International Association of Oil & Gas Producers

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S-705

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

JIP33
JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
1.0	June 2020	Issued for Use

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 2014).

Table of Contents

List of Tables

List of Figures

Introduction

The purpose of this specification is to define a minimum common set of requirements for welding of pressure containing equipment and piping in accordance with API Recommended Practice 582, Third Edition, May 2016 for application in the petroleum and natural gas industries.

This specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.

JIP33 Specification for Procurement Documents
Supplementary Technical Specification

This specification is to be applied in conjunction with the supporting data sheet, quality requirements specification (QRS) and information requirements specification (IRS) as follows.

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

This specification defines the technical requirements for the welding of pressure containing equipment and piping 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 to the extent applicable to the scope of supply.

Modifications to API 582 defined in this specification are identified as *Add* (add to clause or add new clause), *Replace* (part of or entire clause) or *Delete*.

IOGP S-705D: Data Sheet for Welding of Pressure Containing Equipment and Piping

The data sheet defines application specific requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents may also be incorporated or referenced in the data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-705Q: Quality Requirements for Welding of Pressure Containing Equipment and Piping

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 data sheet or in the purchase order.

IOGP S-705L: Information Requirements for Welding of Pressure Containing Equipment and Piping

The IRS defines the information requirements, including contents, format, timing and purpose to be provided by the supplier. It may also define specific conditions which invoke information requirements.

The terminology used within this specification and the supporting data sheet, QRS and IRS follows that of API 582 and is in accordance with ISO/IEC Directives, Part 2 as appropriate.

The data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The supplementary specification and QRS are fixed documents.

The order of precedence (highest authority listed first) of the documents shall be:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser defined requirements (data sheet, QRS, IRS);

d) this specification;

e) API 582.

1 Scope

1.1

Replace clause with

This specification applies to the procurement of equipment packages. This specification provides requirements, supplementary guidelines and practices for welding and welding related topics for shop and field fabrication, repair and modification of the following:

a) pressure-containing equipment such as pressure vessels, heat exchangers, piping (including package items and special piping items), heater tubes, and pressure boundaries of rotating equipment and attachments welded thereto;

b) shop-fabricated tanks and attachments welded thereto;

c) simple load bearing applications, e.g. braces, that are welded directly to pressure containing equipment;

d) other equipment or component items when referenced by an applicable purchase document.

1.2

Replace clause with

This document is general in nature and augments the welding requirements of ASME *BPVC* Section IX, ISO 15614, and similar codes, standards, specifications and practices such as those listed in Section 2. The intent of this document is to be inclusive of chemical, oil and gas industry standards, although there are many areas not covered herein. Welding related to the fabrication of the following equipment or components is excluded from the scope of this specification:

a) structures;

b) pipelines;

c) subsea production systems;

d) field erected storage tanks;

e) marine related equipment e.g. ballasting pipework, systems covered by classification societies;

f) wellheads, drilling and downhole equipment;

g) bulk material components covered by a manufacturer's material certificate e.g. seam welded pipe and fittings, clad pipe;

h) heating, cooling and air conditioning;

i) non-metallic materials;

j) other fabrication methods e.g. bending and forming, brazing and mechanical connections;

k) high pressure equipment and piping (ASME B16.5 pressure classes above 2500).

NOTE The scope of application of this supplementary specification is focused on the upstream segment.

1.3

Delete clause

2 Normative References

ASME *BPVC* Section II, Part D, *Properties - Materials*

ASME *BPVC* Section IX, *Welding and Brazing Qualifications*

ASTM A262, *Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels*

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

EN 1011, *Welding - Recommendations for welding of metallic materials*

EN 10204, *Metallic products - Types of inspection documents*

ISO 3690, *Welding and allied processes — Determination of hydrogen content in arc weld metal*

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 6507, *Metallic materials - Vickers hardness test*

ISO 9001, *Quality management systems - Requirements*

ISO 9606, *Qualification testing of welders — Fusion welding*

ISO 10474, *Steel and steel products - Inspection documents - Second Edition*

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes - Second Edition*

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes - Second Edition*

ISO 14731:2019, *Welding coordination — Tasks and responsibilities*

ISO 14732, *Welding personnel – Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15609, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification*

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

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

ISO/TR 17671, *Welding — Recommendations for welding of metallic materials*

ISO 17781, *Petroleum, petrochemical and natural gas industries - Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels - First Edition*

AWS D1.1, *Structural Welding Code—Steel*

AWS D1.6, *Structural Welding Code—Stainless Steel*

3 Terms and Definitions

3.2
Duplex Stainless Steel

Replace definition with

duplex stainless steel with 22 % or 25 % chromium (22Cr duplex and 25Cr duplex)

3.6
purchaser

Delete definition

Add new definition

3.9
carbon equivalent
CE (IIW)

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$$

Add new definition

3.10
pitting resistance equivalent number
PREN

$$PREN = Cr + 3.3\left(Mo + \frac{W}{2}\right) + 16N$$

Add new definition

3.11
Low-Alloy Steel
steel with significant alloy additions (e.g. P-No. 3 to P-No. 5 and P-No. 15E)

Add new definition

3.12
weld zone
a grouping of weld passes with similar parameters and function, e.g. root, fill and cap

3.13 Acronyms, Abbreviations and Symbols

ASS	austenitic stainless steel
CRA	corrosion resistant alloy
CS	carbon steel
CSWIP	Certification Scheme for Welding Inspection Personnel
CWB	Canadian Welding Bureau
CWI	Certified Welding Inspector
DHT	dehydrogenation heat treatment
DSS	duplex stainless steel
EBW	electron beam welding
ECA	engineering critical assessment
ESW	electroslag welding
FN	ferrite number
GMAW	gas metal arc welding
GMAW-Sp	spray gas metal arc welding

GMAW-S	short circuiting gas metal arc welding
GMAW-P	pulsed gas metal arc welding
GTAW	gas tungsten arc welding
GTAW-P	pulsed gas tungsten arc welding
FCAW-G	gas shielded flux-cored arc welding
HAZ	heat affected zone
IIW	International Institute of Welding
IWE	International Welding Engineer
IWI-S	International Welding Inspector Standard Level
LAS	low-alloy steel
LBW	laser beam welding
LTCS	low temperature carbon steel
MDMT	minimum design metal temperature
Mf	martensite finish temperature
MT	magnetic particle testing
NDE	non-destructive examination
PAW	plasma arc welding
PWHT	post weld heat treatment
PT	penetrant testing
SAW	submerged arc welding
SMAW	shielded metal arc welding

4 General Welding Requirements

4.1

Delete clause

4.2

Delete clause

4.3

Replace first sentence with

Welding procedure specifications (WPSs) and procedure qualification records (PQRs) shall be made available for purchaser's review and acceptance prior to the start of fabrication or construction unless waived by the purchaser.

4.5

Replace clause with

Pressure boundary welds and welds to the pressure boundary shall comply with the specified design code and ASME *BPVC* Section IX or the applicable parts of ISO 15614.

Add new clause

4.6

Welding shall be performed under a weld quality management system complying to ISO 3834-2 or equivalent requirements in the specified fabrication code (e.g. ASME B31.3 Appendix Q or ASME VIII Appendix 10).

Add new section

4.7 Welding Procedure Specification (WPS)

4.7.1

WPSs shall be in accordance with ASME *BPVC* Section IX or the applicable parts of ISO 15609, and the applicable code.

