International Association of Oil & Gas Producers

SPECIFICATION S-705

October 2019

Supplementary Specification to API Recommended Practice 582 Welding Guidelines for the Chemical, Oil, and Gas Industries

JIP33 JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	AMENDMENTS
0.1	October 2019	Issued for public review

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Project 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 a 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 for projects 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 approved specification, building on recognized industry and/or 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, facilitating improved standardization of major projects across the globe. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardisation 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).

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Introduction

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

This JIP33 standardized procurement 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

It is required to use all of these documents in conjunction with each other when applying this specification, as follows:

S-705: Supplementary Specification to API Recommended Practice 582 Welding Guidelines for the Chemical, Oil, and Gas Industries

This specification is written as an overlay to API RP 582, following the clause structure of the parent standard, to assist in cross-referencing the requirements. Where clauses from the parent standard API RP 582 are not covered in this specification, there are no supplementary requirements or modifications to the respective clause. The terminology used within this specification follows that of the parent standard and otherwise is in accordance with ISO/IEC Directives, Part 2.

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

S-705D: Datasheet for Welding Requirements

This document provides project specific requirements where this specification requires the purchaser to define an application specific requirement. It also includes information required by the purchaser for technical evaluation. Additional purchaser supplied documents are also listed in the datasheet, to define scope and technical requirements for enquiry and purchase of the equipment.

S-705L: Information requirements for Welding

This document defines the information requirements, including format, timing and purpose, for information to be provided by the vendor. It also defines the specific conditions which must be met for conditional information requirements to become mandatory. The information requirements listed in the IRS have references to the source of the requirement.

S-705Q: Quality requirements for Welding

This document includes a conformity assessment system (CAS) which specifies standardized user interventions against quality management activities at four different levels. The applicable CAS level is specified by the purchaser in the datasheet.

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

Unless defined otherwise in the purchase order, 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 (datasheet, IRS, QRS);

d) this specification;

e) the parent standard.

1 Scope

1.1

Replace with

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) tanks (transportable) and attachments welded thereto;

d) Simple load bearing applications using ASME IX, e.g. braces, that are welded directly to pressure containing equipment

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

1.2

Replace with

This document is general in nature and augments the welding requirements of ASME BPVC Section IX 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. The following is excluded from the scope of this specification:

a) structural welding;

b) pipelines;

c) subsea production systems;

d) field erected storage tanks (different base standards; API 620, API 650);

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 material welding;

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

h) pressure classes above 2500.

NOTE The scope of application is focused on the upstream segment and as a consequence the use of the specification in downstream applications will be limited.

1.3

Delete clause

2 Normative References

ASME BPVC Section II, Part D	Properties - Materials
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 6507	Metallic materials - Vickers hardness test
ISO 9001:2015	Quality management systems - Requirements
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 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/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

3 Terms and Definitions

Add new definition

3.9 CE

Carbon Equivalent

CE (IIW)

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

Add new definition

3.10 PREN

Pitting Resistance Equivalent Number

PREN

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

Add new section

3.11 Acronyms, Abbreviations, and Symbols

ASS	Austenitic Stainless Steel
CS	Carbon Steel
DHT	Dehydrogenation heat treatment
DSS	Duplex Stainless Steel
EBW	Electron beam welding
ECA	Engineering Critical Assessment
ESW	Electroslag welding
FCAW-G	Gas shielded flux-cored arc welding
FN	Ferrite number
GMAW	Gas metal arc welding
GMAW-P	Pulsed gas metal arc welding
GMAW-S	Short circuiting gas metal arc welding
GMAW-Sp	Spray gas metal arc welding
GTAW	Gas tungsten arc welding
GTAW-P	Pulsed gas tungsten arc welding
HAZ	Heat affected zone
LAS	Low Alloy Steel
LBW	Laser beam welding
LTCS	Low Temperature Carbon Steel
MDT	Minimum design temperature
Mf	Martensite finish temperature
MT	Magnetic particle testing
NDE	Non-destructive testing
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

4.5

Replace with

Any pressure boundary welds and welds to the pressure boundary shall comply with the specified design code and related welding code.

