

AS 3992:2020
(Incorporating Amendment No. 1)



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Pressure equipment — Welding and brazing qualification



AS 3992:2020

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- Australasian Institute of Engineer Surveyors
- Australian Aluminium Council
- Australian Industry Group
- Australian Institute for Non-Destructive Testing
- Australian Institute for the Certification of Inspection Personnel
- Australian Institute of Petroleum
- Bureau of Steel Manufacturers of Australia
- Compressed Air Association of Australasia
- Energy Networks Australia
- Engineers Australia
- Gas Energy Australia
- Insurance Council of Australia
- Materials Australia
- National Association of Testing Authorities Australia
- Office of Industrial Relations, Qld
- SafeWork NSW
- SafeWork SA
- Victorian WorkCover Authority (WorkSafe Victoria)
- Weld Australia
- WorkSafe Division — Department of Mines, Industry Regulation and Safety (DMIRS), WA

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Pressure equipment — Welding and brazing qualification

Originated as AS 3992—1992.
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Preface

This Standard was prepared by the Australian members of Joint Standards Australia/Standards New Zealand Committee ME-001, Pressure Equipment, to supersede AS/NZS 3992:2015, *Boilers and pressure vessels—Welding and brazing qualification*.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

A1 This Standard incorporates Amendment No. 1 (February 2023). The start and end of changes introduced by the Amendment are indicated in the text by tags including the Amendment number 1. **A1**

The objective of this Standard is to reduce misunderstanding, costs and delays in qualifying welding, avoid unnecessary duplication of testing, promote greater confidence in reciprocal acceptance of approved procedures, and improve safety. It also aims for greater alignment with ASME and ISO Standards, and to be consistent with the current work health and safety laws.

The inclusion of roles and responsibilities in AS 3992:2020, was approved by the Standards Development and Accreditation Committee on 2 May 2019, as a one-off exemption to the directives of Standardization Guide 009: Preparation of Standards for Legislative Adoption.

This Standard unifies and revises the requirements for the qualification of welding and brazing procedures, welding and brazing personnel, and production test plates and welds, specified in AS 1210, *Pressure vessels*, AS 1228, *Pressure equipment—Boilers*, and AS 4041, *Pressure piping*.

This Standard is a major revision of AS/NZS 3992:2015, with due allowance for latest practices or requirements of AS 1210, AS 1228 and AS 4041.

Requirements have been formulated with a view to maximize compatibility with recognized leading International Standards including ISO 9606 (all parts) and ISO 15614 (all parts).

The main changes in this revision are as follows:

- (a) The roles and responsibilities in this revision have been changed (reduced); however some level of roles and responsibilities have been retained. The inclusion of roles and responsibilities in this Standard was approved by the Standards Development and Accreditation Committee (SDAC).
- (b) Revision and addition of new requirements to [Sections 1, 5, 6, 7, 8](#) and [9](#) including revision of figures and tables within.
- (c) Clarification of testing requirements particularly those requiring impact testing.
- (d) Revision of [Appendices B](#) and [D](#), and new [Appendix G](#).
- (e) Addition of a new [Appendix I](#) to provide guidance on oxidation colours for stainless steels and titanium.
- (f) Correction of identified errors and ambiguities throughout the Standard.
- (g) Revision of procedure qualification requirements for special welds and welding of service exposed materials ([Section 8](#)).
- (h) Updating of referenced documents and alignment.

It is not intended that the publication of this edition will invalidate welding tests that were accepted in respect of other Standards referenced in AS/NZS 1200, *Pressure equipment*.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

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Australian Standard®

Pressure equipment — Welding and brazing qualification

Section 1 Scope and general

1.1 Scope and application

1.1.1 Scope

This Standard specifies requirements for the qualification of welding and brazing procedures, welders and brazers, and requirements for production weld testing other than non-destructive examination, when used in the manufacture, alteration and repair of boilers, pressure vessels, pressure piping and their components as specified in AS/NZS 1200, AS 1210, AS 1228 and AS 4041. See [Figure 1.1](#) for a summary of the welding and brazing qualification process.

This Standard is intended for use by designers, manufacturers, welders, brazers, inspection bodies, inspectors, testing authorities and all persons concerned with the welding and brazing of pressure equipment.

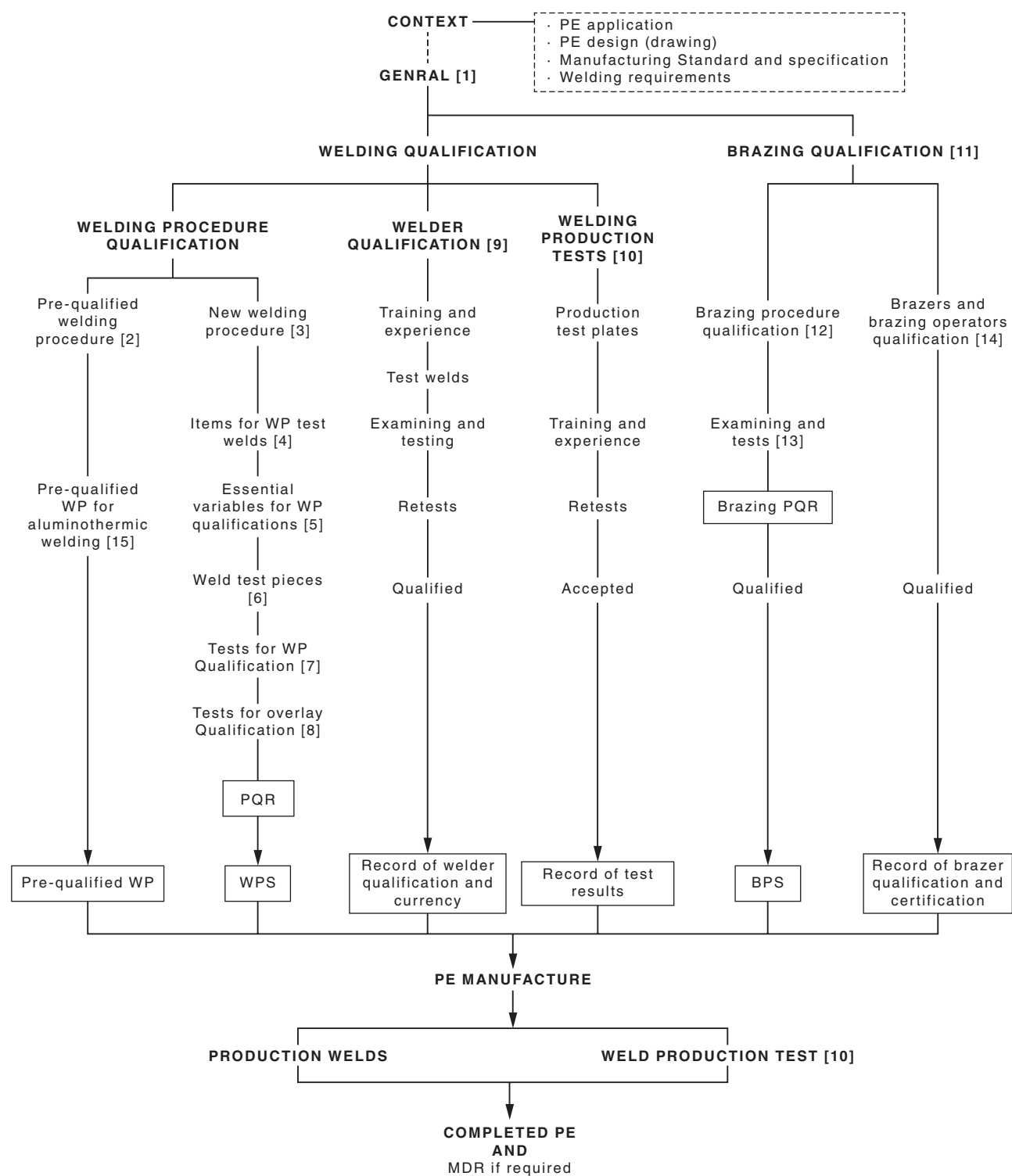
This Standard may apply to automotive LP Gas fuel vessels (covered by AS/NZS 3509), serially produced pressure vessels (covered by AS 2971) or welded gas cylinders (covered by AS 2030.1), where specified by these Standards. This Standard does not apply to pipelines in accordance with AS/NZS 2885.2, except where referenced.

The Standard provides specific details for the following:

- (a) Manual metal-arc welding, flux cored arc welding, gas metal-arc welding, gas tungsten-arc welding, submerged arc welding, plasma arc welding, electroslag welding and oxy-acetylene welding.
- (b) Torch brazing, furnace brazing, induction brazing, resistance brazing and dip brazing.
- (c) The welding and brazing of carbon, carbon-manganese, and low and high alloy steels; and copper, aluminium, nickel, titanium, zirconium and alloys of these materials.
- (d) Welding procedure qualification.
- (e) Welder qualification.

Specific details for stud welding, electron-beam welding, explosion welding, laser beam welding, electro-gas welding, fusion welding of plastics and friction welding processes are not covered by this Standard. For these, see ASME BPVC-IX or equivalent.

The principles established in this Standard may be used in the qualification of processes, materials and applications not covered by the scope outlined above (see also [Clause 1.5](#) and [Clause 1.6](#)).



LEGEND

[X] Numbers in brackets identify relevant section in this Standard

Figure 1.1 — Summary of welding and brazing qualification process

1.1.2 Application

Where there are differences between this Standard and AS 1210, AS 1228 or AS 4041, the requirements of this Standard apply.

Where this Standard makes reference to other Standards, these referenced Standards are not intended to be limiting or exclusive and other equivalent national standards acceptable to the parties concerned may be substituted for the referenced Standards. AS/NZS 1200 provides a list of pressure equipment Standards used in Australia and New Zealand.

Conformance to ASME BPVC-IX, ISO 15607, or ISO 15614-1 is deemed to be an acceptable alternative to the requirements of this Standard where agreed between manufacturer and purchaser. Where this Standard (AS 3992) requires tests not already completed under these ASME and ISO Standards, then this can be covered by those additional tests only, rather than repeating the full set of tests; for example, as part of a production test plate.

Users of this Standard are reminded that it has no legal authority in its own right, but may acquire legal standing in one or more of the following circumstances:

- (a) Adoption by a government or other authority having jurisdiction.
- (b) Adoption by a purchaser or owner as the required standard of manufacture when placing a contract.
- (c) Adoption where a manufacturer states that pressure equipment is in accordance with an application Standard which mandates conformance to this Standard.

1.2 Referenced documents

The documents referred to in this Standard are listed in [Appendix A](#).

Where reference is made to a Standard by its number only, the reference applies to the current edition of the Standard. Where reference is made to a Standard by number, year and, where relevant, an amendment number, the reference applies to that specific document.

1.3 Terms and definitions

For the purpose of this Standard, the definitions in AS 2812 and those below apply.

Weld positions are defined within AS/NZS 3545.