4.7.2

WPSs shall, as minimum, contain the information as per ASME *BPVC* Section IX, QW-482 or ISO 15609-1, Annex A.

4.7.3

WPSs shall include the applicable additional essential variables stated in Table 11.

4.7.4

WPSs shall be issued directly to the welder or posted on a notice board adjacent to the welding activity.

4.7.5

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

Add new section

4.8 Procedure Qualification Record (PQR)

4.8.1

Welding procedures shall be qualified in accordance with Section 11 of this document, the applicable code, and ASME *BPVC* Section IX or the applicable parts of ISO 15614.

4.8.2

Additional welding procedure qualification requirements shall be in accordance with the data sheet.

4.8.3

When required by regulations or jurisdictional requirements, the PQR shall be endorsed by an accredited independent third party.

4.8.4

Where there is conflict between the requirements of the applicable code and the welding code, the most stringent requirements shall apply.

4.8.5

Test laboratories for mechanical, chemical and corrosion testing shall have a certified laboratory system in compliance with ISO/IEC 17025 for the test methods employed.

Add new clause

4.9

Pressure retaining groove welds shall be full penetration.

Add new clause

4.10

Except for piping, pressure retaining welds shall, where practical, be double sided.

Add new clause

4.11

The weld and the area around it to a distance of at least 3.3 ft (1 m) shall be protected from wind, rain or other unfavorable weather conditions.

Add new clause

4.12

Adequate wind shielding shall be ensured in the area where gas shielded welding (GTAW, FCAW-G, GMAW or PAW) is taking place.

Add new section

4.13 Welder and Welding Operator Qualification

4.13.1

Welders, including tack welders, shall be qualified in accordance with applicable parts of ISO 9606 or ASME *BPVC* Section IX.

4.13.2

Welding operators shall be qualified in accordance with ISO 14732 or ASME *BPVC* Section IX.

4.13.3

Specific welder or welding operator qualification requirements shall be in accordance with the data sheet.

Add new clause

4.14 Welding Inspector Qualification

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

4.15 Welding Coordinator Qualification

4.15.1

Welding coordinator qualification shall be as specified in ISO 14731:2019, 6.2.2.

NOTE Welding coordinators holding IWE certification are considered to satisfy the requirements of ISO 14731:2019, 6.2.2. Engineers or technologists holding equivalent technical qualifications or certifications, or relevant experience may also be acceptable.

4.15.2

The tasks and responsibilities of the welding coordinator shall be in accordance with ISO 14731.

5 Welding Processes

5.1 Acceptable Welding Processes

Replace clause with

Acceptable welding processes are given in Table 7.

Add new table

Table 7—Acceptable Welding Processes

Welding processes[1]	Root pass[2]	Second pass	Fill/cap	Cladding	Buttering
Shielded metal arc welding (SMAW)	x[3]	x	x	x	x
Gas tungsten arc welding (GTAW/GTAW-P)	x	x	x	x	x
Gas metal arc welding - spray (GMAW-Sp)		x	x	x	x
Gas metal arc welding - short circuiting (GMAW-S)	x[4]				
Gas metal arc welding - pulsed (GMAW-P)		x	x	x	
Submerged arc welding (SAW)			x	x	
Electroslag welding (ESW)				x	
Gas shielded flux-cored arc welding (FCAW-G)		x	x	x	x
Plasma arc welding (PAW)	x	x	x	x	x

NOTE 1 This table is a list of welding processes that are commonly used and are deemed to be acceptable. Other welding processes and applications may be acceptable subject to purchaser's approval.

NOTE 2 Single sided weld where the root pass is not removed.

NOTE 3 Only acceptable for carbon and low-alloy steel NPS 3 (DN 75) and above and subject to purchaser's approval.

NOTE 4 Refer to 5.2.3 b).

5.2 Limitations of Fusion Welding Processes

5.2.1 General

Replace clause with

The fusion welding processes included in Table 7 are acceptable with the restrictions and notes contained in 5.2.

Replace clause 5.2.2 title with

5.2.2 GTAW

Add new clause

5.2.2.1

The restriction in 5.2.2 shall also apply to the remainder of the weld.

Add new clause

5.2.2.2

GTAW machines shall be equipped with arc starting devices (e.g. high frequency starting unit), crater-elimination, slope-in and slope-out control, and pre-gas and post-gas flow.

5.2.3 GMAW-S

Replace list item b) with

b) GMAW-S shall only be used with adapted/modified arc transfer mode.

Delete list item c)

Delete "and second pass" from list item d)

Delete list item e)

Add list item f)

f) GMAW-S shall only be used in the fixed position for pipe sizes NPS 4 and over.

5.2.5 FCAW

5.2.5.1

Replace clause with

FCAW-S shall not be used.

5.2.5.2

Replace clause with

FCAW-G shall only be used as allowed by Table 7.

5.2.5.4

Add to clause after "ASME/AWS"

or ISO

5.2.5.5

Replace clause with

See 6.1.13 for diffusible hydrogen limits.

Delete Table 1

5.2.6 EGW

Delete clause

5.2.7 SAW

5.2.7.1

Add to clause after "AWS"

or ISO

5.2.7.2

Delete "unless approved by the purchaser"

Add new clause

5.2.7.4

Run-on and run-off plate shall have the same P-No. as the base material.

5.3 Single-sided Welded Joints

Replace clause with

For single sided welded joints, slag on the process side of root passes shall be removed completely.

6 Welding Consumables (Filler Metal and Flux)

6.1 General

6.1.1

Add after "Part C/AWS"

or ISO

Add after first sentence

When the brand name is an essential variable, the brand name shall be specified in the WPS.

Add after "ASME/AWS"

or ISO

6.1.2

Add to item a) after "ASME/AWS"

or ISO

6.1.3

Delete clause

6.1.4

In first sentence, replace "should" with

shall

Replace second sentence with

The weld metal toughness shall be certified by the filler metal manufacturer according to ASME *BPVC* Section II, Part C/AWS or ISO filler metal specifications, or established by an approved PQR.

6.1.5

In second sentence, replace "should" with

shall

6.1.6

Add after "AWS"

or ISO

6.1.7

Delete "Unless specifically authorized by the purchaser,"

Add after "AWS"

or ISO

Add new clause

6.1.9

Welding consumables shall be purchased from manufacturers operating a quality management system based on ISO 9001 or equivalent.

Add new clause

6.1.10

Filler metals shall be delivered with their product data sheet and batch certificate, including chemical analysis, according to ASME *BPVC* Section II, Part C minimum Sch. 3/H or ISO 10474/EN 10204 minimum Type 3.1.

Add new section

6.1.11 Lot Classification

6.1.11.1

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

6.1.11.2

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

6.1.11.3

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

6.1.11.4

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

Add new clause

6.1.12

Welding consumables shall produce welds with tensile properties that are equal or exceed the minimum requirements specified for the weaker base metal.

Add new clause

6.1.13

Welding consumables shall achieve a maximum diffusible hydrogen level as specified in Table 8.

Add new table

Table 8—Diffusible Hydrogen Limits for Consumables

Base Material	SMYS for the Base Material	Maximum Diffusible Hydrogen (ml/100 g weld metal)
Carbon and low-alloy steel	≤ 60 ksi (415 MPa)	8
Carbon and low-alloy steel	> 60 ksi (415 MPa)	5
Ferritic and martensitic stainless steel	all	5

Add new clause

6.1.14

Diffusible hydrogen content shall be type-tested in accordance with ISO 3690 or AWS A4.3/A4.3M.