Add new sub section

4.6 Welding Procedure Specification (WPS)

4.6.1

Welding procedure specifications (WPSs) shall be prepared in accordance with ASME BPVC Section IX or the applicable parts of ISO 15609 and the applicable code.

4.6.2

The WPS shall include all additional essential variables stated in Table 10 of this specification.

Add new sub section

4.7 Procedure Qualification Record (PQR)

4.7.1

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

4.7.2

The PQR shall be endorsed by a recognised independent third party.

NOTE This clause has been added for worldwide acceptance as it is a legal requirement in several regions, but can be waived in other regions with purchaser approval.

Add new clause

4.8

All pressure retaining welds shall be full penetration.

Add new clause

4.9

All pressure retaining welds shall be, where practical, double sided.

Add new clause

4.10

Vertical down welding shall not be used.

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 inclement weather.

Add new clause

4.12

The wind speed shall not exceed 0.5 mph (0.2 m/s) in the area where gas shielded welding (GTAW, FCAW-G, GMAW, PAW) is taking place.

5 Welding Processes

5.1 Acceptable Welding Processes

Replace with

Acceptable welding processes are given in Table 7.

Add new table

Table 7 - Acceptable welding processes

Welding processes	Root pass[1]	2nd pass	Fill/cap	Cladding	Buttering[4]
Shielded metal arc welding (SMAW)		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[2]	x[2]	x[3]		
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
Laser beam welding (LBW)		x	x	x	x

Welding processes	Root pass[1]	2nd pass	Fill/cap	Cladding	Buttering[4]
Electron beam welding (EBW)	x	x	x		
NOTE 1 Single sided weld where the root pass is not removed. NOTE 2 Refer to 5.2.3 b) NOTE 3 Refer to 5.2.3 c) NOTE 4 Some of the processes below are typically only used on reinstatements.					

5.2 Limitations of Fusion Welding Processes

5.2.1 General

Replace with

Autogenous welding shall not be used except for EBW.

Replace sub section heading 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

All 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

GMAW-S shall only be used with interrupted arc transfer mode (e.g. STT, RMD).

Delete list item d)

Delete list item e)

Add item f) to list

f) GMAW-S shall only be used for pipe sizes NPS 3 and over.

5.2.4 GMAW-P

Delete first sentence

5.2.5 FCAW

5.2.5.1

Replace with

FCAW-S shall not be used.

5.2.5.2

Replace 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

Delete clause

Delete Table 1

5.2.6 EGW

Delete clause

5.2.7 SAW

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 with

For single sided welded joints, any 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 to clause 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 specification

6.1.2

Add to item a) after "ASME/AWS"

or ISO

Review WPS

6.1.3

Delete clause

6.1.4

First sentence replace "should" with

shall

6.1.4

Replace 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

Replace second sentence "should" with

shall

6.1.6

Add after "AWS"

or ISO

6.1.7

Delete "Unless specifically authorized by the purchaser,"

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

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

Add new sub 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 C4 or C5 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 T3 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

All welding consumables shall produce welds with mechanical properties that are the same or better as the minimum requirements specified for the base metal.

Add new clause

6.1.13

All pressure containing butt welds or welds onto pressure retaining parts shall be made using welding consumables, including fluxes, having a maximum diffusible hydrogen of 5 ml/100 g of weld metal.

Add new clause

6.1.14

For carbon steel or low alloy steel with sour service requirements, welding consumables that produce a deposit containing more than 1 % Ni shall pass a weld sulfide stress cracking qualification test in accordance with NACE MR0175/ISO 15156-2.

Add new clause

6.1.15

Consumables for the root and second pass shall be selected to avoid preferential weld corrosion.

NOTE Recommended compositions for carbon steel are as follows:

— for water injection systems:

- 0.8 % to 1.0 % Ni, or
- 0.4 % to 0.8 % Cu and 0.5 % to 1.0 % Ni.

— for sweet inhibited hydrocarbon service: max 0.3% Ni, 0.6% Si, 0.5% Mo

6.2 Dissimilar Welding

Add NOTE to 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 new clause

6.2.3

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.