1.3.1

backing gas

backing using gas primarily for the purpose of preventing atmospheric reaction on the reverse side of a joint preparation

1.3.2

brazer

person who performs a manual brazing operation

1.3.3

brazing operator

person who operates furnaces or other automatically controlled or timed brazing equipment

1.3.4

build-up

overlay welding to restore required dimensions

1.3.5

buttering

surfacing variation in which one or more layers of weld metal are deposited on the weld face of one member (e.g. a high alloy weld deposit on steel base metal that is to be welded to a dissimilar base metal). The buttering provides a suitable transition weld deposit for subsequent completion of the butt joint

1.3.6**cladding**

material deposited on the parent material in order to produce a clad material

1.3.7**cladding process**

surfacing (see [Clause 1.3.28](#)) used for cladding (see [Clause 1.3.6](#))

1.3.8**competent person**

a person who has acquired, through education, training, qualification or experience, or a combination of these, the knowledge and skill enabling that person to perform the required task correctly and safely

1.3.9**essential variables (for a welder qualification)**

those variables in the welding procedure in which a change outside the limits specified in this Standard is considered to reduce the ability of a welder to make a weld with the required mechanical properties and soundness, (e.g. change in welding process or technique, or the omission of a backing strip, bar or ring)

1.3.10**essential variables (for a welding or brazing procedure)**

those variables in the welding or brazing procedure in which a change outside the limits specified in this Standard is considered to affect the mechanical properties of the weld, (e.g. change in welding process, consumables, or heat treatment)

1.3.11**in-service welding**

welding onto pipe or vessel containing a process fluid or residue that may be pressurized and/or flowing

Note 1 to entry: In-service welding is also referred to as 'hot-tapping'.

1.3.12**inspection body**

a body corporate or firm that performs inspection, which may be any one or more of design verification, manufacture inspection and in-service inspection

Note 1 to entry: The manufacturer may be the inspection body when permitted by AS 3920.

Note 2 to entry: See also AS/NZS ISO/IEC 17020 and the Standards Australia/Standards New Zealand Miscellaneous Publication, SAA/SNZ MP76, for more information on inspection bodies.

1.3.13**inspector**

a competent person employed by, or acceptable to, the inspection body for the purpose of inspecting pressure equipment in accordance with this Standard

1.3.14**manufacturer**

the person or organization responsible for the manufacture, welding and testing of pressure equipment in accordance with this Standard. A manufacturer may also be the designer

Note 1 to entry: In this Standard, 'manufacturer' includes 'fabricator', 'constructor', 'assembler', 'installer', 'erector' and 'repairer'. The term 'manufacturer' is used to embrace all or some of these terms and is applicable to all locations, on or off site, where pressure equipment is welded or brazed. It also includes a manufacturer's authorized representative.

1.3.15**metallurgical properties**

metallurgical properties are the material properties, such as tensile strength, yield strength, impact toughness and metallurgical structure

1.3.16**overlay**

surfacing by means of welding

1.3.17**owner**

a body corporate, company or person who has the right of title to, or management of, or control over the pressure equipment and includes a person exercising such management or control as an agent of the owner

Note 1 to entry: In Australia, the owner is also a 'Person Conducting a Business or Undertaking' (PCBU).

1.3.18**preliminary welding procedure specification (pWPS)**

Document containing the required variables of the welding procedure which is intended to be qualified

1.3.19**prequalified welding procedure**

a documented welding procedure satisfying the requirements of [Section 2](#). It has the same standing as a qualified welding procedure when used within the limits specified in [Section 2](#)

1.3.20**pressure equipment**

boilers, pressure vessels, pressure piping and their components covered by AS/NZS 1200

1.3.21**procedure qualification record (PQR)**

a document recording test variables and test results to establish a welding procedure

1.3.22**purging gas**

gas used for the purpose of replacing the atmosphere in a hollow section and subsequently for gas backing

1.3.23**qualified welding procedure**

a welding procedure which has been conducted, tested, assessed, documented and verified as conforming to the requirements of this Standard

Note 1 to entry: This definition is intended to include the use of prequalified welding procedures as detailed in [Section 2](#).

1.3.24**service-exposed welding**

welding on material degraded by service

1.3.25**shall**

indicates a requirement

1.3.26**should**

indicates a recommendation

1.3.27**sound or soundness**

a weld or braze that is free from unacceptable imperfections (defects)

1.3.28**surfacing**

deposition of filler metal over an area of a metal surface for building up, wear or corrosion resistance

1.3.29**temper-bead welding**

the welding of a bead at a specific location on a weld for the purpose of improving the metallurgical properties of the heat-affected zone of the previously deposited weld metal

1.3.30**test piece**

components welded together in accordance with a specified welding procedure, or a portion of a welded joint detached from a structure, for test (see [Clause 1.3.28](#))

1.3.31**test specimen**

a portion detached from a test piece and prepared, as required, for testing

1.3.32**welder qualification test**

a documented test, carried out by a welder, working to an approved welding procedure, to determine the welder's ability to deposit sound weld metal using the manufacturer's available equipment

1.3.33**welding procedure specification (WPS)**

a documented qualified welding procedure prepared to provide direction for making production welds to the requirements of this Standard (see also [Clause 1.3.23](#))

1.3.34**welding procedure test**

the making and testing of a welded joint representative of that to be used in production in order to prove the weldment is capable of providing the required properties for its intended application

1.3.35**weld production test**

the making and testing of a representative sample of production welds to check the quality of welds during the manufacture of pressure equipment

1.4 Other processes

This Standard does not prohibit the use of processes not specifically listed in [Clause 1.1](#). Where another process is to be used, it shall give a result at least equal to that set by this Standard.

1.5 Other materials

Materials not specified in [Clause 1.1\(c\)](#) may be welded in accordance with this Standard provided the welding method gives a result at least equal to this Standard.

1.6 Welding and brazing—supervision

Welding for assessment of welding or brazing procedure and welder and brazer qualification shall be supervised by a competent person.

Personnel with a minimum of three year's experience in the welding and fabrication of pressure equipment and holding a AS 1796 Certificate 10, or equivalent or higher conforming to the requirements of AS/NZS ISO 14731, are deemed to conform.

NOTE See [Clause 1.3.8](#) for definition of competent person.

Section 2 Prequalified welding procedures

2.1 General

Welding procedure qualification testing is not required for welding procedures classified as 'prequalified' in accordance with this [Clause 2.1](#).

Welding procedures which conform to [Table 2.1](#) shall be deemed to be prequalified and do not require further qualification in accordance with [Sections 3](#) to [7](#), provided that—

- (a) each procedure is documented in accordance with the applicable requirements of [Appendix B](#);
- (b) each procedure has a signed endorsement by the manufacturer (see [Appendix B](#));
- (c) each procedure is only applicable within the limits of the essential variables listed in [Table 5.1](#) but not [Table 5.4](#) which does not apply to prequalified procedures; and
- (d) each procedure has been used by a welder (named) employed by the manufacturer and who has met the requirements of a welder qualification test (date given) in accordance with [Clause 9.2](#).

The use of prequalified welding procedures does not relieve the manufacturer of any responsibilities, in respect of the provisions of this Standard, for welder qualification and weld production testing.

NOTE 'Prequalified welding procedures' are known as 'Standard welding procedure specifications' in ASME BPVC.

The following also apply:

- (i) Carbon equivalent = $C + \frac{\text{Mn}}{6} + \frac{\text{Cr} + \text{Mo} + \text{V}}{5} + \frac{\text{Cu} + \text{Ni}}{15}$ percent.

Where heat analysis of all of these elements is not quoted, the value of $C + \frac{\text{Mn}}{6} = 0.42$ percent maximum applies.

These equations do not apply where $B \geq 0.0008\%$.

- (ii) Runout ratio = $\frac{\text{length of weld run}}{\text{length of electrode consumed}}$.

Table 2.1 — Conditions for prequalified welding procedures

Item	Range of application
Pipe diameter	All diameters
Plate or pipe thickness (nominal)	3 mm to 40 mm thickness (see also Weld preparation below)
Parent metal group	A1 and A2 as welded or with PWHT, K1 as welded
Carbon equivalent [see Clause 2.1(i)]	0.45% maximum based on actual or specified values
Welding processes	Manual metal-arc, submerged arc, gas tungsten-arc welding, flux cored arc welding, gas metal arc (spray transfer) or combination of these processes
Design minimum temperature	Equal to and above 0°C
Welding consumables	Table 2.2 and Clause 2.2
Weld preparation	Table 2.3
Welding position	A1 Figures 5.1, 5.2 and Clause 1.3 A1
Welding current, voltage and polarity	In accordance with consumable supplier's requirements and recommendations
Preheat temperature	Above 0°C and in accordance with the pressure equipment Standard (see Note)
Travel speed	Runout length for manual electrodes ≤ 1 [see Clause 2.1(ii)]. Submerged arc welding between 200 mm/min and 600 mm/min
Initial and interrun cleaning	Free from any materials which may impair the weld quality
Storage and handling of welding consumables	In accordance with the pressure equipment Standard and the consumable supplier's requirements and recommendations
Post weld heat treatment	In accordance with AS 4458

NOTE: Preheat should also conform to AS 4458, EN 1011-2 or Weld Australia TN 01.

Table 2.2 — Prequalified welding consumables (see Notes 1 and 2)

1	2	3	4	5	6	7
Material Group (see Table 5.2)	Manual metal-arc (AS/NZS 4855)		Submerged arc (AS/NZS ISO 14171, AS/NZS ISO 14174)	Flux-cored arc (AS/NZS ISO 17632)	Gas metal arc (AS/NZS 14341, AS/NZS 21952, AS/NZS 16834) (ISO 14341)	Gas tungsten arc (AS/NZS 1167.2) (ISO 636)
A1	A-E35 3 A-E38 3 A-E42 3					
A2 (see Note 3)	A-E35 3 A-E38 3 A-E42 3	B-E43X6 U B-E43X8 U B-E49X5 U B-E49X6 U B-E49X8 U	A-S35 3 A-S38 3 A-S42 3 B-S43 3U B-S49 3U	A-T35 3 A-T38 3 A-T42 3 B-T43 3U B-T49 3U	A-G35 3 A-G38 3 A-G42 3 B-G43 3U B-G49 3U	A-W35 3 A-W38 3 A-W42 3 B-W43 3U B-W49 3U
K1	See Note 4					

NOTE 1: Consumables for material Group A2 are suitable for Group A1 materials.

NOTE 2: Consumables with a higher impact grading than that shown or equivalent in accordance with ASME BPVC-IIC are acceptable.

NOTE 3: For material Group A2, consumables of the A-E35, B-E43XX, A-S35, B-S43, A-T35, B-T43, A-G35 or B-G43, A-W35 or B-W43 type will equal or exceed the specified minimum yield strength of the material and will usually give a tensile strength of not less than 95% of the specified minimum tensile strength of the parent material.

NOTE 4: Equivalent or alternative consumables complying with ASME BPVC-IIC and listed in [Table 5.5](#).

2.2 Prequalified gases

For GTAW, argon gas of 'welding quality' only shall be used for a prequalified welding procedure. The maximum impurity content shall not exceed 1 part in 2000 by volume (i.e. the gas shall be at least 99.95% pure).

For FCAW A_1 and GMAW A_1 , shielding gases shall be in accordance with the specifications and qualification of the consumable manufacturer.