Add new clause

6.1.15

For carbon steel or low-alloy steel with sour service requirements, welding consumables shall produce a deposit containing less than 1 % Ni.

NOTE Any variation should be subject to qualification testing in accordance with NACE MR0175/ISO 15156-2.

Add new clause

6.1.16

For wetted carbon steel in water injection systems, consumables for the root and second pass shall have the following composition to prevent preferential weld corrosion:

a) 0.8 % to 1.0 % Ni; or

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

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

6.2 Dissimilar Welding

6.2.2

Add NOTE to list item c) 2)

NOTE Caution needs to be applied using Ni-based alloy 625 for buttering of components in alloy steel requiring PWHT. Although most joints using Ni-based alloy 625 as a buttered transition layer have been in service successfully, a small number of failures with severe economic consequences have been experienced in the industry. Failures reported have been caused by hydrogen embrittlement at the interface between the buttering and the low-alloy steel triggered by the interaction between stresses and local brittle zones of martensite or carbon supersaturated zones originated during PWHT.

Add list item d)

d) When welding stainless steel alloyed with nitrogen, e.g. 22Cr Duplex, 25Cr Duplex or 6Mo, to carbon or low-alloyed steels, the weld consumable shall not contain deliberate additions of niobium.

Add new clause

6.2.3

Ferritic steels (P-No. 1 through P-No. 5 and P-No. 15E) shall not be welded to CRAs for sour service.

6.4 Stainless Steel Welding (P-No. 6, P-No. 7, and P-No. 8)

6.4.1

Add NOTE to clause

NOTE While no consumable selection is outlawed, the purchaser reserves the right to reject consumables considered unsuitable for the application.

6.4.2

6.4.2.1

Replace clause with

For materials requiring impact testing, PWHT or materials in high-temperature service (see ASME *BPVC* Section II, Part D, Table A-360), the ferrite number (FN) for the deposited weld metal shall not exceed 10 FN measured prior to PWHT.

6.4.2.2

In first sentence, replace "should" with

shall

6.4.2.5

Add NOTE to clause

NOTE Exact requirements cannot be defined in a general document and needs to be specified by the end user. The end user should define the restrictions on grain size and chemical stabilization in the purchase specification.

Add new clause

6.4.2.6

Comparable low carbon or stabilized austenitic consumables shall be used if welding low carbon "L" grade stabilized austenitic base materials.

Add new clause

6.4.3

For austenitic stainless steels 6Mo and 904L, the consumable shall have an enhanced molybdenum content compared to the base material (e.g. ERNiCrMo-3).

Add new clause

6.4.4

For austenitic stainless steels 6Mo and 904L, the consumable shall have a sulphur content not exceeding 0.015 %.

6.5 Duplex and Super Duplex Stainless Steel Welding

6.5.2

Replace "11.3 of this RP" with

Section 11 of this specification

6.5.3

Delete clause

6.5.5

Add new clause

6.5.5.3

The pitting resistance equivalent number (PREN) for 22Cr Duplex filler metals shall be 34 ≤ PREN ≤ 40.

Add new clause

6.5.5.4

The pitting resistance equivalent number (PREN) for 25Cr Duplex filler metals not in sour service shall be 40 ≤ PREN ≤ 48.

Add new clause

6.5.5.5

The maximum pitting resistance equivalent number (PREN) for 25Cr Duplex filler metals in sour service shall be 45.

6.5.7

Replace clause with

See Section 7 for limitations on back purge quality.

6.5.8

Delete second sentence

Replace Table 3 with

Table 3—Additional Chemical Requirements for Duplex and Super Duplex Stainless Steel Consumables and As-welded Deposits

Element	Chemical Composition (Duplex)	Chemical Composition (Super Duplex)
Nitrogen	min. 0.14 %	min. 0.22 %
Nickel	min. 8.0%	min. 9.0 %
Molybdenum	min. 3.0 %	min 3.5 %
Sulphur	max. 0.015 %	max. 0.015%

6.6 SAW

6.6.3

Replace clause with

With the exception of compensation of losses of alloying elements due to the welding arc, deliberate additions of principal alloying elements through the flux is prohibited; only neutral fluxes shall be used.

6.6.5

Add after "moisture"

and build-up of fines.

Add new clause

6.6.6

Where flux recycling is applied, the supplier's consumable control procedure shall address new and reused recycling ratios, and the number of times a flux may be recycled in accordance with the flux manufacturer's recommendation.

Add new clause

6.6.7

Flux remaining unused (including flux remaining in the machine hoppers) at the end of each shift of more than eight hours or in accordance with the flux manufacturer's recommendation shall be returned to the storage facility.

Add new clause

6.6.8

The baking of SAW fluxes shall be in accordance with the flux manufacturer's recommendations.

Add new clause

6.6.9

SAW flux shall be clearly identified and stored in moisture-proof containers located indoors as per the flux manufacturer's recommendations.

Add new clause

6.6.10

Open containers of SAW flux shall be stored in a humidity-controlled area, with a relative humidity and temperature in accordance with the manufacturer's recommendations.

Add new clause

6.6.11

Fluxes for SAW processes shall be delivered with certification according to ASME *BPVC* Section II, Part C Sch. 2/G or EN 10204 Type 2.2.

6.8 Consumable Storage and Handling

6.8.1

Add after "stored"

, baked (if required)

6.8.3

Add NOTE to clause

NOTE The purchaser may require positive material identification (PMI) on consumables prior to production welding, but this is considered outside the scope of this welding specification.

Add new clause

6.8.4

SMAW electrodes that have been re-dried shall be marked in a clear manner to indicate the number of drying cycles to which they have been subjected.

Add new clause

6.8.5

No SMAW electrode shall be subject to more than three re-drying cycles or more than the consumable manufacturer's recommendation, whichever is lower.

Add new clause

6.8.6

Unidentified, contaminated or otherwise damaged consumables, including those suspected of being damp, that are found in storage or fabrication areas, shall be immediately discarded.

Add new clause

6.8.7

Solid wire filler metals shall be dry and free from rust, oil or other foreign matter.

6.9 Alloy Consumable Controls

Delete clause

7 Shielding and Purging Gases

7.2

Replace first sentence with

Shielding and purging gases shall meet the purity requirements of ASME/AWS SFA/A5.32/5.32M or ISO 14175.

Replace second sentence with

Gas purity shall be specified on the PQR and WPS when a single gas is used.

7.3

Replace first sentence with

Unless a joint is ground or back gouged to sound metal, back purging shall be used if the base material has a nominal chromium content greater than 2.25 % or is non-ferrous, excluding titanium.

Replace second sentence with

Back purging shall be used for tack welding where the tack weld is incorporated into the final weld.

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

0.3125 in. (8 mm)

Replace list item c) with

c) For seal and attachment welds on base materials less than 0.3125 in. (8 mm) thick, the back purging shall be maintained throughout the welding operation, unless inspection and rectification is practical, in which case the limit is 0.25 in. (6.5 mm).

Add list item d)

d) The oxygen content of the purge gas for each production weld shall be less than 0.05 % (500 ppm) of the back-purged volume during welding.

NOTE 1 Alternatively, a maximum oxygen content of 0.5 % (5000 ppm) is permissible, when directly measured at the weld root opening before welding e.g. when it is necessary to introduce the purging gas through the root opening.

NOTE 2 This is the criteria to be achieved. This does not mean that the fabricator needs to measure this criterion for every weld. This requirement may be achieved by established purging rules, e.g. 5X replacement volumes.