6.3 Low-alloy Steel Welding (P-No. 3 to P-No. 5 and P-No.15E)

Replace first sentence with

The welding guidelines referenced in API 934-A, API 934-C, and API 934-E shall be followed for welding Cr-Mo steel pressure vessels for high-temperature, high-pressure hydrogen service.

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

6.4.2

6.4.2.1

Replace 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

Replace first sentence "should" with

shall

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.

Add new clause

6.4.2.6

Comparable low carbon or stabilised austenitic consumables shall be used if welding low carbon “L” grade 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 sulfur 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 shall be 30 ≤ PREN ≤ 40.

Add new clause

6.5.5.4

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

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 %
Sulfur	max. 0.015 %	max. 0.015%

6.5.7

Replace clause with

See section 7 for limitations on back purge quality.

6.6 SAW

6.6.3

Replace with

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

6.6.5

Add to clause 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.

Add new clause

6.6.7

Flux remaining unused at the end of each shift of more than 8 hours (including flux remaining in the machine hoppers) 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.

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 to clause after "stored"

, baked (if required)

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.

Add new clause

6.8.6

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

6.9 Alloy Consumable Controls

Delete from first sentence

using a weld metal button/pad or other suitable means, as agreed with the purchaser.

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 recorded on the PQR and WPS when a single gas is used.

7.3

Replace first sentence with

Back purging is required for welding materials having a nominal chromium content greater than 2.25 % and non-ferrous metals, unless the joint is ground or back gouged to sound metal.

Replace second sentence with

Back purging is required for tack welding where the tack weld will be incorporated into the final weld.

Replace in list item b) "1/4 in. (6.5 mm)" with

0.3125 in. (8 mm)

Replace in list item c) "1/4 in. (6.5 mm)" with

0.3125 in. (8 mm)

Add item d) to list

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 Alternatively, less than 0.5 % (5000 ppm) 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).

Add new clause

7.4

Dew point of shielding and purging gas shall be less than -58 °F (-50 °C).

Add new clause

7.5

Hydrogen gas mixtures shall not be used for either shielding or purging.

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

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 sub 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 fulfill the criteria specified in Table 8.

Add new table

Table 8 - 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 8, 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 fulfill the criteria specified in Table 9. Annex C provides guidance on acceptable and unacceptable oxidation levels.

Add new Table

Table 9 - 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 9, the oxidation shall be removed and the shielding shall be improved.

8 Preheating and Interpass Temperature

8.1

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 start of welding and maintained until welding is completed.

Add after first sentence

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

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

Replace second sentence with

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

8.7

Replace first sentence with

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

Replace Table 4 title with

Table 4 - Maximum Interpass Temperatures

Add new row to table

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

Replace Table 5 title with

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

Add new clause

8.8

The preheat temperature and preheat maintenance temperatures shall be measured at a distance of not less than 1.5 in. (38 mm) on either side of the weld groove.

Add new clause

8.9

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

Add new clause

8.10

Where PWHT applies for low alloy steels, electric resistance or induction heating shall be used for pre-heating.

Add new clause

8.11

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

8.12

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

Add new sub section

8.13 Welding interruption

8.13.1

If welding is interrupted without maintenance of minimum preheat, the requirements 8.14.2 through 8.14.5 shall apply.

8.13.2

If welding is interrupted before 30 % of the total joint thickness is completed, then appropriate surface inspection (e.g., MT or PT) shall be performed to ensure freedom from deleterious defects.

8.13.3

During interruption of ferritic and martensitic steels, the joint cooling rate shall be reduced by using insulation.

8.13.4

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

8.13.5

For low alloy steels, dehydrogenation heat treatment shall be performed before being allowed to cool.

9 Post-weld Heat Treatment (PWHT)

Add to end of final sentence

that includes these variables.

9.2

Replace first sentence "should" with

shall

Delete sub section

9.4

Delete clause

Delete clause

Delete clause

9.5

Replace with

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

9.8

Delete clause

Delete NOTE

Replace clause with new sub section

9.11 Code exemptions

Add new clause

9.11.1

Exemption of code required PWHT for P-No. 1 materials is not permitted for thicknesses above 0.75 in. (20 mm) unless supported by an engineering critical assessment (ECA) approved by the purchaser. This ECA may be item-specific or generic industry guidance, eg. EEMUA Publication 235.