Table 2.3 — Acceptable weld preparations for prequalified weld procedures (see Notes 1 to 5)

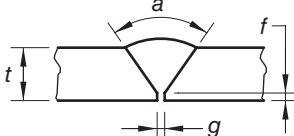
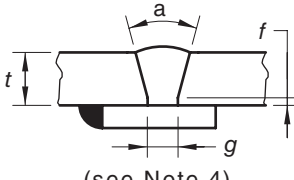
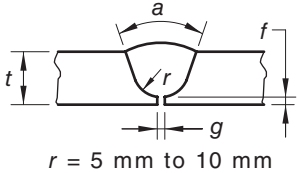
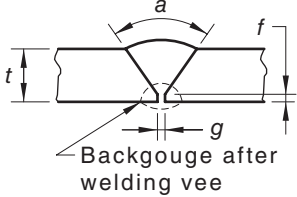
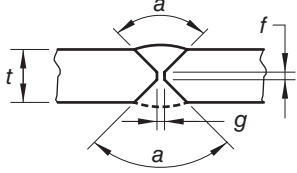
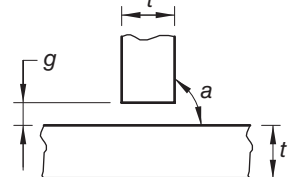
Item	Joint type	Joint form (sectional view)	Dimensions of joint			
			Thickness (t), (max.) mm	Gap (g) mm	Bevel angle (a) degrees	Root face (f) mm
1	Single-welded single-V butt joint—complete penetration		20	1.5–3	60–90	0–3
2	Single-welded single-V butt joint with backing strip—complete penetration		20	5–10	15–45	0–3

Table 2.3 (continued)

Item	Joint type	Joint form (sectional view)	Dimensions of joint			
			Thickness (<i>t</i>), (max.) mm	Gap (<i>g</i>) mm	Bevel angle (<i>a</i>) degrees	Root face (<i>f</i>) mm
3	Single-welded single-U butt joint—complete penetration	 <i>r</i> = 5 mm to 10 mm	20	0–3	20–40	0–3
4	Double-welded single-V joint back gouged—complete penetration	 Backgouge after welding vee	20	0–3	60–90	0–3
5	Double-welded double-V joint— complete penetration		40	0–3	60–90	0–3
6	Single or double welded fillet joint		40	0–2	80–120 on each side	—

NOTE 1: All weld preparations are applicable to one of the welding processes (or combinations) permitted in [Table 2.1](#).

NOTE 2: Branch welds are qualified by butt welds using maximum parent metal thickness nominated for *t* above.

NOTE 3: The use of minimum angle should be associated with maximum radius or gap and conversely the minimum radius or gap should be associated with the maximum angle.

NOTE 4: Indicate in welding procedure specification whether backing strip has intermittent or continuous welds.

NOTE 5: See AS 1210, AS 1228 and AS 4041 for other acceptable weld preparations.

Section 3 Qualification of welding procedures for butt, branch and fillet welds

3.1 General

With the exception of prequalified welding procedures (see [Section 2](#)), each welding procedure that is used in the manufacture of pressure equipment shall be qualified in accordance with this Standard. Qualification is intended to demonstrate—

- (a) the suitability of the welding procedure for the material used in the construction;
- (b) that the weld can be made without unacceptable imperfections (defects) in the weld deposit and heat affected zone;
- (c) that the mechanical properties, such as strength, and if applicable fracture toughness and hardness, satisfy specified requirements; and
- (d) the manufacturer's organization and equipment is capable of successfully using this procedure.

Requirements to satisfy other parameters such as microstructure, corrosion resistance, fatigue or erosion for specific service requirements may be specified by the purchaser. Such requirements are outside of the scope of this Standard.

Only qualified welding procedures shall be used in the manufacture of pressure equipment.

NOTE 1 The welding procedure qualification test may also be used to qualify a welder (see [Section 9](#)).

NOTE 2 AS 3920 provides guidance for inspection bodies in relation to welding procedures.

3.2 Methods of qualification of welding procedure

A preliminary weld procedure (pWPS) should be drafted prior to qualification of the welding procedure. Qualification of a welding procedure shall be carried out by one of the following methods:

- (a) The making and testing of a procedure test weld in accordance with the requirements of [Sections 6](#) and [7](#).
- (b) Simultaneously with the welding and testing of a production test plate or pipe provided that testing is carried out in accordance with [Section 7](#).
- (c) Using a prequalified welding procedure in accordance with [Section 2](#).

Where option (b) above is used, production welds carried out in conjunction with the proving of a welding procedure which fails to meet the requirements of this Standard shall be rejected.

3.3 Recording of welding procedure data

Each procedure shall be recorded in detail, with the results of qualification tests. These records shall be accessible to the inspector (and purchaser where required). [Appendix C](#) specifies the required information for a welding procedure qualification record (PQR).

3.4 Testing of welding procedure test welds

The type, number, and methods of tests required to prove the suitability of the welding procedure for the welding of joints in the components shall be in accordance with this Standard. Where necessary, additional tests may be required to assess corrosion resistance or other properties of a weld joint.

3.5 Requalification of a welding procedure

Provided that there are no changes in the essential variables (as listed in [Section 5](#)), a qualified welding procedure shall remain in force indefinitely. Requalification of a welding procedure is only required where there is any change in the essential variables as specified in [Section 5](#).

Where additional tests have to be carried out to make the approval technically equivalent, it is only necessary to do the additional tests on a test piece which should be made in accordance with this Standard. Welding procedures for manufacturing and fabrication shall be in accordance with the current version of this Standard, or as nominated by contract.

This Standard does not invalidate previous welding procedure approvals made to former national standards or specifications provided that the intent of the technical requirements are satisfied, refer to [Clause 3.9](#) and [Clause 8.4](#).

3.6 Portability of qualified welding procedures

A welding procedure qualified by one manufacturer shall be valid for use by a second manufacturer, provided that—

- (a) the original qualification tests were carried out in accordance with this Standard, and were fully documented;
- (b) the second manufacturer has adequate equipment and facilities and demonstrates successful welding of welder qualification tests or production tests using the procedure;
- (c) the application of the welding procedure is acceptable to both manufacturers and the purchaser; and
- (d) the welding procedure specification identifies the original and second manufacturer.

NOTE ISO 15612 gives information on weld procedures qualified by other manufacturers.

3.7 Welding procedure specification for new pressure equipment

For production welding, a welding procedure specification shall be prepared listing all necessary information for production welds to be made to the requirements of this Standard. This specification shall include essential variables together with any acceptable ranges for such variables, and any other variables which may affect the properties and soundness of the welded joint.

An example of the requirements for a welding procedure specification is given in [Appendix B](#). Other methods of presentation of a welding procedure specification are acceptable provided that they contain all relevant information to satisfy the requirements of this Clause for production welds.

3.8 Welding procedures for repair welding of new pressure equipment

For new equipment, visual or non-destructive examination which reveals unacceptable imperfections in the equipment that has not been subject to service environment shall be repaired. Such repair welding shall be carried out to the original welding procedure or, where this is not practicable, to a repair procedure approved to this Standard.

[A1] NOTE Weld procedures should be suitably amended where difficulties or improvements are identified during manufacture, testing of pressure equipment and test plates, or feedback from service. **[A1]**

3.9 Repairs, replacement or alteration to in-service pressure equipment

Where repairs, replacement, modifications or alterations are made by welding to pressure equipment that is or has been in service, the welding shall conform to requirements of [Clause 8.4](#), AS/NZS 3788 and AS 3873 (when applicable) and the following:

- (a) For material, which has not been damaged [see Item (b)] or deteriorated in service, the welding procedure shall be qualified in accordance with this Standard.
- (b) For material that has been damaged or deteriorated in service (e.g. by creep, hydrogen embrittlement, temper embrittlement, fatigue, erosion, or other forms of deterioration as referenced in AS/NZS 3788, API 570 or API 571, etc.), a repair welding procedure (see [Clause 8.4](#)) shall only be effected after the cause of the deterioration has been ascertained and taken into account to ensure a satisfactory repair procedure. Such a welding procedure shall be capable of producing welds acceptable to the owner.
- (c) For in-service weld repair procedures, a similar approach to Item (b) shall be undertaken. In addition, all precautions shall be taken during the in-service weld repair procedures to ensure the safety of the welding personnel and the repair procedures have been adequately reviewed.

NOTE 1 For Item (c) above, AS/NZS 2885.2, AS 4041, AS 5601 and API RP2201 provide processes that may be suitable.

NOTE 2 When weld metal is to be deposited over a previously welded surface, all slag and contamination should be removed, the surface suitably shaped for a restart, and the specified minimum preheat applied, refer to AS 4458 and AS ISO 13916.

Section 4 Items to be recorded for welding procedure test welds

4.1 General

The following items shall be recorded for each welding procedure test:

- (a) Welding process or processes when more than one is used, in making a complete joint.

NOTE Parent metal specification and group number, thickness, and for pipe, the outside diameter or outside dimensions.
- (b) Weld joint detail, including sketch and weld deposit thickness for welding processes used.

NOTE See [Table 5.1](#), [Clause 5.1](#) and [Appendix C](#) for more information.
- (c) Initial and interrun method for cleaning, degreasing, etc.
- (d) Welding position and direction of weld travel.
- (e) Classification of welding consumables (filler metal material specification and size, flux and gas).
- (f) Preheating and interrun temperature ranges, including method and control.
- (g) Approximate number and arrangement of runs and welding sequence, including sketch and string or weave technique, as applicable.
- (h) Back gouging or reverse side treatment, when applicable.
- (i) Postweld heat treatment, temperature and holding time.
- (j) Special features applicable to a specific welding procedure not covered in [Table 4.1](#).

NOTE See [Section 18](#).
- (k) Name of manufacturer responsible for carrying out the procedure test.
- (l) Name of welder performing the test weld.

4.2 Items specific to nominated welding processes

The items listed in [Table 4.1](#), in relation to a specific welding process, shall be recorded for each welding procedure test in addition to those items in [Clause 4.1](#).

4.3 Recording of welding procedure test welds

A record of the welding procedure and test results shall be retained.

[Appendix C](#) lists the required details of the procedure qualification record (PQR) for the recording of welding procedure test welds.

Table 4.1 — Items specific to nominated welding processes

Item to be recorded	Welding process (see Note)							
	MMAW	GTAW	GMAW	SAW	ESW	GW	FCAW	PAW
Amperage	X	X	X	X	X		X	X
Arc voltage	X	X	X	X	X		X	X
Wire feed speed			X	X	X		X	X
Travel speed or runout length of electrode	X	X	X	X	X		X	X
Current type and polarity	X	X	X	X	X		X	X
Welding flux				X	X			
Shielding gas and flow rate		X	X				X	X
Arc energy (when applicable)	X	X	X	X	X		X	X
Electrode stick out			X	X			X	X
Purging gas and flow rate		X	X				X	
Tungsten electrode (diameter and type)		X						
Nozzle diameter		X						X
Gas type and pressure						X		
Flame characteristic						X		
Number of electrodes and configuration				X	X			
Oscillation width and dwell periods					X			X
Slag depth					X			
Special baking temperature of electrodes	X							
Special baking temperature of flux				X	X			

LEGEND:

MMAW = manual metal-arc welding

GTAW = gas tungsten-arc welding

GMAW = gas metal-arc welding

SAW = submerged arc welding

ESW = electroslag welding

GW = oxy-acetylene (gas) welding

FCAW = flux cored arc welding

PAW = plasma transferred arc welding

X = item to be recorded when applicable

NOTE: For multi-wire arc processes, record details for each wire.

For runout length, see Clause 2.1(ii).

Section 5 Essential variables for welding procedure qualification

5.1 General

Essential variables in qualifying a welding procedure shall be as specified in this Section and [Table 5.1](#).

When changes are made to a qualified welding procedure, the welding procedure shall be requalified when any of the changes to the essential variables, as listed in [Table 5.1](#), are applicable. Changes to other items of [Table 4.1](#) that are not classified as essential variables by [Table 5.1](#) may be made to a qualified welding procedure without requalification.

The following also apply:

- (a) For multi-process procedures, each welding process may be approved separately or in combination with other processes. Similarly, one or more processes may be added or deleted from an approved welding procedure provided the joint thickness is within the thickness range of the remaining process or processes.
- (b) Single or double V, J, U or bevel or a square butt may be changed without requalification provided the form of the weld preparation is in agreement with recommended joint detail as listed in the pressure equipment Standards. See [Clause 6.1](#) for changes between butt, branch and fillet welds.
- (c) For GMAW, this includes a change from spray arc, globular arc or waveform-controlled arc to short-circuiting arc or vice versa.

A change from flat to tubular form of product or vice versa is not an essential variable.