NOTE 3 Achieving this criterion does not eliminate the need to achieve the required low levels of oxidation on stainless steels and titanium in 7.8.1 and 7.8.4.

Add new clause

7.4

Hydrogen gas mixtures shall not be used for either shielding or purging other than for austenitic stainless steels.

Add new clause

7.5

Shielding and back purging shall be applied when welding titanium.

Add new clause

7.6

Shielding and back purging gases for titanium shall be argon, helium or argon helium mixtures.

Add new clause

7.7

When welding titanium alloys, the back purging gas and trailing secondary inert gas shield shall be established and maintained over the solidified, cooling weld metal and HAZ until the metal temperature falls below 750 °F (400 °C).

Add new section

7.8 Verification of Shielding and Purging Gas Effectiveness

7.8.1

Evaluation on surface oxidation of the weld zone in titanium and titanium alloys shall fulfil the criteria specified in Table 9.

Add new table

Table 9 —Maximum Oxidation Levels for Titanium

Weld color	Significance	Shielding	Comment
Silver	Acceptable weld	Correct shielding	No action
Light straw	Acceptable weld	Fair shielding	No action
Blue, grey or powdery white	Unacceptable weld	Insufficient shielding	See 7.8.2

7.8.2

When the oxidation level of the weld is deemed unacceptable as per Table 9, the weld and the whole oxidized area shall be cut out and a new weld performed.

7.8.3

Any welds in titanium cleaned prior to inspection shall be rejected.

7.8.4

Evaluation on surface oxidation of the weld zone in stainless steels and nickel alloys shall fulfil the criteria specified in Table 10.

NOTE Annex C provides guidance on acceptable and unacceptable oxidation levels.

Add new table

Table 10—Maximum Oxidation Levels for Stainless Steel and Nickel Alloys

Weld color	Shielding	Comment
Light brown to brown	Acceptable shielding	No action
Narrow band of dark brown color and intermittent spots of blue color	Acceptable shielding	No action
Darker or more extensive oxidation colors	Unacceptable shielding	See 7.8.5

7.8.5

When the oxidation level of the weld is deemed unacceptable as per Table 10, the oxidized surface shall be removed by mechanical tools and the shielding for subsequent welds improved.

8 Preheating and Interpass Temperature

8.1

Add to first sentence after "tack welding"

arc gouging

Add to second sentence after "such as"

EN 1011, ISO/TR 17671

8.2

Replace first sentence with

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

Add after first sentence

The preheat temperature shall be achieved before the start of welding and maintained until welding is completed.

Add before second sentence

For low-alloy steels, the preheat shall be maintained until PWHT is completed, unless a purchaser-approved dehydrogenation heat treatment (DHT) is applied immediately after welding is complete.

Replace second sentence with

For tempered martensitic low-alloy steels, consideration shall be given to lowering the preheat temperature to below Mf (martensite finish temperature) prior to PWHT.

8.4

Replace first sentence with

The interpass temperature shall not exceed the interpass temperature specified in the WPS.

Replace second sentence with

The maximum interpass temperature specified in the WPS shall not exceed the value specified in Table 4.

Replace Table 4 title with

Table 4—Maximum Interpass Temperatures

Add new rows to Table 4

Material Group	Maximum Interpass Temperature
P-No. 34 (CuNi)	350 °F (175 °C)
P-No. 51, P-No. 52, P-No. 53 (Ti)	300 °F (150°C)

Replace Table 5 title with

Table 5–Maximum Interpass Temperatures for Duplex and Super Duplex Stainless Steels

8.7

Replace first sentence with

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

Add new clause

8.8

The preheat temperature and preheat maintenance temperatures shall be measured at a distance of not less than 3 in. (75 mm) on either side of the weld groove.

Add new clause

8.9

The material to be welded shall be at a temperature above the ambient dew point temperature.

Add new clause

8.10

Where gas burners are used for preheating, temperature equalization throughout the weld zone shall be ensured by using gas burners designed for this purpose.

Add new clause

8.11

Oxyacetylene flame burners shall not be used for pre-heating.

Add new section

8.12 Welding Interruption

8.12.1

If welding is interrupted without maintenance of minimum preheat, the requirements in 8.12.2 through 8.12.5 shall apply.

8.12.2

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

8.12.3

During interruption of ferritic and martensitic steels (P-No. 1 through 5, P-No. 15E & P-No. 10), the joint cooling rate shall be reduced by using insulation.

8.12.4

Preheating shall be restored to the minimum preheat temperature specified in the WPS before welding is recommenced.

8.12.5

If welding on low-alloy steels is interrupted, a purchaser-approved dehydrogenation heat treatment shall be performed before welds are allowed to cool down.

9 Post-weld Heat Treatment (PWHT)

9.1

Replace clause with

Heat treatment procedures shall be made available for the purchaser's review and acceptance prior to PWHT.

9.2

In first sentence, replace "should" with

shall

Add to end of last sentence

that includes these variables.

9.3

Replace "procedure" with

method

9.4

Delete clause (including NOTE)

9.4.1

Delete clause

9.4.2

Delete clause

9.5

Replace clause with

If specified, production hardness testing shall be performed to verify adequacy of heat treatments.

9.6

Add after "austenitic"

, ferritic, martensitic

9.8

Delete clause (including NOTE)

9.11 Code exemptions

Replace clause with new section

9.11.1

The ASME B31.3 PWHT thickness exemption (above 0.75 in. (20 mm)) for P-No. 1 materials is not permitted unless supported by an engineering critical assessment (ECA) approved by the purchaser.

NOTE 1 This ECA may be item-specific or generic industry guidance, e.g. EEMUA Publication 235. While the ECA would normally be a fracture mechanics assessment, this clause may also be satisfied by agreement of established rules based on historical safe operation and risk-based assessment.

NOTE 2 The ECA should also assess the risk of environmental cracking.

9.11.2

Code exemption of PWHT for P-No. 4 and P-No. 5 materials is not permitted for applications in sour, hydrogen or amine service, or where the nominal chromium content of the material exceeds 1.25 %.

9.12

Replace clause with

PWHT holding temperatures, heating/cooling rates and times shall be evaluated by the fabricator and purchaser, considering code requirements, purchaser specifications, operating conditions, environmental service standards and metal properties.

NOTE The requirements and recommendations in the application code and environmental service standards (e.g. NACE MR0103, MR0175/ISO 15156, NACE SP0472) can conflict with each other and/or maintain base steel properties. See 9.19.

Delete Table 6

Add new clause

9.15

PWHT procedures shall include the following information:

— material and item type;

— holding temperature ranges and soaking times;

— heating and cooling rates;

— methods of heating and cooling. (e.g. gas, electrical resistance, induction, furnace);

— location and number of thermocouples used to control and record the PWHT;

— precautions taken to prevent distortion, collapse or other damage as appropriate;

— extent of heating and insulation for local or partial PWHT, including a sketch;

— parent design code;

— PWHT type (enclosed locally or fully);

— atmosphere control;

— chart speed and type of recording;

— production test piece location.

Add new clause

9.16

When PWHT is required, it shall be performed after the completion of welding activities including weld repairs, weld overlay and cladding restoration.

NOTE In situations where the overlay material used for reinstatement would be damaged by PWHT, an alternative approach will need to be agreed between the supplier and purchaser.

Add new clause

9.17

Where production tests are required, the test plates shall be subject to the same PWHT conditions as the actual items they represent.