9.11.2

Code exemption of PWHT for P-No. 4 and P-No. 5 materials is not permitted for applications in sour or hydrogen service [8] or where the nominal chromium content of the material exceeds 1.25 %.

9.12

Replace first sentence "suggested" with

typical

Replace second sentence "should" with

shall

Replace with

Table 6 - PWHT Temperatures and Holding Times

P-No.	Material Type	Nominal Thickness at Weld	Service Environment	Holding Temperature °F (°C) [a]	Time at Holding Temperature
1	carbon steel	according to code	code	1100 to 1200 (595 to 650)	1, minimum
1	carbon steel	all	wet H_2S	1150 to 1200 (620 to 650)	1, minimum
1	carbon steel	all	caustic	1150 to 1200 (620 to 650)	1, minimum
1	carbon steel	all	amine	1150 to 1200 (620 to 650)	1, minimum
1	carbon steel	all	carbonates	1200 to 1250 (650 to 675)	1, minimum
1	carbon steel	all	HF acid	1150 to 1200 (620 to 650)	1, minimum
1	carbon steel	all	deaerator	1150 to 1200 (620 to 650)	1, minimum
1	carbon steel	all	ethanol	1150 to 1200 (620 to 650)	1, minimum
3	C-1/2Mo	according to code	code	1150 to 1200 (620 to 650)	1, minimum
3	C-Mn-Mo	all	all	1150 to 1200 (620 to 650)	1, minimum
4	1Cr-½Mo, 1 ¼Cr-½Mo	all	for maximum tempering (creep)	1275 to 1325 (690 to 720)	2, minimum

P-No.	Material Type	Nominal Thickness at Weld	Service Environment	Holding Temperature °F (°C) [a]	Time at Holding Temperature
4	1Cr-½Mo, 1 ¼Cr-½Mo	all	for optimum high-temperature properties (toughness)	1250 to 1300 (675 to 705)	2, minimum
4	1Cr-½Mo, 1 ¼Cr-½Mo	all	heavy wall pressure vessels for high-pressure hydrogen service operating at or below 825 °F (441 °C)	1225 to 1275 (660 to 690)	2, minimum, see to API 934-C for more details
4	1 ¼Cr-½Mo	all	pressure vessels for service above 825 °F (440 °C)	1225 to 1275 (660 to 690)	2, minimum, see to API 934-E for more details
5A	2 ¼Cr-1Mo	all	for maximum tempering (creep)	1300 to 1350 (705 to 730)	2, minimum
5A	2 ¼Cr-1Mo	all	for maximum high-temperature properties (toughness)	1275 to 1325 (660 to 720)	2, minimum
5A	2 ¼Cr-1Mo	all	heavy wall pressure vessels for high-temperature, high-pressure hydrogen service	1250 to 1300 (675 to 705)	2, minimum, see API 934-A for more details
5B	5Cr-½Mo	all	all	1325 to 1375 (720 to 750)	2, minimum
5B	9Cr-1Mo	all	all	1350 to 1400 (730 to 760)	2, minimum
15E	9Cr-1Mo-V	according to code	all	1375 to 1425 (750 to 775)	2, minimum
5C	2 ½Cr-1Mo-V	all	heavy wall pressure vessels for high-temperature, high-pressure hydrogen service	1275 to 1325 (660 to 720)	8, minimum, see API 934-A for more details
6	martensitic stainless steels	according to code	all	according to code [b]	2, minimum
7	ferritic stainless steels	according to code	all	according to code	1, minimum
8	austenitic stainless steels	according to code	all	according to code [c]	according to code
9A	1 ½ to 2 ½ Ni	according to code	all	1100 to 1150 (595 to 620)	1, minimum

P-No.	Material Type	Nominal Thickness at Weld	Service Environment	Holding Temperature °F (°C) [a]	Time at Holding Temperature
9B	3 ½ Ni	according to code	all	1100 to 1150 (595 to 620)	1, minimum
10H	duplex stainless steels	according to code	all	according to code	according to code
11A	8 Ni, 9 Ni	according to code	all	according to code [d]	1, minimum
45	alloy, 800, 800H, 800HT	according to code	all	according to code	according to code

a) For quenched and tempered or normalized and tempered materials, the PWHT holding temperature shall be at least 25 °F (15 °C) below the original tempering temperature of the base metal, unless the fabricator demonstrates that mechanical properties can be achieved at a higher PWHT temperature and holding time.