For essential variables for special welding processes, see [Section 8](#).

5.2 Material grouping

5.2.1 General

The material grouping system, referred to in [Table 5.2](#) and throughout this Standard, is applied throughout the Australian pressure equipment Standards. [Table 5.2](#) provides an outline of the classification of material groups.

[Table 5.2](#) gives a basis for the grouping of materials for the purpose of specifying requirements for manufacture, postweld heat treatment, welding procedure and welder qualification, fabrication and non-destructive examination. It is presented to assist in grouping steels, including those not covered by Australian Standards but it is not to be considered the only basis of material specifications, as other factors, not listed may need to be taken into account, particularly with borderline compositions.

For Group K and M materials, requalification of a welding procedure is required when specific corrosion resistance tests are required or where parent metal impact tests are required by the pressure equipment Standard for cryogenic service. In such instances the procedure is only applicable to the stainless steel grade of material used in the procedure test. [Appendix D](#) provides comparisons between AS 3992 group materials and SA/SNZ TR ISO 15608 material numbers.

NOTE Some examples of the application of essential variables to welding procedures for pressure equipment construction are given in [Appendix H](#).

5.2.2 Extension of qualification

To minimize the number of procedure qualification tests, grouping of parent materials as per [Tables 5.3\(A\)](#), [5.3\(B\)](#) and [5.3\(C\)](#) may be used to extend the range of qualification.

Permanent backing bars or rings shall be considered as a parent material within the approval subgroup.

For [Table 5.3\(A\)](#), qualification of a welding procedure using A1 to A1 (or A1 to A2) as the steel group originally qualified is only permitted for A2 materials if—

- (a) the test values of transverse tensile test, all weld metal tensile test, and notch bar impact tests, when required, exceed the minimum properties required for A2 group materials; and
- (b) weld preheat temperatures are applied in accordance with the requirement of AS 4458, EN 1011-2 or Weld Australia TN 01, (where a production test plate is required, other pre-heat temperatures are permitted).

5.3 Welding energy input

Welding energy input is determined from the following equation:

$$Q = \frac{60EI}{v \times 10^3}$$

where

- Q = welding energy input, in kJ/mm
- E = arc voltage, in volts (RMS value for a.c.)
- I = welding current, in amperes (RMS value for a.c.) per electrode
- v = welding speed, in mm/min

This equation only applies to MMAW, SAW, GMAW, GTAW, FCAW and for nonwaveform-controlled welding.

For waveform-controlled welding, an increase in energy input may be determined by—

- (a) an increase in bead size (width × thickness); or
- (b) total energy as reported on the power source for the weld run; or
- (c) direct measurement, see ISO/TR 18491.

Additional consideration for preheat and energy input is required for any C-Mn steel with $B \geq 0.0008\%$ (see Weld Australia TN 01, SA TS 103 and EN 1011-2).

5.4 Preheat and post weld heat treatment

Unless otherwise specified, the preheat and post weld heat treatment shall conform to the requirements of AS 4458. In addition, the following applies:

- (a) Where the parent metal thickness of the production weld differs from that used in the test weld adjustment shall be made to achieve a satisfactory cooling rate by conforming to the preheats listed in the pressure equipment Standard, Weld Australia TN 01 or EN 1011-2.
- (b) Group B1 reflects Group B materials in the previous edition of this Standard and other Australian Standards.
- (c) Material Groups B2, B3, B4, D3 and D4, are yet to be incorporated into other Australian Standards including AS 4458. These materials shall be considered on a case by case basis until incorporation; this includes, but not limited to, requirements in regard to preheat, PWHT and NDE. Specialist advice should be sought from the original equipment manufacturer, material manufacturer or competent persons.

NOTE Group B5 materials in this Standard were previously classed as 'D1 materials' within AS/NZS 3992:2015.

- (d) When welding Group A1, A2 or B1 material to Group D2 or D3, the postweld heat treatment temperature shall not exceed 700°C.

Table 5.1 — Essential variables for welding procedure qualification

Item	Essential variable
1 Parent material specification (see Clause 5.2)	A change from a material group to any other material group or for a combination of material groups, as listed in Table 5.2 , except as permitted in Tables 5.3(A) , 5.3(B) and 5.3(C)
2 Parent material and weld deposit thickness and form (for mixed processes see Item 6 below)	Parent material and weld deposit thicknesses outside the limits given in Table 5.4 , where 't' is dependent on joint details as given in Table 5.6 ~~A1~~ Where impact tests are required, the minimum thickness qualified is— (a) 0.5t when the test plate thickness (t) < 16 mm; and (b) 15 mm when the test plate thickness (t) ≥ 16 mm. ~~A1~~
3 Weld joint detail (see Clause 5.1)	Omission of backing strip or consumable backing ring in a butt joint. For fillet welds, see Clause 6.1.2
4 Welding position and weld direction (see Note 1)	The following are essential variables: (a) When impact tests are not required, change to or from vertical down. (b) When impact tests are required, any change in fundamental welding position (flat, horizontal, vertical and overhead), or change in weld direction (see Figures 5.1 and 5.2). Testing in the maximum heat input position, i.e. vertical up in plate or 5G or 6G positions in pipe shall qualify for all positions.
5 Welding consumables	The following are essential variables: (a) For all welding processes, a change in the numerical grouping (F number) of an electrode or filler rod as shown in Table 5.5 . (b) For ferrous metals only, an increase or decrease in the weld metal specified minimum strength outside the parent metal specified tensile strength range. ~~A1~~ By agreement, a change from the use of standard consumable to low carbon ('L' symbol) consumable or vice versa does not require requalification. ~~A1~~ (c) ~~A1~~ For ferrous metals only, a variation of the alloy content of the weld metal outside of the specified range of the classification of the welding consumables used in the procedure test, except that for— ~~A1~~ (i) carbon and carbon manganese steels the addition or deletion of 0.5% molybdenum from the weld metal composition shall not require requalification; and (ii) 3xx series austenitic Cr-Ni steels (K ₁ group) a change in weld metal composition shall not require requalification. (d) For flux cored arc welding, any change in flux formulations (e.g. rutile, basic or metal core) other than that which varies iron powder content only (see Note 2). (e) For submerged arc welding— (i) a change in flux classification as listed in AS/NZS ISO 14171, AS/NZS ISO 14174 or other International Standard; or (ii) a change from a flux recommended for one to three weld runs to a multi-pass flux or vice versa. (f) A change in the nominal composition of a shielding or backing gas outside the range specified in AS 4882 or ISO 14175. (g) A decrease in gas flow rate of the shielding gas by more than 10%. (h) Deletion of a backing gas. (i) For GTAW a change from solid wire to flux cored wire or vice versa.

Table 5.1 (continued)

Item	Essential variable
	(j) For all consumables—outside the limits of the applicable weld consumable Standard and manufacturer's requirements.
6 Welding process (see Clause 5.1) For mixed processes, see Clause 5.1(a) , Appendix C , Paragraph C2(h) and (m) and Figure C1	A change in welding processes or combination of welding processes
7 Welding energy input (see Clause 5.3)	The following are essential variables for each weld run: (a) For Groups F and G steels, an increase or decrease in arc energy greater than 15%. (b) For low temperature operation requiring impact testing of weld metal, an increase in arc energy greater than 15%. (c) For materials operating in their creep range and Group M materials, arc energy outside the range 1 to 3 kJ/mm, or for GTAW welding, the range is 0.7 to 3.0 kJ/mm. Refer to API 579-1/ASME FFS-1 for creep ranges. (d) For conditions other than Items (a), (b) or (c), an increase in arc energy greater than 30% or decrease in arc energy greater than 25% (see Note 4).
8 Welding current and polarity (see Clause 5.1)	For all processes, any change in the type of welding current and polarity
9 Preheat and interrump temperature	The following are essential variables: (a) An increase in the maximum of more than 50°C— (i) for Groups F and G steels; or (ii) when impact tests are required on the weld or heat affected zone. (b) An increase of more than 100°C in preheat or interrump temperature for all other ferrous materials. (c) A decrease of more than 50°C in preheat or interrump temperature recorded on the PQR for all ferrous materials provided that the temperature is not less than that defined in Clause 5.4(a) and that specified in the welding procedure specification (see also Clauses 5.3 and 5.4).
10 Delayed cooling	Any change in the control of cooling rate after welding when specified in the qualified welding procedure (see also Clause 5.4).
11 Postweld heat treatment	A change in postweld heat treatment which requires the deletion of postweld heat treatment; or the addition of postweld heat treatment within a temperature range (see also Clause 5.4).

NOTE 1: For the limits of deviation from fundamental welding positions, see AS/NZS 3545.

NOTE 2: 'All-positional' coating or flux core formulations do not require requalification for single position welds provided there is no designated increase in the deposited weld metal hydrogen content.

NOTE 3: For multi-process procedures, each welding process may be approved separately or in combination with other processes. Similarly, one or more processes may be deleted from an approved welding procedure provided the joint thickness is within the thickness range of the remaining process or processes. See also Item 8, [Table 9.1](#).

NOTE 4: Consideration should be given to the appropriate service application, e.g. sour service.

Table 5.2 — Parent material grouping

AS material group (Note 3)	Material type [A1] (Note 8) [A1]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.		
Ferrous materials (Fe ≥ 50 %)									
Carbon and carbon manganese steel									
A1	Carbon and carbon manganese low strength steel CE _{max} 0.45 C ≤ 0.30 Si ≤ 0.60 Mn ≤ 1.7 R _e ≤ 360 R _m ≤ 460	C-Mn	430	PS	AS 1548 (PT430)	1	1	101	1.1
		C-Mn-Si	460	PS	AS 1548 (PT460)	1	1	101	1.1
		C-Mn-Si	415	PT	ASTM A106B (K03006)	1	1	101	11.1
		C-Mn	414– 455	PT	API 5L X42, X52	1	1	101	11.1
		C	330	PT	API 5L X42M, X52M	1	1	101	1.2
[A1] A2	Carbon and carbon manganese Medium strength steel CE _{max} 0.55 C ≤ 0.33 Mn ≤ 1.7 R _e ≤ 400 460 < R _m ≤ 540	C-Mn-Si	490	PS	AS 1548 PT 490	1	2	101	1.2
		C-Mn-Si	485	PT	ASTM A106C (K03501)	1	2	101	11.1 [A1]
A3	Carbon and carbon manganese high yield strength steel CE _{max} 0.40 C ≤ 0.15 Mn ≤ 1.7 400 < R _e ≤ 530 520 < R _m ≤ 620	C-Mn	570	PS	AS/NZS 1594 (XF 500)	1	3	101	2.2
		C-Mn	565	PT	API 5L X70 API 5L X70M	1	3	101	11.1 2.2

Table 5.2 (continued)