Add new clause

9.18

When PWHT is required, simulated PWHT of weld procedure qualifications shall be subjected to a minimum of two additional PWHT cycles.

Add new clause

9.19

For quenched and tempered, or normalized and tempered carbon steel materials, the PWHT holding temperature shall be at least 36 °F (20 °C) below the original tempering temperature of the base metal, unless the vendor demonstrates and the purchaser approves that mechanical properties can be achieved at a different PWHT temperature and holding time.

Add new clause

9.20

Thermocouples shall be used to continuously and automatically record the PWHT temperature on a chart from the start of controlled heating until the end of the controlled cooling.

Add new clause

9.21

Thermocouples shall be in contact with the internal and external surfaces of a vessel.

Add new clause

9.22

Thermocouples shall be insulated from the heat source.

Add new clause

9.23

PWHT soak time shall exceed one hour.

Add new clause

9.24

Reduced PWHT temperatures for longer duration shall not be permitted outside the applicable code tolerances.

Add new clause

9.25

Heating methods associated with PWHT which apply direct flame impingement on the equipment shall not be permitted, except as stated in 9.14.

Add new clause

9.26

Pipe ends, flange faces, threads and other machined surfaces shall be protected against oxidation during PWHT.

Add new clause

9.27

When required in the data sheet, unclad carbon and low-alloy steel pressure vessels at risk of environmental cracking shall be subject to PWHT irrespective of application code thickness exemptions.

10 Cleaning and Surface Preparation

10.2

Delete clause

10.5

Delete "unless otherwise permitted by the purchaser"

10.6

Delete clause

10.8

Replace first sentence with

If thermal cutting or gouging are used, the surface shall be ground or machined to a bright surface finish.

Replace second sentence with

Carbon-arc cutting or gouging is prohibited on CRAs.

Delete NOTE

10.9

Delete clause

Add new clause

10.10

Prefabrication of stainless steels and non-ferrous alloys shall be performed in a workshop, or parts thereof reserved exclusively for those types of materials.

Add new clause

10.11

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

Add new clause

10.12

Surfaces to be welded shall be clean and free from paint, oil, dirt, scale, oxides and other foreign material detrimental to weld integrity for a minimum of 1 in. (25 mm) on either side of a weld.

Add new clause

10.13

Arc strikes outside of the weld area shall be removed by light grinding and the areas inspected with MT or PT.

Add new clause

10.14

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

Add new clause

10.15

Power-driven tools shall not be used for cleaning stainless steel and non-ferrous material welds not subjected to subsequent painting unless work hardening of the surface is ensured.

Add new clause

10.16

Laminations identified on the bevel surface by visual examination shall be investigated by NDE prior to removal.

11 Special Procedure Qualification Requirements/Testing

11.1 General

11.1.1

Replace first paragraph with

PQRs shall contain all information as per ASME *BPVC* Section IX, QW-483 or ISO 15614-1, Annex B.

Replace list with

PQRs shall include:

a) preliminary WPS (pWPS);

b) laboratory test reports, including photomicrographs;

c) parent material certificates;

d) consumable certificates;

e) PWHT records, if applicable;

f) NDE reports, if applicable;

g) when hardness, impact or corrosion testing is required, as-run welding parameter details.

11.2 Tube-to-tubesheet Welding

11.2.1

Add after "QW-288"

or ISO 15614-8.

11.2.2

Add after "b, or c"

or ISO 15614-8

Add new clause

11.2.3

A minimum of three tensile pull-tests shall be performed on the qualification test coupon whenever it cannot be proven by calculation that the strength of the weld is greater than the axial strength of the tube.

Add new clause

11.2.4

Strength-welded tube-to-tubesheet welds shall be produced by gas tungsten arc welding (GTAW) using filler material.

Add new clause

11.2.5

Strength-welded tube-to-tubesheet welds shall have a minimum of two weld passes.

11.3 Additional Procedure Qualification Requirements for Duplex and Super Duplex Stainless Steels

11.3.1 General

Add after "requirements"

, except that UNS S31803 and UNS S32205 are interchangeable.

Replace NOTE with

NOTE Sections 11.4 through 11.10 include additional requirements applicable for welding qualification of duplex stainless steels.

11.3.2 Thickness and Heat Input

11.3.2.2

Replace clause with

The heat input range shall be derived in accordance with Table 11.

Add new clause

11.3.2.3

As an alternative to 11.3.2.2, the supplier may qualify a welding procedure with multiple test coupons welded at the lowest and highest heat input to qualify intermediate heat inputs.

Add new clause

11.3.2.4

The production WPS heat input range should be within 12.7 to 63.5 kJ/in. (0.5 to 2.5 kJ/mm) for 22Cr duplex.

NOTE It is recommended to weld the second pass with less heat input than the heat input of the root pass in order to avoid the formation of secondary austenite. Secondary austenite reduces the corrosion resistance.

Add new clause

11.3.2.5

The production WPS heat input limit range should be within 12.7 to 38.1 kJ/in. (0.5 to 1.5 kJ/mm) for 25Cr duplex.

NOTE It is recommended to weld the second pass with less heat input than the heat input of the root pass in order to avoid the formation of secondary austenite. Secondary austenite reduces the corrosion resistance.

11.3.3 Welding Position

Replace clause with

For manual and semi-automatic welding, a change in position according to ASME *BPVC* Section IX, QW-461.9 shall be considered an essential variable for procedure qualification.

11.3.4 Ferrite to Austenite Ratio

11.3.4.3

Delete NOTE 1

Add new clause

11.3.4.4

Conformance with ISO 17781 for ferrite measurement is acceptable as an alternative to 11.3.4.1, 11.3.4.2 and 11.3.4.3.

11.3.6 Corrosion and Impact Testing

11.3.6.1 General

Replace clause with

The corrosion and impact tests described in 11.3.6.2 and 11.3.6.3 respectively shall be performed on the PQR sample.

Delete NOTE

11.3.6.2 Corrosion Test

Add list item d)

d) As an alternative to 11.3.6.2 a), the corrosion test and acceptance criteria of ISO 17781 shall be permitted.

11.3.6.3 Impact Test

Replace list item a) with

a) Impact tests shall be performed in accordance with the governing code and ISO 17781.

NOTE It is recognized that existing procedure qualifications may have been tested according to other testing requirements that do not conform to this requirement. These weld procedure qualifications do not require retesting unless requested by the purchaser.

Delete list item b)

Replace list item c) with

c) The minimum energy values shall be the higher of those specified in the governing code and QLII of ISO 17781.

NOTE It is recognized that existing procedure qualifications may have lower energies that are acceptable to the governing code. These weld procedure qualifications do not require retesting unless requested by the purchaser.

Add list item e)

e) The test temperature shall be -50 °F (-46 °C) or the MDMT, whichever is less.

11.3.7 Tube-to-tubesheet Joints

11.3.7.1

Add after "WQ-193"

or ISO 15614-8

Add new clause

11.4 Essential Variables

In addition to the essential variables listed in ASME *BPVC* Section IX or applicable parts of ISO 15614, the WPS requires requalification if the essential variables in Table 11 are exceeded.