b) For Type CA6NM material, a double tempering heat treatment is required. Initial heat treatment at 1225 °F (660 °C) to 1275 °F, (690 °C) followed by air cooling to ambient temperature, and second heat treatment at 1100 °F (595 °C) to 1150 °F (620 °C) and air cooling to ambient temperature.

c) For Type 321 and Type 347 materials, postweld thermal stabilization may be specified at 1600 °F (870 °C) to 1650 °F (900 °C) for two to four hours.

d) For 9 % Ni, the entire vessel, assembly, or plate must be at the PWHT holding temperature at the same time. The cooling rate from the holding temperature shall not be less than 300 °F (167 °C) per hour down to a temperature of 600 °F (315 °C). A local or partial PWHT cannot be used since this results in portions of the structure being in the embrittlement range of 600 °F (315 °C) to 1000 °F (540 °C) for extended periods of time, thereby impairing material toughness.

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.

Add new clause

9.16

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

NOTE There are some situations where the overlay material used for reinstatement will be damaged by PWHT and 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 production test plates and weld procedure qualifications shall be subjected to a minimum of one additional PWHT cycle.

Add new clause

9.19

For quenched and tempered or normalized and tempered carbon steel materials, the PWHT holding temperature shall be at least 25 °F (15 °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 cool down.

Add new clause

9.23

When PWHT is required, the minimum soak time shall not be less than one hour.

Add new clause

9.24

Reduced PWHT temperatures for longer duration shall not be permitted.

Add new clause

9.25

Any heating method associated with PWHT, which applies direct flame impingement on any part of the equipment shall not permitted.

Add new clause

9.26

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

Add new clause

9.21

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

Add new clause

9.22

Thermocouples shall be insulated from the heat source.

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 must be ground to a bright surface finish.

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, which is reserved exclusively for those types of materials.

Add new clause

10.11

All 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

10.12

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

Add new clause

10.13

Surfaces of corrosion resistant alloys, including cladding, contaminated with iron during fabrication shall be pickled and passivated.

Add new clause

10.15

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

Add new clause

10.14

Power-driven stainless steel brushes shall not be used for cleaning of stainless steels and non-ferrous material welds not subjected to subsequent painting.

11 Special Procedure Qualification Requirements/Testing

11.1 General

11.1.1

Replace first paragraph with

PQRs shall comply with the requirements of ASME BPVC Section IX, QW-483 or ISO 15614-1, Annex B.

Replace list with

PQRs shall also 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.

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

Delete NOTE

Add new clause

11.3.1.1

Sections 11.4 through 11.10 shall also apply to duplex and super duplex stainless steels.

11.3.2 Thickness and Heat Input

11.3.2.2

Replace with

The heat input shall not exceed the maximum value recorded during procedure qualification that is sampled by Charpy impact testing.

Add new clause

11.3.2.3

The minimum heat input for a weld zone shall not be lower than 75 % of the lowest value recorded in that weld zone during procedure qualification.

11.3.2.4

As an alternative to 11.3.2.3, the supplier may qualify a welding procedure with multiple test coupons welded at the lowest and highest heat input to qualify all intermediate heat inputs.

Add new sub clause

11.3.2.5

The heat input limit of 22Cr duplex shall be 12.7 to 63.5 kJ/in (0.5 to 2.5 kJ/mm).

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 sub clause

11.3.2.6

The heat input limit of 25Cr duplex shall be 12.7 to 38.1 kJ/in (0.5 to 1.5 kJ/mm).

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 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

11.3.4.1

Replace first paragraph with

Measurement of the ferrite to austenite content and microstructural examination shall be carried out for each PQR in accordance with ISO 17781.

Delete second paragraph

11.3.4.2

Replace first paragraph and list with

One additional ferrite measurement shall be performed in mid-thickness.

Delete second paragraph

11.3.4.3

Delete clause

Delete NOTE 1

11.3.6 Corrosion and Impact Testing

11.3.6.1 General

Replace with

The corrosion and impact tests described below shall be performed on the PQR sample.