AS material group (Note 3)	Material type A ₁ (Note 8) A ₁	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608		
						Welding		Brazing			
						P. No.	Group No.			P. No.	
A4	Carbon and carbon manganese steel (quenched and tempered or equivalent) CE _{max} 0.40 C ≤ 0.25 Mn ≤ 1.7 360 < R _e ≤ 550 460 < R _m ≤ 660	C-Mn-Si-V-Nb	450	PS	ASTM A656 T3-80	1	4	101	2.2		
		C-Mn-Si-V-Nb	550	PS	ASTM A656 T4-80	1	4	101	—		
		C-Mn-Si	620	PS	ASTM A714 A (K11831)	1	4	101	1.3		
		C-Mn-Si	655	PS	ASTM A714 B (K12031)	1	4	101	1.3		
		C-Mn-Si	620	PS	ASTM A714 C (K12037)	1	4	101	1.3		
		C-Mn	620	PT	API 5L X80M, X80MO	1	4	101	2.2		
Low alloy steel		C-Mn-(B)	490	PS	JIS G3115 SPV 490	1	4	101	2.2		
		B1	Low alloy steel (alloy < 0.7) R _m ≤ 485	CE _{max} 0.48 % Max alloy content of any of Cr, Mo, Ni is 0.7 %	≤ 485		EN 10216-2 16Mo3 (Mn- 0.5Mo) Mn-0.5Mo-0.25 Ni C-0.5Mo	3	1, 2	101	A ₁ 1.2 A ₁
		B2	Low alloy steel (alloy < 11/2) R _m ≤ 650	Max combined alloy content Mn, Cr, Mo, Ni, Cu ≤ 1.5 %	≤ 650		0.5Cr-0.5Mo SA213 T2 (no V added)	3	3		A ₁ — A ₁
		B3	Low alloy steel (alloy < 11/2 & V ≤ 0.1)	Max combined alloy content Mn, Cr, Mo, Ni, Cu ≤ 1.5 % + V ≤ 0.1							A ₁ 4.1, 4.2 A ₁
B4	Low alloy steel, Ni-Cu- Mo (WB36)	1.5Ni 0.6Cu 0.35Mo 0.3Nb V ≤ 0.1 % Mo ≤ 0.7 %	440	610	WB 36, EN 10216-2 15NiCuMoNb5-6-4 (1.6368)	—	—	—	4.2		
B5	Low alloy steel (alloy < 11/2 & V ≤ 0.35)	0.5Cr-0.5Mo-0.25V	610		EN 10216-2 14MoV6-3 BS 3604 HF660	—	—	—	6.1		

Table 5.2 (continued)

AS material group (Note 3)	Material type [A1] (Note 8) [A1]	Nominal composition	Rm MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.		
C	Low alloy steel (11/2 ≥ total alloy < 3) Re ≤ 430 Rm ≤ 550	1Cr-0.5Mo	300	PS	ASTM A387 12-1 (K11757)	4	1	100	5.1
			450	PS	ASTM A387 12-2 (K11757)	4	1	102	5.1
		1.25Cr-0.5Mo	415	PS	ASTM A387 11-1 (K11789)	4	1	102	5.1
			515	PS	ASTM A387 11-2 (K11789)	4	1	102	5.1
[A1] D1	Low alloy steel [Vanadium type] (V ≤ 0.35, Cr ≤ 3.5)	3Cr-1Mo-V-Ti-B	585	F	ASTM A182 F3V (K31830)	5C	1	102	6.2
		2.25Cr-1Mo-V	585	PS	ASTM A182 F22V (K31835)	5C	1	102	6.2
		3Cr-1Mo-25V-Nb-Ca	585	F	ASTM A182 F3VCb (K31390)	5C	1	102	6.2
		3Cr-1Mo-V-Ti-B	585	F	ASTM A182 F3V (K31830)	5C	1	102	6.2 [A1]
D2	Low Mo alloy steel (Cr ≤ 3.5, total alloy < 5)	2.25Cr-1Mo	415	PS	ASTM A387 22-1 (K21590)	5A	1	102	5.2
		2.25Cr-1Mo	515	PS	ASTM A387 22-2 (K21590)	5A	1	102	5.2
		3Cr-1Mo	515	PS	ASTM A387 21-2 (K31545)	5A	1	102	5.2
D3	Cr-Mo steel Cr ≤ 10.0 Re ≤ 430 Rm ≤ 550	5Cr-1/2Mo	515	PS	ASTM A387 5-2 (K41545)	5B	1	102	5.3
		9Cr-1Mo.....(F9)	515		ASTM A182 F9 (K90941)	5B	1	102	5.4

Table 5.2 (continued)

AS material group (Note 3)	Material type [A ₁] (Note 8) [A ₂]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.	P. No.	
D4	Alloy steel Cr > 7 % (Vanadium or tungsten type) R _e ≤ 430 R _m ≤ 650	9Cr-1Mo-V.....(F91)	585	F	ASTM A182 (K90901)	15E	1	102	6.4
		9Cr-1Mo-V.....(F91)	585	PS	ASTM A387 (K91560)	15E	1	102	6.4
		9Cr-1Mo-V.....(T91 and P91)	585	PT	ASTM A213 and A335 (K90901)	15E	1	102	6.4
		9Cr-1Mo-V	630	PT	EN 10216-2 X10CrMoVNb9-1	15E	1	102	6.4
E1	Nickel steel (1.0 < Ni ≤ 3)	9Cr-2W.....(P92)	620	PS	ASTM A335 (K92460)	15E	1	102	6.4
		1.5Ni	415	F	ASTM A350 LF5-1 (K13050)	9A	1	101	9.1
		2Ni-1Cu	435	PT	ASTM A333 (K22035)	9A	1	101	9.1
		2.5Ni	450	PS	ASTM A203A (K21703)	9A	1	101	9.1
E2	Nickel steel (3 < Ni < 8)	3.5Ni	450	PS	ASTM A203D (K31718)	9B	1	101	9.2
		4.5Ni	485	C	ASTM A352 (J41500)	9C	1	101	9.2
F	8 and 9 Nickel steel	8Ni	690	S	ASTM A553-II (K71340)	11A	1	101	9.3
		9Ni	690	PS	ASTM 353 (K81340)	11A	1	101	9.3
		9Ni	690	PT	ASTM A333-8 (K81340)	11A	1	101	9.3
			690	F	ASTM A522-1 (K81340)	11A	1	101	9.3
G1	Quenched and tempered low alloy steel (R _e > 360 R _m ≤ 750)	Mn-0.5Mo	690	PS	ASTM A533-A3 (K12521)	11A	4	101	3.1
		Mn-0.5Mo-0.25Ni	690	PS	ASTM A533-D3 (K12529)	11A	4	101	3.1
		3.5Ni-1.75Cr-0.5Mo-V	725	F	ASTM A508-4Ni (K22315)	11A	5	102	3.1
		3Ni-1.75Cr-5Mo	725	PS	ASTM A543-B1 (K42399)	11A	5	102	3.1
		2.75Ni-1.5Cr-0.5Mo	725	PS	ASTM A543-C1	11A	5	102	3.1

Table 5.2 (continued)

AS material group (Note 3)	Material type [A ₁] (Note 8) [A ₁]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.		
G2	Quenched and tempered low alloy steel (R _e ≥ 550 R _m ≥ 750)	3.5Ni-1.75Cr-5Mo	795	PS	ASTM A543-82 (K42339)	11B	10	102	3.2
		Ni-Cr-Mo-B	790	PS	AS 3597 700PV	11B	10	102	3.2
		0.75Ni-0.5Cr-0.5Mo-V	760	PS	ASTM A514-F (K11576)	11B	3	101	3.2
		0.5Cr-0.25Mo-V	760	PS	Other ASTM A514 grades— A, B, E, P, Q	11B	1, 2, 4, 8, 9	101	3.2
		0.5Cr-0.25Mo-Si	795	F	ASTM A517—A (K11856)	11B	2, 3, 4, 8	102	3.2
High alloy steel									
H	Martensitic chromium steel (Cr ≥ 10.5)	13Cr; 13Cr-5Mo	450	PS	ASTM A240 F6a class 3 (S41000)	6	1	102	7.2
		13Cr-4.5Ni-Mo	795	PT	ASTM A268 F6Mn (S41500)	6	4	102	7.2
		15Cr	415	PT	ASTM A268 F429 (S42900)	6	2	102	7.2
J	Ferritic high chromium steel (10.5 ≤ Cr < 19)	12Cr (403)				7	1	102	7.1
		12Cr-1Al (405)	415	PS	ASTM A240 (S40500)	7	1	102	7.1
		12Cr-Ti (408)	380	PT	ASTM A268 (S40800)	7	1	102	7.1
		11Cr-Ti (409)	380	PS	ASTM A240 (S40920)	7	1	102	7.1
		12Cr-1Ni (401)	455	PS	ASTM A1010 (S41000)	7	1	102	—
		13Cr (401)	450	PS	ASTM A240 (S41000)	7	1	102	7.2
		17Cr (430)	415	TS	ASTM A268 (S43000)	7	2	102	7.1
		18Cr-Ti (439)	415	T	ASTM A268 (S43035)	7	2	102	7.1
		18Cr-Ti (439)	415	PT	ASTM A731 (S43035)	7	2	102	7.1
	18Cr-2Mo	415	PT	ASTM A731 (S44400)	7	2	102	7.1	

Table 5.2 (continued)

AS material group (Note 3)	Material type $\overline{A_1}$ (Note 8) $\overline{A_1}$	Nominal composition	R_m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.	P. No.	Group No.
K1	Austenitic Cr-Ni steel (Cr < 19 %)	17Cr-7Ni (301)	515	PS	ASTM A240 (S30100)	8	1	102	8.1
		18Cr-8Ni (302)	515	PS	ASTM A240 (S30200)	8	1	102	8.1
		18Cr-8Ni (304)	515	PS	ASTM A240 (S30400)	8	1	102	8.1
		18Cr-8Ni	520	PS	EN 10028-7 (X5Cr-Ni-Mo17-12-2)	8	1	102	8.1
		18Cr-8Ni (304L)	485	S	ASTM A240 (S30403)	8	1	102	8.1
		18Cr-8Ni (304N)	550	S	ASTM A240 (S30451)	8	1	102	8.1
		18Cr-8Ni (304LN)	515	S	ASTM A240 (S30453)	8	1	102	8.1
		18Cr-11Ni (305)	515	PS	ASTM A240 (S30500)	8	1	102	8.1
		16Cr-12Ni-2Mo (316, 316N, 316LN)	515	PS	ASTM A240 (S31600)	8	1	102	8.1
		18Cr-13Ni-3Mo (317)	515	PS	ASTM A240 (S31700)	8	1	102	8.1
$\overline{A_1}$ K2	Austenitic Cr-Ni steel (Cr ≥ 19)	18Cr-10Ni-Ti (321)	515	PS	ASTM A240 (S32100)	8	1	102	8.1
		18Cr-10Ni-Nb (347)	515	PS	ASTM A240 (S34700)	8	1	102	8.1
		18Cr-10Ni-Nb (348)	515	PS	ASTM A240 (S34800)	8	1	102	8.1
		18Cr-10Ni-2Si (XM-15)	515	PS	ASTM A240 (S38100)	8	1	102	8.1
		21Cr-11Ni-N (308)			ASTM A240 (S30815)	8	2	102	8.2
		23Cr-12Ni (309) (also with Nb)			ASTM A240 (S30915)	8	2	102	8.2
		25Cr-20Ni (310 S)	515	PS	ASTM A240 (S31008)	8	2	102	8.2
		25Cr-20Ni (310 H)	515	PS	ASTM A240 (S31009)	8	2	102	8.2
		25Cr-20Ni-Nb (310 Nb)	515	PS	ASTM A240 (S31040)	8	2	102	8.2
		25Cr-22Ni-2Mo-N	550	PS	ASTM A240 (S31050)	8	2	102	8.2 $\overline{A_1}$

Table 5.2 (continued)

