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

or ISO 15614-8

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

HV10

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

Add new section

## **D.10 DSS Repair Procedure Qualification Methodology**

### **D.10.1**

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

### **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.

### **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.

### **D.10.4**

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

### **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.

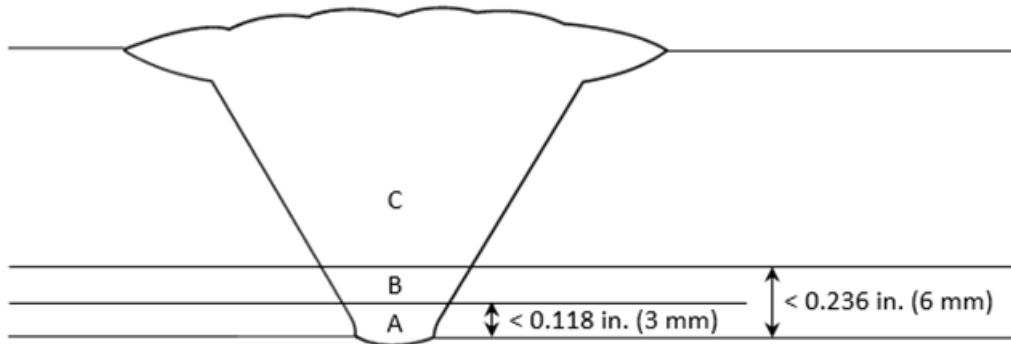
### **D.10.6**

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.

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**

## **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

In second sentence, replace "are shown in" with

shall be in accordance with

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## **Annex F** **(normative)**

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

#### **F.6 Preheating and Interpass Temperature**

##### **F.6.3**

Replace "should" with

shall

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## 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, Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry
- [4] API Specification Q2, Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries
- [5] ASME B31.3:2022, 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.

**Registered Office**

City Tower  
Level 14  
40 Basinghall Street  
London EC2V 5DE  
United Kingdom  
T +44 (0)20 3763 9700  
reception@iogp.org

**Brussels Office**

Avenue de Tervuren 188A  
B-1150 Brussels  
Belgium  
T +32 (0)2 790 7762  
reception-europe@iogp.org

**Houston Office**

15377 Memorial Drive  
Suite 250  
Houston, TX 77079  
USA  
T +1 (713) 261 0411  
reception-americas@iogp.org

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