Delete NOTE

11.3.6.2 Corrosion Test

Add to list

d) As an alternative to 11.3.6.2 a), 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 or ISO 17781.

Replace list item b) with

b) One set of three Charpy V notch impact tests shall be taken from the weld metal and another set from the HAZ.

NOTE The minimum Charpy values may need to be increased in accordance with the base code, e.g. ASME B31.3 requires higher values for thicknesses above 1 in. (25 mm).

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.

Add to list after item c)

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

11.3.7 Tube-to-tubesheet Joints

11.3.7.1

Add after "WQ-193"

or ISO 15614-8

Add new sub section

11.4 Essential variables

11.4.1

In addition to the essential variables listed in ASME BPVC Section IX or the applicable parts of ISO 15614, the WPS requires requalification if the essential variables in Table 10 are exceeded.

Add new table

Table 10 - Additional essential variables for procedure qualification per ASME BPVC Section IX

Essential Variable	Description	Girth Welds						Cladding	Buttering
		CS/ LAS	ASS[1]	Ti	6Mo	DSS	Ni-alloy		
Joints	A change from double sided welding to single sided welding [2]	x	x	x	x	x	x		
Joints	A decrease in the included angle of more than 10° where this results in an included angle that is less than 50°	x	x	x	x	x	x		x
Joints	A deviation from qualified angle of more than ±2.5º if the qualified angle is less than 30° (except for portions of compound bevels)	x	x	x	x	x	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:	x						x	x

Essential Variable	Description	Girth Welds						Cladding	Buttering
		CS/ LAS	ASS[1]	Ti	6Mo	DSS	Ni-alloy		
	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) subject to impact toughness requirements; e) base material used during qualification testing has CE > 0.43.								
Base material	For titanium alloys, a change in material grade [3]			x					
Base material	For duplex, a change in UNS number, except that UNS S31803 and UNS S32205 are interchangeable					x			
Base material	For P-No. 8, a change from any other material to P-No. 8, Gr. 4.		x		x				
Material thickness	For duplex, 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
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
Welding position	For mechanised and automated welding processes, a change in position exceeding QW-461.9	x	x	x	x	x	x	x	x
Welding position	For duplex 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.					x			
Preheat	A reduction from the temperature used during welding qualification	x	x	x	x	x	x	x	x
Interpass	A increase from the temperature used during welding qualification	x	x	x	x	x	x	x	x
Gas	Addition or removal of backing gas	x	x	x	x	x	x	x	x
Gas	A change in shielding or backing gas composition or purity level	x	x	x	x	x	x	x	x
Heat input	For duplex, the heat input shall not exceed the maximum value recorded during procedure qualification that is sampled by charpy impact testing.					x			

Essential Variable	Description	Girth Welds						Cladding	Buttering
		CS/ LAS	ASS[1]	Ti	6Mo	DSS	Ni-alloy		
Heat input	For duplex, the minimum heat input for a weld zone shall not be lower than 75 % of the lowest value recorded in that weld zone during procedure qualification.					x			
Heat input	When impact testing or corrosion testing is required, a change exceeding ±25 % of the average heat input for a weld area used during qualification welding	x	x	x	x	x	x	x	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
Weaving	When impact testing is required, any 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

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 Not applicable for Titanium grade 1, 2 and 3 provided grade 1 or 2 consumable is used in the qualification.

Add new sub section

11.5 PQR Hardness testing

11.5.1

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

11.5.2

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

11.5.3

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.

11.5.4

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

11.5.5

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

11.5.6

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

11.5.7

For sour service, hardness testing results shall not exceed the lower of the values specified by NACE standard and Table 11.

11.5.8

For non-sour service, the hardness values shall not exceed the values listed in Table 11.

11.5.9

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

Add new table

Table 11 - 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

Material type	Maximum hardness (HV10)
P-No 10H 25Cr duplex	350
P-No. 51, 52, 53 Titanium	200

Add new sub 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 MDT is below -155 °F (-104 °C).

11.6.3

The Charpy V-notch absorbed energy shall comply with the minimum values in Table 12 or as specified in the datasheet.