Add new table

Table 11—Additional Essential Variables for Procedure Qualification per ASME *BPVC* Section IX or ISO 15614-1

Essential Variable	Description	Girth Welds							Cladding	Buttering
		CS/LAS	ASS [1]	Ti	6Mo	DSS	Ni-alloy	Cu-alloy		
Joints	A change from double sided welding to single sided welding [2]	x	x	x	x	x	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° [3]	x	x	x	x	x	x			
Joints	A deviation from qualified included angle of more than ±2.5° if the qualified included angle is less than 30° (except for portions of compound bevels) [3]	x	x	x	x	x	x			
Joints	Any change in nominal root gap tolerance ±0.04 in. (±1 mm) for single sided welding				x	x				
Backing	For environmental crack sensitive applications, e.g. sour service, a weld made without backing does not qualify a weld made with backing	x				x				
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: a) subject to sour service regardless of 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 wall thickness; d) pressure vessel component 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 SMYS > 52 ksi (360 MPa).	x							x	x

Table 11 *(continued)*

Essential Variable	Description	Girth Welds							Cladding	Buttering
		CS/LAS	ASS [1]	Ti	6Mo	DSS	Ni-alloy	Cu-alloy		
Base material	A change in material grade [4]			x						
Base material	A change in UNS number, except that UNS S31803 and UNS S32205 are interchangeable					x				
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 exceeding what is specified in 11.3.2.1					x				
Consumable	A change in brand name when impact testing is required, except for solid wire	x	x	x	x	x	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.1.12)								x	
Wire diameter	An increase in diameter for FCAW-G	x	x	x	x	x	x		x	x
Flux	A change in brand name for SAW	x	x	x	x	x	x		x	x
Welding position	A change from vertical uphill to vertical downhill welding and vice versa	x	x	x	x	x	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	x	x	x	x	x
Welding position	For manual and semi-automatic welding, a change in position according to ASME *BPVC* Section IX, QW-461.9.					x				
Gas	Removal of backing gas except in accordance with 7.3	x	x	x	x	x	x	x		

Table 11 *(continued)*

Essential Variable	Description	Girth Welds							Cladding	Buttering
		CS/LAS	ASS [1]	Ti	6Mo	DSS	Ni-alloy	Cu-alloy		
Gas	A change in shielding or backing gas composition or decrease in purity level, e.g. a change from high purity to industrial purity argon	x	x	x	x	x	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 ±25 % of the average heat input for a weld zone measured during procedure qualification welding	x	x	x	x	x	x	x	x	x
Heat input	For sour service, 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	x	x		x	x
Welding equipment	A change in make, model and program settings for GTAW-P or GMAW-P	x	x	x	x	x	x	x	x	x
Weaving	When impact testing is required, a change from stringer bead to weaving technique or vice versa	x				x				
Welding process	A change between manual, semi-automatic, mechanized and automatic welding	x	x	x	x	x	x	x	x	x

NOTE 1 ASS: Austenitic stainless steels, P-No 8, group 1.
NOTE 2 Single sided welding with backing strip is equivalent to double sided welding.
NOTE 3 Fabricator may deviate from this requirement by demonstrating their ability to meet heat input requirement and achieving mechanical properties with the altered geometry.
NOTE 4 Not applicable for Titanium grade 1, 2 and 3 provided grade 1 or 2 consumable is used in the qualification.

Add new section

11.5 PQR Hardness testing

11.5.1

A hardness survey shall be performed for PQRs where service is specified as sour.

11.5.2

A hardness survey shall be performed for PQRs where the material is duplex stainless steel.

11.5.3

A hardness survey shall be performed for PQRs when specified in the data sheet.

11.5.4

Hardness test locations shall be as per the governing code. If test locations are not specified, hardness test locations shall be in accordance with NACE MR0175/ISO 15156-2 Figure 2 for butt welds, Figure 4 for repair, partial penetration welds and Figure 6 for overlay welding.

NOTE Where qualifications are carried out to ISO 15614, additional surveys may be required in accordance with that specification.

11.5.5

Specimens for hardness testing shall be taken at the lowest heat input position.

11.5.6

Hardness testing shall be performed using the Vickers hardness, HV10 or HV5 method as per ASTM E384 or ISO 6507-1.

11.5.7

For sour service, the hardness testing shall comply with NACE MR0175/ISO 15156 or NACE MR0103, whichever is applicable.

11.5.8

For sour service, hardness testing results shall not exceed the lower of the values specified by NACE standard and Table 12.

11.5.9

For non-sour service, if hardness testing is required as part of the PQR, the hardness values shall not exceed the values listed in Table 12.

11.5.10

The hardness of the weld metal and HAZ for Titanium gr. 2 shall not exceed the base material by more than 50 HV10.

Add new table

Table 12—Permitted Maximum Hardness Values (HV10) for Non-sour Service

Material type	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 Steels	350
P-No. 15E 9Cr-1Mo-V	290
P-No. 6 Martensitic stainless steel 410	248
P-No 10H 22Cr duplex	320
P-No 10H 25Cr duplex	350
P-No. 51, 52, 53 Titanium	200

Add new section

11.6 Impact Testing

11.6.1

Charpy V-notch impact testing shall not be required for thicknesses less than 0.25 in (6 mm).

11.6.2

Impact testing of austenitic stainless steels shall be performed if the MDMT is below -150 °F (-101 °C).

11.6.3

The Charpy V-notch absorbed energy shall comply with the minimum values in Table 13 or as specified in the data sheet.

Add new table

Table 13—Minimum Charpy V-notch Absorbed Energy Values

Material	Test Temperature	Minimum Average Absorbed Energy	Minimum Single Absorbed Energy
Non impact tested CS	Not applicable		
LTCS (e.g. A333 Gr. 6, A350 LF2)	-50 °F (-46 °C) or MDMT, whichever is lower	20 ft·lb (27 J)	15 ft·lb (20 J)
Other CS and LAS (e.g #52, #60) [1]	As per design code or base material specification (see data sheet)	20 ft·lb (27 J) or design code, whichever is higher	15 ft·lb (20 J) or design code, whichever is higher
Austenitic stainless steels	MDT [2]	lateral expansion min. 0.015 in. (0.38 mm)	
22Cr and 25Cr duplex	See 11.3.6.3		

NOTE 1 Applies to impact tested steels. Higher values may be required by the data sheet, design code or EEMUA 235. Energy values have been selected to allow ECA based on master curve toughness estimate.

NOTE 2 Refer to 11.6.2.

11.6.4

If the location, orientation and number of specimens are not specified by the governing code, specimens shall be as per ASME *BPVC* Section VIII, Div. 1, UG84 or applicable parts of ISO 15614.

11.6.5

In welds that join two different base materials, both sides of the weld shall be tested.

11.6.6

In welds that join two different base materials, the weld metal shall fulfil the less stringent of the impact values.

Add new section

11.7 Macroscopic Examination

11.7.1

When a macro is required, including for hardness surveys, sections shall be prepared and etched such that the whole cross section of the weld, inclusive of HAZ, and adjacent parent material and individual weld passes are visible.

11.7.2

The macroscopic examination shall be performed with a magnification between 3x and 8x.

11.7.3

The acceptance criteria shall be as per ISO 15614-1 Level 2.

Add new clause

11.8 Corrosion Testing of 6Mo

Corrosion testing for 6Mo shall be performed and assessed in accordance with the requirements for 25Cr duplex in ISO 17781.

Add new section

11.9 Qualification of Repair Procedures

11.9.1

Repair welding shall be qualified by the original PQR if it is within the essential variables, or by a separate PQR qualified for the specific repair scenario. See Figure 1 for clarification on acceptable repair methodology for duplex stainless steel.