AS material group (Note 3)	Material type $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$ (Note 8) $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$	Nominal composition	R_m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608	
						Welding		P. No.	Brazing	Group No.
						P. No.	Group No.			
K3	Austenitic Cr-Ni-Mn steel (4 ≤ Mn ≤ 12)	17Cr-4Ni-6Mn (201)	515	PS	ASTM A240 (S20100)	8	3	102		8.3
		18Cr-5Ni-9Mn	620	PS	ASTM A240 (S20200)	8	3	102		8.3
		22Cr-13Ni-5Mn (209)	690	PS	ASTM A240 (S20910)	8	3	102		8.3
		19Cr-8Mn-6Ni-Mo-N (216)	620	PS	ASTM A240 (S21600)	8	3	102		8.3
		21Cr-6Ni-9Mn (219)	620	PT	ASTM A321 (S21900)	8	3	102		8.3
K4	Austenitic Cr-Ni-Mo steel (Mo ≥ 4 %) (Alloy ≥ 38 %)	18Cr-3Ni-12Mn (240)	690	PT	ASTM A249 (S24000)	8	3	102		8.3
		20Cr-18Ni-6Mo (312)	650	PS	ASTM A240 (S31254)	8	4	102		8.2
		19Cr-15Ni-4Mo (317)	515	PS	ASTM A240 (S31725)	8	4	102		8.1
		19Cr-15.5Ni-4Mo (317)	515	PS	ASTM A240 (S31726)	8	4	102		8.1
		24Cr-17Ni-6Mn-4.5Mo-N	795	PS	ASTM A240 (S34565)	8	4	102		8.3
L	High Cr steel (Ferritic stainless) (Cr ≥ 20; Ni < 5)	27Cr	450	PT	ASTM A268 TP446-2(S44600)	10I	1	102		7.1
		27Cr-1Mo-Ti	470	PS	ASTM A240 XM-33 (S44626)	10I	1	102		7.1
		27Cr-1Mo	450	PS	ASTM A240 XM-27 (S44627)	10I	1	102		7.1
		25Cr-4Ni-4Mo-Ti	620	PS	ASTM A268 (S44635)	10I	1	102		7.1
		29Cr-4Mo	550	PS	ASTM A240 (S44700)	10I	1	102		7.1
		26Cr-3Ni-3Mo	585	PT	ASTM A268 (S44660)	10K	1	102		7.1
		29Cr-4Mo-2Ni	550	PT	ASTM A731 (S44800)	10K	1	102		7.1

Table 5.2 (continued)

AS material group (Note 3)	Material type $\overline{A_1}$ (Note 8) $\overline{A_1}$	Nominal composition	R_m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.	P. No.	Group No.
M1	Austenitic-ferritic Cr-Ni steel (Duplex) (Cr $\leq$ 24)	18Cr-5Ni-3Mo-N	625	PT	ASTM A789 315 (S31500)	10H	1	102	10.1
		21Cr-5Mo-1.5Ni-Cu-N	650	PS	ASTM A240 320 (S32001)	10H	1	102	10.1
		22Cr-5Ni-3Mo-N	655	PS	ASTM A240 2205 (S32205)	10H	1	102	10.1
		22Cr-4Ni-3Mo-N	620	PS	ASTM A240 318 (S31803)	10H	1	102	10.1
		23Cr-4Ni-Mo-Cu-N	690	PT	ASTM A789 323 (S32304)	10H	1	102	10.1
M2	Cr > 24	25Cr-6Ni-Mo-N	690	PS	ASTM A240 312 (S31200)	10H	1	102	10.2
		25Cr-5Ni-3Mo-2Cu	760	PS	ASTM A240 325 (S32550)	10H	1	102	10.2
		25Cr-8Ni-3Mo-W-Cu-N	745	PS	ASTM A240 327 (S32760)	10H	1	102	10.2
		26Cr-4Ni-Mo	620	PS	ASTM A240 329 (S32900)	10H	1	102	10.2
		25Cr-7Ni-3Mo-2W-Cu-N	800	PT	ASTM A790 392 (S39274)	10H	1	102	10.2

Table 5.2 (continued)

AS material group (Note 3)	Material type [A ₁] (Note 8) [A ₂]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		P. No.	
						Group No.	Brazing		
Non-ferrous materials									
Aluminium and aluminium alloys									
21	Al alloys Alloy ≤ 1 (R _m < 150)	99.6Al (1060)	55	PS	AS/NZS 1734, ASTM B209 (A91060)	21	—	104	21
		99Al-Cu (1100)	76	PS	ASTM B209 (A91100)	21	—	104	22.1
		Al-Mn-Cu (3003)	97	PS	ASTM B209 (A93003)	21	—	104	22.1
		Al-1.5Mg	125	PS	ASTM B209 (A95050)	21	—	104	22.1
22	Al alloys (Mg ≤ 3.5) (5000 series) (R _m < 230) (non-heat treatable)	Al-Mn-Mg (3004)	150	PS	ASTM B209 (A93004)	22	—	104	22.2
		Al-2.5Mg (5050)	170	PT	ASTM B209 (A95052)	22	—	105	22.3
		Al-2.5Mg (5052)	170	PS	AS/NZS 1867, ASTM B210 (A95052)	22	—	105	22.3
		Al-2.7Mg-Mn (5454)	215	PS	ASTM B209 (A95454)	22	—	105	22.3
23	Al-Mg-Si alloys (heat treatable)	Al-3.5Mg (5154)	205	PS	ASTM B209 (A95154)	22	—	105	22.4
		Al-Mg-Si-Cu (6061)	165	PS	ASTM B209 (A96061)	23	—	105	23.1
		Al-Mg-Si (6063)	115	PT	ASTM B210 (A96063)	23	—	105	23.1
25	Al-Mg alloys (Mg > 3.5) (R _m ≥ 230) (non-heat treatable)	Al-4.4Mg-Mn (5083)	275	PS	ASTM A5058	25	—	105	22.4
		Al-4Mg-Mn	235	PS	ASTM A5086	25	—	105	22.4
		Al-5.1Mg-Mn	290	PS	ASTM A5456	25	—	105	22.1
26	Al-Si castings (Si > 5, Cu ≤ 1)	Al-Si	170	C	ASTM B26 T71 (A03560)	26	—	104	24.1
		Al-10Si-Mg	150	C	EN 1706 (AC 43000)	26	—	104	24.2

Table 5.2 (continued)

AS material group (Note 3)	Material type [A ₁] (Note 8) [A ₁]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding	Brazing		
						P. No.	Group No.	P. No.	Group No.
Copper and copper alloys									
31	Copper (min 99.0Cu)	99.9Cu	205	PS	ASTM B152 (C11000)	31	—	107	31
		99.95Cu-P	205	PT	ASTM B68 (C10200)	31	—	107	31
		99.95Cu + Ag	205	PS	ASTM B152 (C10400)	31	—	107	31
		99.9Cu-P	205	PT	ASTM B68 (C12000)	31	—	107	31
		99.4Cu-As-P	205	PS	ASTM B152 (C14200)	31	—	107	31
32	Cu-Zn alloys	60Cu-39Zn-Pb	275	PS	ASTM B71 (C36500)	32	—	107	32.2
		60Cu-39Zn-Pb	345	PS	ASTM B171 (C36400)	32	—	107	32.2
		85Cu-15Zn	275	PT	ASTM B395 (C23000)	32	—	107	32.2
		71Cu-28Zn-1Sn-0.6As	310	PS	ASTM B171 (C44300)	32	—	107	32.2
		78Cu-20Zn-2Al	345	PT	ASTM B171 (C68700)	32	—	107	32.2
		60Cu-40Zn	345	PT	ASTM B111 (C28000)	32	—	107	32.1
		71Cu-28Zn-1Sn-0.6Sb	310	PS	ASTM B171 (C44400)	32	—	107	32.2
		71Cu-28Zn-1Sn-0.06P	310	PS	ASTM B171 (C44500)	32	—	107	32.2
		76Cu-20Zn-2Al	345	PT	ASTM B543 (C68700)	32	—	107	32.2
		97Cu-3Si	345	PS	ASTM B96 (C65500)	33	—	107	37
33	Cu-Si alloys								
34	Cu-Ni alloys	90Cu-10Ni (<64 mm)	275	PS	ASTM B171 (C70600)	34	—	107	34
		80Cu-20Ni	310	PT	ASTM B359 (C71000)	34	—	109	34
		70Cu-30Ni (<64 mm)	315	PS	ASTM B171 (C71500)	34	—	107	34
35	Aluminium bronze alloys (>5Al)	88Cu-9Al-3Fe	450	C	ASTM B271 (C95200)	35	—	108	35
		90Cu-7Al-3Fe	485	PS	ASTM B171 (C61400)	35	—	108	35
		95Cu-5Al	345	PT	ASTM B111 (C60800)	35	—	108	35
		81Cu-10Al-5Ni-3Fe	550	PS	ASTM B171 (C63000)	—	—	—	—

Table 5.2 (continued)

AS material group (Note 3)	Material type $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$ (Note 8) $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$	Nominal composition	R_m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608 Group No.
						Welding		Brazing	
						P. No.	Group No.	P. No.	
36	Cu-Ni-Zn alloys					Note 2	—	—	36
37	Copper alloys, low-alloyed (<5 % other elements not in 31 to 36)					Note 2	—	—	37
38	Other copper alloys (≥5 % other elements not in 31 to 36)					Note 2	—	—	38
Nickel and nickel alloys									
41	Nickel and low carbon nickel	99.0Ni (200)	380	PS	ASTM B162 (N02200)	41	—	110	41
		99.0Ni-low C (201)	345	PS	ASTM B162 (N02201)	41	—	110	41
42	Ni-Cu alloy (Ni ≥ 45, Cu ≥ 10)	67Ni-30Cu (400)	485	PS	ASTM B127 (N04400)	42	—	110	42
		67N-30Cu	485	PT	ASTM B165, B168 (N04400)	42	—	110	42
43	Ni-Cr alloy (Ni > 45)	72Ni-15Cr-8Fe (600)	550	PP	ASTM B168 (N06600)	43	—	111	43
		58Ni-29Cr-9Fe	585	PT	ASTM B163 (N06690)	43	—	111	43
		55Ni-21Cr-13Mo	690	PS	ASTM B575 (N06622)	43	—	111	44
		65Ni-28Mo-2Fe	795	PS	ASTM B333 (N10601)	44	—	112	44
44	Ni-Mo alloy (Ni ≥ 45, Mo ≤ 32)	62Ni-25Mo-8Cr-2Fe	725	PS	ASTM B434 (N10242)	44	—	112	44
		65Ni-28Mo-5Fe	690	PT	ASTM B622 (N10001)	44	—	112	44
		65Ni-28Mo-2Fe	760	PT	ASTM B622 (N10065)	44	—	112	44
		66Ni-28Mo-3Fe-1.3Cr-0.25Al	760	PS	ASTM B333 (N10629)	44	—	112	44
		65Ni-29.5Mo-2Fe-23Cr	760	PS	ASTM B333 (N10675)	44	—	112	44
		70Ni-16Mo-7Cr-5Fe	690	PS	ASTM B434 (N10003)	44	—	112	44

Table 5.2 (continued)