Add new table

Table 12 - 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 MDT, 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 datasheet)	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 clause 11.3.6.3		

NOTE 1 Applies to impact tested steels. Higher values may be required by the datasheet or design code. 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, they shall be as per ASME BPVC, Section VIII Div. 1, UG84 or the applicable parts of ISO 15614.

Add new sub 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 sub clause

11.9 Qualification of repair procedures

Add new clause

11.9.1

Repair welding shall be qualified by the original PQR or a separate repair PQR qualified for the specific repair scenario.

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).

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 with

Peening shall not be used.

12.3 Weld Overlay and Clad Restoration (Back Cladding)

12.3.1

Replace "ASME BPVC Section IX" with

Weld overlays shall be qualified in accordance with Section 11 and Annex B of this specification.

12.6 Hardness Testing - Weld Procedure Qualification and Production Testing

12.6.1

Replace with

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

12.6.2

Replace with

For sour service, production hardness testing shall comply with NACE MR0175/ISO 15156 or NACE MR0103.

12.6.3

Add new clause

For sour service, hardness testing results shall not exceed the lower of the values specified by NACE standard and Table 11.

12.6.4

Add new clause

For non-sour service, the hardness values shall not exceed the values listed in Table 11.

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

Delete clause

12.8.3

Replace all "should" in item b) with

shall

12.8.4

Delete clause

Add new clause

12.9 Permanent Attachments

All welds directly on to pressure parts shall be continuous.

Add new sub 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

All 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 round (or other shape) 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

Removal of tack welding shall be done by grinding.

Add new sub 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:

a) Method of defect removal;

b) method for verification of defect removal;

c) the shape and size of excavation prior to re-welding;

d) repair WPS;

e) PQR;

f) PWHT procedure (if applicable);

g) type and extent of NDE after repair;

h) 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

For all other materials not covered by 12.11.2, only two repair attempts shall be allowed in the same area.

12.11.5

Arc gouging is only permitted on carbon steels and low alloy steels.

12.11.6

For 22Cr duplex and 25Cr duplex, the remaining ligament shall be minimum 0.125 in. (3 mm).

12.11.7

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

12.11.8

Back purging in conformance to Section 7 shall be required for all 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 sub 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 datasheet.

12.12.2

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

Add new sub section

12.13 Ferrite Control for Austenitic Stainless Steels

12.13.1

Ferrite control shall be required for austenitic stainless steel weld metal as specified in section 6.4.2.

12.13.2

Ferrite number measurements of production welds shall as a minimum include all longitudinal and circumferential pressure retaining welds.

12.13.3

A minimum of three separate ferrite number measurements shall be performed per weld.

Add new sub section

12.14 Proximity of Welds

12.14.1

The distance between main seam welds (longitudinal and circumferential joints) and nozzles, reinforcement or other welded attachments shall be at least two times wall thickness or 2 in. (50 mm), whichever is greater, measured weld toe to weld toe.

12.14.2

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

12.14.3

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

Annex B
(normative)
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 to list

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

B.1.8

Replace with

For SAW, alloy additions shall not be made via the flux.

B.1.10

Delete second sentence

Add row to Table B.1

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

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

Delete second sentence from Table B.1 NOTE b)

Add new clause

B.1.13

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

Add new clause

B.1.14

When PWHT is required for austenitic stainless steel, weld procedure qualifications shall include corrosion testing according to ASTM A262 practice E.

Add new clause

B.1.15

Test coupons 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) from the surface.

B.2 Clad Restoration (Back Cladding)

B.2.2

Add after "ASME BPVC Section IX"

ISO 15614-7

B.3 Austenitic (300 Series) Stainless Steel Overlay

B.3.2

Delete second and third sentences

B.3.3

Second sentence delete "and this is approved by the purchaser"

Delete clause

B.4 Ferritic Stainless Steel Alloys

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

Delete clause

Add new clause

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 nickel based alloy.