11.9.2

Impact testing of repair weld procedure qualification shall sample weld metal and both adjacent HAZs i.e. the HAZ in the original weld metal and the HAZ in the parent material.

11.9.3

For carbon and low-alloy steels in sour service, a specific repair welding procedure test shall be carried out and as a minimum subjected to macro-hardness examination testing in accordance with Figure 4 in NACE MR0175/ISO 15156-2.

11.9.4

For duplex stainless steel, full penetration repairs shall have specific purchaser approval. See Figure 1 for clarification on acceptable repair methodology for duplex stainless steel.

11.9.5

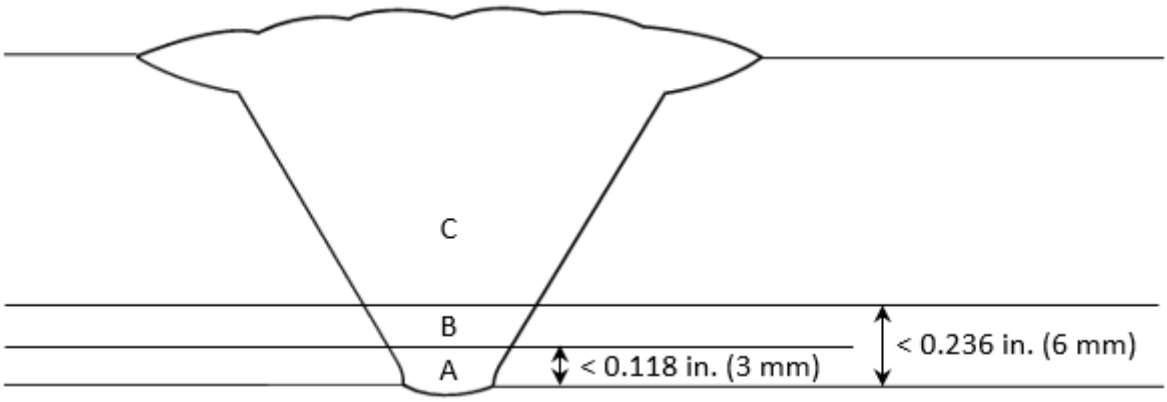
For duplex stainless steel, partial penetration repairs deeper than within 0.25 in. (6 mm) of the inner surface, a specific repair welding procedure test shall be carried out on the minimum required ligament (see 12.11.7).

NOTE See Figure 1 for clarification on acceptable repair methodology for duplex stainless steel.

11.9.6

The repair weld test coupon shall be subjected to a macro examination according to 11.7 and a corrosion test according to 11.3.6.2.

Add new figure



Key

Weld zone A: cut out or purchaser approval for full penetration repair. See 11.9.4 and 12.11.7.

Weld zone B: see 11.9.5.

Weld zone C: repair as original – method statement/WPS. See 11.9.1.

Figure 1—Repair Methodology for Duplex Stainless Steel

Add new clause

11.10 Qualification of Buttering

Buttering of the weld end of a component, which at a later stage will become a part of a pressure containing butt weld, e.g. as a transition between a corrosion-resistant alloy and a carbon or low-alloy steel, shall be qualified as a butt weld.

12 Other Items

12.1 Backing Materials

Add new clause

12.1.1

Permanent backing strips shall not be used.

Add new clause

12.1.2

After the removal of temporary backing strips, the root of the weld shall be ground smooth.

12.2 Peening

Replace clause with

Peening shall not be used.

12.3 Weld Overlay and Clad Restoration (Back Cladding)

12.3.1

Replace "ASME BPVC Section IX" with

Section 11 and Annex B

Replace section 12.6 title with

12.6 Hardness Testing—Production Testing

12.6.1

Replace clause with

Production hardness testing shall be performed when specified in the data sheet and carried out in accordance with a method statement approved by the purchaser.

12.6.2

Replace clause with

For sour service, production hardness testing results shall not exceed the values given in NACE MR0175/ ISO 15156 or NACE MR0103, whichever is applicable.

12.6.3

Add new clause

Hardness testing results shall not exceed the values listed in Table 12.

12.7 Single-pass Welds

Delete "unless approved by purchaser"

12.8 Additional Production Requirements for Welding Duplex and Super Duplex Stainless Steel

12.8.1

Replace clause with

Production testing shall be in accordance with 12.12.

12.8.3

In item b), replace all instances of "should" with

shall

12.8.4

Delete clause

Add new clause

12.9 Permanent Attachments

External and internal attachments in corrosive service welded directly on to pressure parts shall be continuous.

Add new section

12.10 Tack Welding

12.10.1

Tack welds, if left in place, shall be made by a qualified welder following a qualified welding procedure.

12.10.2

Tack welds shall use the same filler metal composition as the completed weld.

12.10.3

Tack welds incorporated into the main weld shall be free of visible defects.

12.10.4

Removable bars welded inside the bevel and cleats pieces, bridge pieces or other attachments welded temporarily to base material shall be of the same or equivalent material as the base material.

12.10.5

Tack welds shall be removed by grinding.

Add new section

12.11 Repair Welding

12.11.1

Weld repair shall be carried out in accordance with a written procedure.

12.11.2

Weld repair procedures shall include:

— method of defect removal;

— method for verification of defect removal;

— shape and size of excavation prior to re-welding;

— repair WPS;

— PQR;

— PWHT procedure (if applicable);

— type and extent of NDE after repair;

— approval requirements.

12.11.3

For 25Cr duplex, 6Mo and titanium, only one repair attempt shall be allowed in the same area.

12.11.4

Materials not covered by 12.11.3, only two repair attempts shall be allowed in the same area.

12.11.5

Arc gouging shall only be used on carbon steels and low alloy steels.

12.11.6

If thermal cutting or gouging are used, the surface shall be ground or machined to a bright surface finish.

12.11.7

For duplex stainless steel, the remaining ligament for partial penetration repairs shall be minimum 0.125 in. (3 mm). See Figure 1 for clarification on acceptable repair methodology for duplex stainless steel.

12.11.8

When repair of a weld is done by a weld cut-out, the original weld and HAZ shall be completely removed.

12.11.9

Back purging in conformance to Section 7 shall be required for repairs in which the remaining ligament is less than or equal to 0.3125 in. (8 mm) if back purging was applied with the original WPS.

Add new section

12.12 Production Tests

12.12.1

Production test coupons and requirements shall be in accordance with the design code or as specified by the data sheet.

12.12.2

Mechanical tests and acceptance criteria shall be the same as required for welding procedure qualifications unless redefined in the data sheet.

12.12.3 Production Parameter Monitoring

12.12.3.1

The recording frequency of production parameter monitoring shall be in accordance with the data sheet, but not less than the first weld per WPS and the first weld by a welder or welding operator.

12.12.3.2

Production parameter monitoring records shall be traceable to a specific welder, WPS and production weld.

12.12.3.3

Production parameter monitoring records shall verify correct fit-up and root pass penetration for single sided welds where full penetration is required, including weldolets and attachment welds.

12.12.3.4

Production parameter monitoring records shall detail the actual preheat and interpass temperature, consumables, welding parameters and resulting heat input.

12.12.3.5

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

12.12.4

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

Add new section

12.13 Ferrite Control for Austenitic Stainless Steel Production Welds

12.13.1

Ferrite control shall be required for austenitic stainless steel weld metal to achieve 3-10 FN, where the service application exceeds 662 °F (350 °C) or if below -150 °F (-101 °C), or where the weld will be subject to PWHT.