AS material group (Note 3)	Material type [A ₁] (Note 8) [A ₁]	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.		
45	Ni-Fe-Cr alloy (Ni > 20)	25Ni-20Cr-6Mo-Co-N	650	PS	ASTM B625 (N08926)	45	—	111	8.2
		25Ni-47Fe-21Cr-5Mo	550	PS	ASTM B599 (N08100)	45	—	111	8.2
		35Ni-35Fe-20Cr-Nb	550	PT	ASTM B729 (N08020)	45	—	111	45
		44Fe-25Ni-21Cr-Mo	490	PT	ASTM B677 (N08904)	45	—	111	8.2
		27Ni-22Cr-7Mo-Co	770	PS	ASTM A240 (S31277)	45	—	111	8.2
		42Ni-21.5Cr-3Mo-2.5Co	585	PS	ASTM B424 (N08825)	45	—	111	45
		33Ni-42Fe-21Cr	450	PT	ASTM B163 (N08800)	45	—	111	45
46	Ni-Cr-Si alloy (Ni > 45)	32Ni-45Fe-20.5Cr-Ti	585	PT	ASTM B163 (N08800)	45	—	111	45
		42Ni-21.5Cr-3Mo-2.5Cu	585	PS	ASTM B424 (N08825)	45	—	111	45
		35Ni-19Cr-1.25Si	485	PS	ASTM B536 (N08330)	46	—	111	45
		37Ni-30C-28Cr-2.7Si	620	PS	ASTM B435 (N12160)	46	—	111	45
		46Ni-27Cr-23Fe-2.8Si	620	B	ASTM B166 (N06045)	46	—	111	45
47	Ni-Fe-Cr-Cu alloy (Ni > 45)	37Ni-30C-28Cr-2.7Si	620	PT	ASTM B622 (N12160)	46	—	111	45
		—	—	—	—	Note 2	—	—	47
48	Ni-Fe-Co-Cr-Mo-Cu alloy (25 ≤ Ni ≤ 45), (Fe ≥ 20)	—	—	—	—	Note 2	—	—	48
Titanium and titanium alloys									
51	Unalloyed and alloyed Ti (R _m ≤ 420 MPa)	Ti	240	F	ASTM B381 (R50250)	51	—	115	51
		Ti (1)	240	PS	ASTM B265-1 (R50250)	51	—	115	51
		Ti (2)	345	PS	ASTM B265-2 (R50400)	51	—	115	51
		Ti (2H)	400	PS	ASTM B265-2H (R50400)	51	—	115	51
		Ti-Ru	345	PT	ASTM B338-26 (R52404)	51	—	115	51
		Ti-Pd	345	PT	ASTM B861-7 (R52400)	51	—	115	51

Table 5.2 (continued)

AS material group (Note 3)	Material type $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$ (Note 8) $\left[\begin{smallmatrix} A_1 \\ A_2 \end{smallmatrix} \right]$	Nominal composition	R_m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608 Group No.
						Welding		Brazing	
						P. No.	Group No.	P. No.	
52	Ti alpha alloys $R_m > 420$ MPa	Ti-0.3Mo-0.8Ni (12)	485	PT	ASTM B338-12 (R53400)	52	—	115	52
		Ti (3)	450	PT	ASTM B338-3 (R50550)	52	—	115	52
		Ti (3)	450	PS	ASTM B265-3 (R50550)	52	—	115	52
		Ti (12)	485	PS	ASTM B265-12 (R53400)	52	—	115	52
53	Ti alpha-beta alloys	Ti-3Al-2.5V (9)	620	PS	ASTM B265-9 (R56320)	53	—	115	53
		Ti-3Al-2.5V-0.1Ru (28)	620	PT	ASTM B861-28 (R56323)	53	—	115	53
		Ti-3Al-6V-2Sn (9)	620	PT	ASTM B862-9 (R56320)	53	—	115	53
		Ti-3Al-2.5V-0.1Ru (28)	620	PT	ASTM B862-28 (R56323)	53	—	115	53
54	Ti near-beta and beta-alloys	Ti-10V-2Fe-3Al and higher alloys			—	Note 2	—	—	54
Zirconium and zirconium alloys									
61	Unalloyed Zr	99.2Zr (702)	380	PS	ASTM B651-702 (R60702)	61	—	117	61
			380	F	ASTM B493 (R60702)	61	—	117	61
			380	T	ASTM B523 (R60702)	61	—	117	61
62	Alloyed Zr	95.5Zr-2.5Nb (705)	550	PS	ASTM B551-705 (R60705)	62	—	117	62
			485	F	ASTM B493-705 (R60705)	62	—	117	62
			550	T	ASTM B523-705 (R60705)	62	—	117	62

Table 5.2 (continued)

AS material group (Note 3)	Material type A ₁ (Note 8) A ₁	Nominal composition	R _m MPa	Form	Typical specification (grade and alloy or UNS number)	ASME BPVC-IX classification			SA/SNZ TR ISO 15608
						Welding		Brazing	
						P. No.	Group No.		
Cast irons									
NOTE: Not normally welded to pressure equipment.									
71	Grey cast irons with R _m or HB	—	—	—	AS 1830, ISO 185 (JL/100 to JL/350)	Note 2	—	—	71
72	Spheroidal-graphite cast irons with specified mechanical properties	—	—	—	SA/SNZ TR ISO 15608	Note 2	—	—	72
					ISO 1831 (370-17)				
					ISO 1831 (400-12)				
					ISO 1831 (500-7)				
73	Malleable cast irons	White heart and black heart	—	—	AS 1832, ISO 5922	Note 2	—	—	73
74	Austempered ductile cast irons	—	—	—	—	Note 2	—	—	74
75	Austenitic cast irons	—	—	—	—	Note 2	—	—	75
76	Cast irons excepting 71-75	—	—	—	—	Note 2	—	—	76

LEGEND:

 R_m = specified minimum tensile strength R_e = specified minimum yield or 0.2 % proof strength

A = % elongation

Cv = Charpy V

HB = Hardness Brinell

B = bar or section

C = casting

F = forging

S = plate, sheet or strip

T = pipe or tube

NOTES TO [TABLE 5.2](#):

NOTE 1: This Table lists material groups according to composition and lists representative standards, primarily plate and pipe and R_m values only for the thinnest plate when R_m varies with the thickness.

NOTE 2: SA/SNZ TR ISO 15608 for these alloys is not adopted in ASME BPVC-IX.

NOTE 3: Where reference is made only to the group letter, all groups with the letter are referenced unless noted. Group B5 materials in this Standard were previously classed as 'D1 materials' within AS/NZS 3992:2015, see also [Clause 5.4](#).

NOTE 4: Document titles for the typical specifications may not appear in the referenced documents list. If this information is required please refer to the website of the relevant Standards organization.

NOTE 5: See ISO/TR 20172, ISO/TR 20173 and/or ISO/TR 20174 (as appropriate) for SA/SNZ TR ISO 15608 material group numbers. These Standards also list the ASME/AWS P/M numbers and groups, including those of superseded material designations.

NOTE 6: SA/SNZ TR ISO 15608 grouping numbers may vary with the product manufacturing route. API 5L grades are particularly affected with chemistry only and microalloyed group numbers being shown in the Table

NOTE 7: The basis for the material groups utilized within AS 3992 are defined within column 2 of this Table (see also [Appendix D](#)). Carbon equivalent (CE) is defined in [Clause 2.1](#).

A1 NOTE 8: For materials that conform to more than one material group, consideration should be given to the appropriate service application. **A1**

Table 5.3(A) — Procedure qualification of other material groups

Material group(s) of original qualified welding procedure	Other material groups or combinations of steel groups (see Note 1)
A1 to A1 A1 to A2 A2 to A2 A3 to A1, A2 or A3	A1 to A2 (see Note 2), A2 to A2 (see Note 2) A1 to A1, A2 to A2 (see Note 2) A1 to A1, A1 to A2 Nil
B1 to B1 B1 to A2 or A1 B2 to B2 B2 to B1 or A2 or A1	B2 to B1, A2 or A1
B5 to B5	B5 to D2 (see Note 3), B5 to C
C to C C to B1, A2 or A1	C to B1, A2 or A1
D1 to D1	D1 to D2 (Note 3)
D2 or D3 to D2 or D3 D2 to C, B1, A2	D2 or D3 to C, B1, A2 or A1 (Note 3)
K to A1, A2, B1, C, D2 or D3	K (see Note 5) to any lower ferritic steel group provided nickel-based alloy welding consumables are used (see Table 5.5)

NOTE 1: Conformance to Item 5(b) of [Table 5.1](#) is required.

NOTE 2: See [Clause 5.2.2](#).

NOTE 3: See [Clause 5.4](#).

NOTE 4: For other materials, refer to [Table 5.3\(B\)](#) and [Table 5.3\(C\)](#).

NOTE 5: K applies to K1 to K4 materials. See also Note 3 of [Table 5.2](#).

Table 5.3(B) — Range of qualification of material groups in SA/SNZ TR ISO 15608

SA/SNZ TR ISO 15608 number	Test piece B (see Notes)									
	1 and 11	2	3	4	5	6	7	8	9	10
1 and 11	11-11 11-1 1-1	11-1 11-2	11-1 11-2 11-3	11-4	11-5	11-6	11-7	11-8	11-9	11-10
2	1-1 1-2	1-1 2-1 2-2	—	—	—	—	—	—	—	—
3	1-1 2-1 3-1	1-1 2-1 2-2 3-1 3-2	1-1 2-1 2-2 3-1 3-2 3-3	—	—	—	—	—	—	—
4	4-1	4-1 4-2	4-1 4-2 4-3	4-1 4-2 4-3 4-4	—	—	—	—	—	—
5	5-1	5-2	5-3	5-4	5-1 5-2 5-5	—	—	—	—	—
6	6-1	6-1 6-2	6-1 6-2 6-3	6-1 6-2 6-3 6-4	6-1 6-2 6-3 6-4 6-5	6-1 6-2 6-3 6-4 6-5 6-6	—	—	—	—
7	7-1	7-1 7-2	7-1 7-2 7-3	7-4	7-5	7-5 7-6	7-7	—	—	—
8	8-1	8-1 8-2	8-1 8-2 8-3	8-4	8-1 8-2 8-4 8-5 8-6	8-1 8-2 8-4 8-5 8-6	8-7	8-8	—	—
9	9-1	9-1 9-2	9-1 9-2 9-3	9-4	9-5	9-6	9-7	9-8	9-9	—
10	10-1	10-1 10-2	10-1 10-2 10-3	10-4	10-1 10-2 10-3 10-4 10-5 10-6	10-1 10-2 10-4 10-6	10-7	10-8	10-9	10-10

NOTE 1: Refer to Appendix D for equivalent AS 3992 and ISO material groups.

NOTE 2: SA/SNZ TR ISO 15608 groups 1, 2, 3 and 11 qualify the equal or lower specified minimum yield strength steels.

NOTE 3: Test pieces of SA/SNZ TR ISO 15608 groups 4, 5, 6, 8 and 9 qualify steels in the same sub-group and any lower sub-group within the same group.

NOTE 4: Test pieces of SA/SNZ TR ISO 15608 groups 7 and 10 qualify steels in the same sub-group.