Add new clause

B.6.2

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

Annex C
(informative)
Acceptance criteria for oxidation of stainless steel weldments

Add new annex

C.1 Examples of acceptable and unacceptable oxidation of stainless steel weldments

Figure 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)

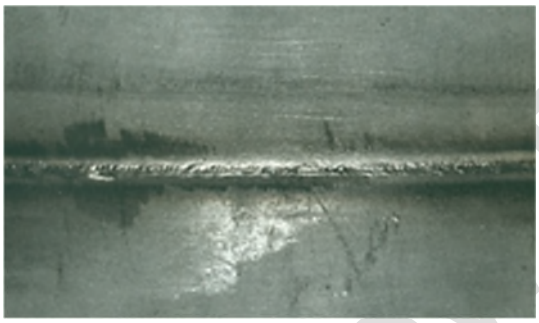

Figure C.1 - Acceptable - Very good result, no discoloration

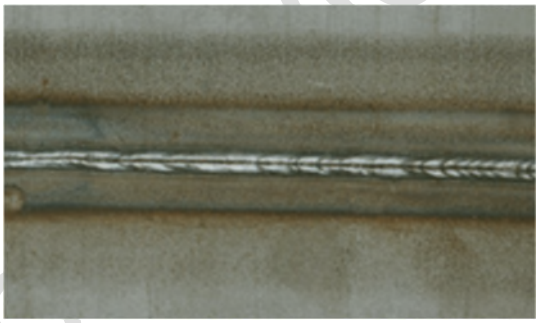

Figure C.2 - Acceptable - Slight discoloration, weld shiny, no scale present

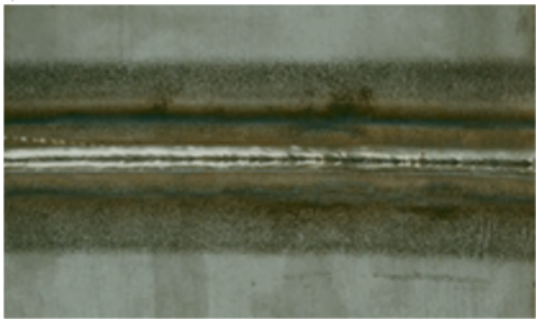

Figure C.3 - Acceptable - Slight discoloration, weld shiny, no scale present

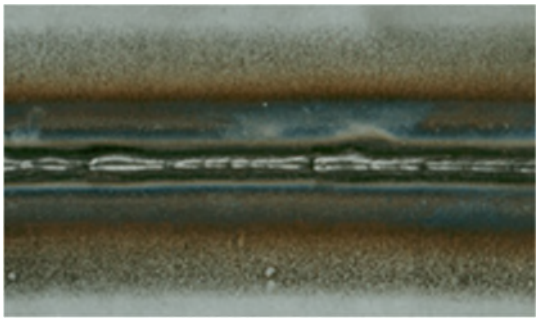

Figure C.4 - Unacceptable - Oxide layer present (grey colour) on and near weld; lack of proper back-purging

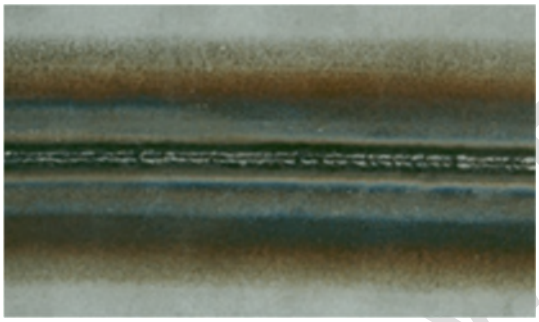

Figure C.5 - Unacceptable - Oxide layer present (grey colour), weld burned; lack of proper back-purging

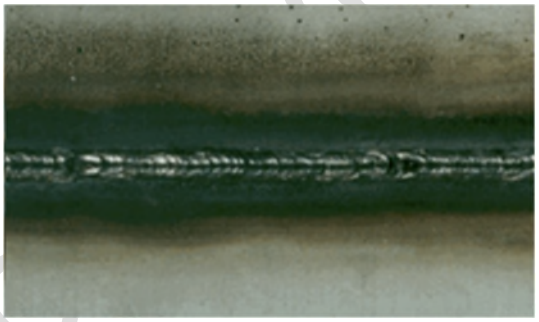

Figure C.6 - Unacceptable - Very heavy oxide layer present

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

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