12.13.2

Where ferrite control is required by 12.13.1, the extent of ferrite number measurements of production welds shall be in accordance with the data sheet.

12.13.3

When required, a minimum of three separate ferrite number measurements shall be performed per weld.

Add new section

12.14 Proximity of Welds

12.14.1

Circumferential welds shall be separated by at least two times the wall thickness or 2 in. (50 mm), whichever is greater, measured between the toe of each weld.

12.14.2

Non-intersecting branch and non-pressure part attachment welds shall be at least two times the wall thickness or 2 in. (50 mm), whichever is greater, from any weld, measured between the toe of each weld.

12.14.3

Branch and non-pressure part attachment welds should not cross main seam welds if possible.

12.14.4

If intersections described in 12.14.3 are unavoidable, the length of the main seam weld covered by the attachment, including a projection at least 2 in. (50 mm) beyond each side of the attachment, shall be ground flush and inspected with minimum MT or PT.

Add new clause

12.15 Calibration of Welding and Measuring Equipment

Welding and parameter-measuring/recording equipment shall be calibrated at least every 12 months or more often if required by the equipment manufacturer's recommendations.

Annex B
(informative)
Weld Overlay and Clad Restoration (Back Cladding)

B.1 General

B.1.2

Replace list item a) with

a) The procedure qualification metallographic examination demonstrates that at least 5 % penetration has been achieved.

Add list item d)

d) Parameters controlling magnetic field shall be included in the WPS and monitored during welding.

B.1.8

Replace clause with

For SAW, with the exception of compensation of losses of alloying elements due to the welding arc, deliberate additions of principal alloying elements through the flux is prohibited.

B.1.10

Delete second sentence

Table B.1—Filler Material Selection for Overlay of Carbon and Low-alloy Steels

Add row to Table B.1

Overlay Material	Weld Overlay Materials [a, d]			
	Equipment Requiring PWHT		Equipment Not Requiring PWHT	
	First Layer	Top Layer(s)	First Layer	Top Layer(s)
Alloy 625	E/ERNiCrMo-3	E/ERNiCrMo-3	E/ERNiCrMo-3	E/ERNiCrMo-3

Replace note b) with

b) See B.1.17.

Add new clause

B.1.13

The minimum thickness of cladding or overlay welding shall be 0.125 in. (3 mm) after machining.

Add new clause

B.1.14

When PWHT is required for base materials with austenitic stainless steel weld overlay, weld procedure qualifications shall include corrosion testing according to ASTM A262 Practice C.

Add new clause

B.1.15

Test coupons for corrosion testing shall be heat treated prior to testing with at least twice the fabrication heat treatment soak time as specified for the equipment.

Add new clause

B.1.16

The weld qualification procedure shall establish that the specified chemical composition of the filler metal is met at a depth of at least 0.0625 in. (1.5 mm) below the minimum specified overlay thickness.

Add new clause

B.1.17

E/ER/EQ308 and E/ER/EQ316 shall not be used in the PWHT condition.

B.2 Clad Restoration (Back Cladding)

B.2.2

Add after "ASME BPVC Section IX"

or ISO 15614-7

Add new clause

B.2.4

Back clad areas shall include CRA thickness measurements recorded at a minimum of six locations around a circumference or back clad area together with ferrite or PMI measurement to verify clad integrity.

B.3 Austenitic (300 Series) Stainless Steel Overlay

B.3.2

Delete second and third sentences

B.3.3

In second sentence, delete "and this is approved by the purchaser"

B.4 Ferritic Stainless Steel Alloys

Delete clause

B.6 Nickel-base Alloys (Other Than Ni-Cu Alloy 400)

Replace clause with

B.6.1

With the exception of iron, the chemical composition for overlay with nickel base alloys shall meet the chemical requirements of the equivalent base materials.

Add new clause

B.6.2

The maximum iron content in the weld deposit for alloy 276 and alloy 625 overlay shall be 10 %.

Add new annex

Annex C
(informative)
Acceptance Criteria for Oxidation of Stainless Steel Weldments

C.1 Examples of Acceptable and Unacceptable Oxidation of Stainless Steel Weldments

Figures C.1 to C.6 show the root side of stainless steel weldments. Figures C.1 to C.3 show examples of acceptable oxidation. Figures C.4 to C.6 show examples of unacceptable oxidation.

Image source: Shell DEP 30.10.60.31-Gen, Oxidation of Stainless Steel Weldments (2013)

Figure C.1—Acceptable - Very good result, no discoloration

Figure C.2—Acceptable - Slight discoloration, weld shiny, no scale present

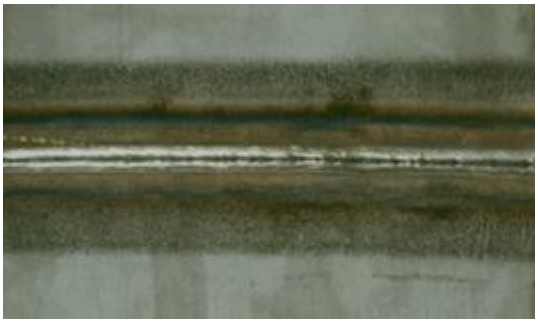


Figure C.3—Acceptable - Slight discoloration, weld shiny, no scale present

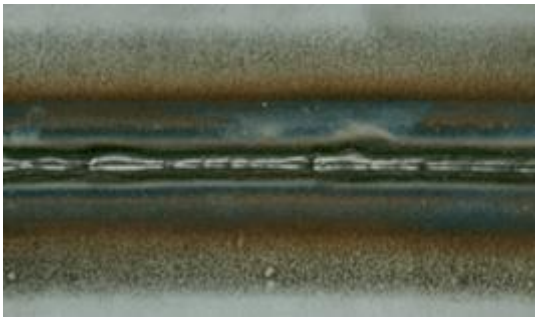


Figure C.4—Unacceptable - Oxide layer present (grey colour) on and near weld; lack of proper back-purging

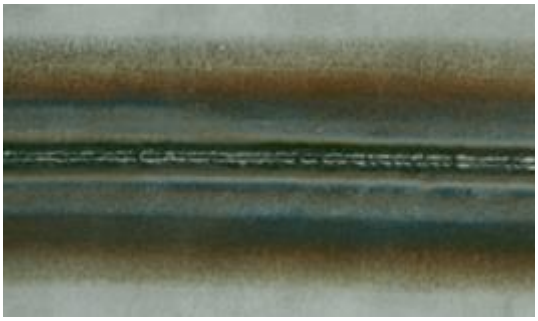
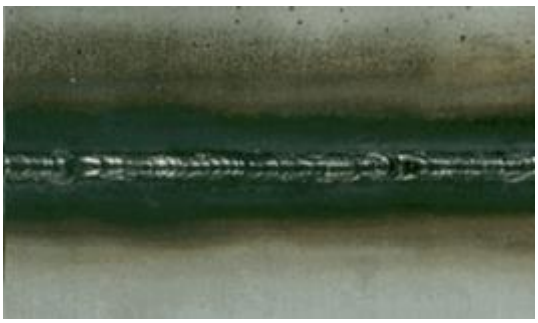


Figure C.5—Unacceptable - Oxide layer present (grey colour), weld burned; lack of proper back-purging



NOTE This may develop when welding with SMAW or GTAW with severe lack of back-purging.

Figure C.6—Unacceptable - Very heavy oxide layer present

Bibliography

[1] EEMUA Publication 235 Guidance on PWHT for P1 CMn steels

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