Table 5.3(C) — Range of qualification of material for nickel alloy and nickel alloy/steel groups

Test piece material A	Test piece material B							
	41	42	43	44	45	46	47	48
41	41 ^c -41	—	—	—	—	—	—	—
42	42 ^c -41	42 ^c -42	—	—	—	—	—	—
43	43 ^c -41	43 ^c -42	43 ^c -43 45 ^c -45 47 ^c -47	—	—	—	—	—
44	44 ^c -41	44 ^c -42	44 ^c -43	44 ^c -44	—	—	—	—
45	45 ^c -41	45 ^c -42	45 ^c -43	45 ^c -44	45 ^c -45 43 ^c -43	—	—	—
46	46 ^c -41	46 ^c -42	46 ^c -43	46 ^c -44	46 ^c -45	46 ^c -46	—	—
47	47 ^c -41	47 ^c -42	47 ^c -43	47 ^c -44	47 ^c -45	47 ^c -46	47 ^c -47 43 ^c -43 45 ^c -45	—
48	48 ^c -41	48 ^c -42	48 ^c -43	48 ^c -44	48 ^c -45	48 ^c -46	48 ^c -47	48 ^c -48
1	41 ^c -1	42 ^c -1	43 ^c -1	44 ^c -1	45 ^c -1	46 ^c -1	47 ^c -1	48 ^c -1
2	41 ^c -2a 41 ^c -1	42 ^c -2a 42 ^c -1	43 ^c -2a 43 ^c -1	44 ^c -2a 44 ^c -1	45 ^c -2a 45 ^c -1	46 ^c -2a 46 ^c -1	47 ^c -2a 47 ^c -1	48 ^c -2a 48 ^c -1
3	41 ^c -3a 41 ^c -2 41 ^c -1	42 ^c -3a 42 ^c -2 42 ^c -1	43 ^c -3a 43 ^c -2 43 ^c -1	44 ^c -3a 44 ^c -2 44 ^c -1	45 ^c -3a 45 ^c -2 45 ^c -1	46 ^c -3a 46 ^c -2 46 ^c -1	47 ^c -3a 47 ^c -2 47 ^c -1	48 ^c -3a 48 ^c -2 48 ^c -1
5	41 ^c -5b 41 ^c -6 41 ^c -4 41 ^c -2 41 ^c -1	42 ^c -5b 42 ^c -6 42 ^c -4 42 ^c -2 42 ^c -1	43 ^c -5b 43 ^c -6 43 ^c -4 43 ^c -2 43 ^c -1	44 ^c -5b 44 ^c -6 44 ^c -4 44 ^c -2 44 ^c -1	45 ^c -5b 45 ^c -6 45 ^c -4 45 ^c -2 45 ^c -1	46 ^c -5b 46 ^c -6 46 ^c -4 46 ^c -2 46 ^c -1	47 ^c -5b 47 ^c -6 47 ^c -4 47 ^c -2 47 ^c -1	48 ^c -5b 48 ^c -6 48 ^c -4 48 ^c -2 48 ^c -1
6	41 ^c -6b 41 ^c -4 41 ^c -2 41 ^c -1	42 ^c -6b 42 ^c -4 42 ^c -2 42 ^c -1	43 ^c -6b 43 ^c -4 43 ^c -2 43 ^c -1	44 ^c -6b 44 ^c -4 44 ^c -2 44 ^c -1	45 ^c -6b 45 ^c -4 45 ^c -2 45 ^c -1	46 ^c -6b 46 ^c -4 46 ^c -2 46 ^c -1	47 ^c -6b 47 ^c -4 47 ^c -2 47 ^c -1	48 ^c -6b 48 ^c -4 48 ^c -2 48 ^c -1
8	41 ^c -8b	42 ^c -8b	43 ^c -8b	44 ^c -8b	45 ^c -8b	46 ^c -8b	47 ^c -8b	48 ^c -8b
11	41 ^c -11	42 ^c -11	43 ^c -11	44 ^c -11	45 ^c -11	46 ^c -11	47 ^c -11	48 ^c -11

^a Covers the equal or lower specified yield strength steels of the same group.

^b Covers steels in the same sub-group and any lower sub-group within the same group.

^c For groups 41 to 48, a procedure test carried out with a solid solution or precipitation hardening alloy in a group covers all solid solution or precipitation hardening alloys, respectively, in the same group.

Table 5.4 — Range of parent material and weld deposit thickness qualified

Item	Welding process	Range of parent material thickness qualified (see Notes)	
1	Gas welding	$\leq t$	
2	Single-run or multi-run welding where any run is greater than 13 mm throat (not applicable to GTAW)	$\leq 1.1t$	
3	Gas metal-arc welding and flux cored arc welding both with short circuiting arc transfer with $t \leq 13$ mm	$\leq 1.1t$	
4	Except for above Items 2 and 3, single or multi-run manual metal-arc, submerged arc, gas tungsten-arc, gas metal-arc and flux cored-arc welding	t to $2t$	for $t < 1.5$ mm
		1.5 mm to $2t$	for $t \leq 10$ mm
		5 mm to $2t$	for $t > 10$ mm < 40 mm
		5 mm to 200 mm.....	for $t \geq 40$ mm and ≤ 150 mm
		5 mm to $1.33t$	for $t > 150$ mm
5	Electroslag welding	$\leq 1.1t$	

NOTE 1: t = thickness of test plate or pipe.

NOTE 2: The maximum weld deposit throat thickness of each run qualified is—

- (a) $2t_r$ when $t_r < 20$ mm; and
- (b) the maximum parent material thickness qualified, when $t_r \geq 20$ mm,

where

t_r = maximum throat thickness of any run in the test weld.

Table 5.5 — Filler metal group classification

F number	Welding process	Welding consumable description (see Note 1)	Australian Standard (see Note 2)	ASME BPVC-IIC	
				Spec. No.	Classification
Ferrous materials					
A1 F1	MMAW	High iron powder or iron oxide electrode for carbon and carbon manganese steels	AS/NZS 4855	SFA 5.1	EXX20, EXX22, EXX24, EXX27, EXX28
F2	MMAW	High titania (rutile) electrode for carbon and carbon manganese steels	AS/NZS 4855	SFA 5.1	EXX12, EXX13, EXX14, EXX19
F3	MMAW	High cellulose electrode for carbon and carbon manganese and low alloy steels	AS/NZS 4855	SFA 5.1 and 5.5	EXX10, EXX11
F4	MMAW	(a) Hydrogen controlled basic electrode for carbon and carbon manganese steels	AS/NZS 4855	SFA 5.1 and 5.5	EXX15, EXX16, EXX18, EXX48
	MMAW	(b) Hydrogen controlled basic electrode for low alloy steels and high chromium other than austenitic and duplex steels	AS/NZS 4856	SFA 5.5	EXX15, EXX16, EXX18, EXX48
F5	MMAW	Hydrogen controlled basic electrode for high alloy austenitic and duplex steels	AS/NZS 4854	SFA 5.4	EXX15, EXX16, EXX17

Table 5.5 (continued)

F number	Welding process	Welding consumable description (see Note 1)	Australian Standard (see Note 2)	ASME BPVC-IIIC	
				Spec. No.	Classification
F6	Oxy acetylene welding	Filler metal rods for carbon and low alloy steels	AS/NZS 1167.2	SFA 5.2	RX
	SAW	Electrodes for carbon and carbon manganese steels	AS/NZS ISO 14171 AS/NZS ISO 14174	SFA 5.17	FX-EXX
	SAW	Electrodes for low alloy steels	AS/NZS ISO 24598	SFA 5.23	FX-EXXX-X
	SAW	Electrodes for high alloy austenitic steels	AS/NZS ISO 14343	SFA 5.9	ERXX
	GTAW GMAW	Electrodes for high alloy austenitic steels	AS/NZS 1167.2 AS/NZS ISO 14343	SFA 5.9	ERXX
	GTAW GMAW	Electrodes for carbon and carbon manganese steels	AS/NZS 1167.2 AS/NZS ISO 636 AS/NZS ISO 14341	SFA 5.18	ERXXS-X
	GTAW GMAW	Electrodes for low alloy steels	AS/NZS 1167.2 AS/NZS 21952	SFA 5.28	ERXXX-X ERXXX-X
	FCAW	Electrodes for carbon and carbon manganese steels	AS/NZS ISO 17632 (see Note 3)	SFA 5.20	EXXT-X
	FCAW	Electrodes for low alloy steels	AS/NZS ISO 17634 (see Note 3)	SFA 5.29	EXXTX-X
	FCAW	Electrodes for stainless and high alloy steels	AS/NZS ISO 17633	SFA 5.22	EXXXT-X ^(A1)
Aluminium alloys					
F21	GTAW GMAW	Aluminium welding rod (99% aluminium)	AS/NZS 1167.2 AS/NZS ISO 18273	SFA 5.10	ER 1100
F22	GTAW GMAW	Aluminium alloy welding rod (magnesium chromium alloy)	AS/NZS 1167.2 AS/NZS ISO 18273	SFA 5.10	ER 5183 ER 5356 ER 5554 ER 5556 ER 5654
F23	GTAW GMAW	Aluminium alloy welding rod (silicon 4.5%–6%)	AS/NZS 1167.2 AS/NZS ISO 18273	SFA 5.10	ER 4043 ER 4009 ER 4047 ER 4010 ER 4145
F24	GTAW GMAW	Aluminium alloy	AS/NZS 1167.2 AS/NZS ISO 18273	SFA 5.10	R 356.0
F25	GTAW GMAW	Aluminium alloy electrode and rod	AS/NZS ISO 18273	SFA 5.10	ER 2319 R 2319
Copper and copper alloys					
F31	GTAW GMAW	Copper rod (Copper 98% minimum)	AS/NZS 1167.2	SFA 5.7	ER Cu
F32	GTAW GMAW	Copper silicon rod (silicon bronze)	AS/NZS 1167.2	SFA 5.7	ER Cu Si-A
F33	GTAW GMAW	Copper tin rod (phosphor bronze)	AS/NZS 1167.2	SFA 5.7	ER Cu Sn-A
F34	GTAW GMAW	Copper nickel rod	AS/NZS 1167.2	SFA 5.7	ER Cu Ni

Table 5.5 (continued)

F number	Welding process	Welding consumable description (see Note 1)	Australian Standard (see Note 2)	ASME BPVC-IIIC	
				Spec. No.	Classification
F35	GW	Copper alloy rod (copper zinc)	AS/NZS 1167.2	SFA 5.27	RB Cu Zn-A RB Cu Zn-B RB Cu Zn-C RB Cu Zn-D
F36	GTAW GMAW	Copper aluminium rod (aluminium bronze)	AS/NZS 1167.2	SFA 5.7	ER Cu Al-A1 ER Cu Al-A2 ER Cu Al-A3
F37	GTAW GMAW	Copper alloy gas welding rods (copper-nickel-aluminium)	AS/NZS 1167.2	SFA 5.7	ER Cu Ni Al ER Cu Mn Ni Al
Nickel and nickel based alloys					
F41	MMAW	Nickel welding electrode (nickel 92% minimum)	—	SFA 5.11	E Ni-1
	GMAW GTAW	Nickel welding rod	AS/NZS 1167.2	SFA 5.14	ER Ni-1
F42	MMAW	Nickel copper welding electrode (monel metal)	—	SFA 5.11	E Ni Cu-7
	GMAW GTAW SAW	Nickel copper welding rod (monel metal)	AS/NZS 1167.2	SFA 5.14	ER Ni Cu-7
F43	MMAW	Nickel chromium iron and nickel chromium molybdenum electrode	—	SFA 5.11	E Ni Cr Fe-1 E Ni Cr Fe-2 E Ni Cr Fe-3 E Ni Cr Fe-4 E Ni Cr Mo-2 E Ni Cr Mo-3 E Ni Cr Mo-6
	GMAW GTAW SAW	Nickel chromium, nickel chromium iron and nickel chromium molybdenum welding rod	AS/NZS 1167.2	SFA 5.14	ER Ni Cr-3 ER Ni Cr Fe-5 ER Ni Cr Fe-6 ER Ni Cr Mo-2 ER Ni Cr Mo-3
F44	MMAW	Nickel molybdenum and nickel chromium molybdenum electrodes	—	SFA 5.11	E Ni Mo-1 E Ni Mo-3 E Ni Mo-7 E Ni Cr Mo-4 E Ni Cr Mo-5 E Ni Cr Mo-7
	GMAW GTAW	Nickel molybdenum and nickel chromium molybdenum welding rod	AS/NZS 1167.2	SFA 5.14	ER Ni Mo-1 ER Ni Mo-2 ER Ni Mo-7 ER Ni Cr Mo-4 ER Ni Cr Mo-5 ER Ni Cr Mo-7
F45	MMAW	Nickel chromium molybdenum electrode	—	SFA 5.11	E Ni Cr Mo-1 E Ni Cr Mo-9
	GMAW GTAW	Nickel chromium molybdenum and nickel iron chromium	AS/NZS 1167.2	SFA 5.14	ER Ni Cr Mo-1 ER Ni Fe Cr-1 ER Ni Cr Mo-8 ER Ni Cr Mo-9