

Australian Standard™

**Pressure equipment—Examination and
testing**

This Australian Standard was prepared by Committee ME/1, Pressure Equipment. It was approved on behalf of the Council of Standards Australia on 16 August 1999 and published on 5 September 1999.

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Australian Standard™

Pressure equipment—Examination and testing

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME/1, Pressure Equipment to supersede AS 4037—1992, *Boilers and pressure vessels—Examination and testing*.

This Standard is the result of a consensus among representatives on the Joint Committee to produce it as a Joint Australian/New Zealand Standard. Consensus means general agreement by all parties. Consensus includes an attempt to remove all objections and implies much more than the concept of a simple majority, but not necessarily unanimity. It is consistent with this meaning that a member may be included in the Committee list and yet not be in full agreement with all clauses of this Standard.

The objective of this Standard is to reduce misunderstanding, costs and delays in non-destructive examination, improve safety, prevent unnecessary duplication of tests and promote greater confidence in reciprocal acceptance of approved procedures.

This Standard is one of the ‘core’ documents which form part of the revised arrangement of the pressure equipment Standards under the umbrella of AS/NZS 1200, *Pressure equipment*.

The first issue of the Standard unified and replaced the requirements for the non-destructive examination methods of test and the qualification of non-destructive examination personnel specified in AS 1210, *Pressure vessels*, AS 1228, *Pressure equipment—Boilers* and AS 4041, *Pressure piping*. This revised issue is utilized by direct reference in the above Standards.

The main changes in this revision are as follows:

- Incorporation of Amendment No.1 to AS 4037—1992.
- Updated referenced documents.
- Recognition of moves to self-regulation in the pressure equipment industry.
- Replacement of inspection authority with inspection body and introduction of testing body.
- Alignment with AS/NZS 3992 and AS 4458.
- Recognition for automatic non-destructive examination (NDE).
- Introduction of time of flight diffraction (ToFD) ultrasonic examination.
- Introduction of requirements for acoustic emission.
- Editorial improvements and clarification in various areas.
- Clarification of NDE for boiler tube.
- Provision for non-destructive examination of non-metallic materials.

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

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Pressure equipment—Examination and testing**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out requirements for non-destructive examination (NDE) and testing of pressure equipment as specified in AS 1210, AS 1228, AS/NZS 3509, AS/NZS 3788, AS 4041 and AS 4458. It also specifies requirements for testing and qualification of non-destructive examination personnel.

This Standard provides specific details for the NDE of welded joints, acceptance criteria for weld joint imperfections, NDE of production and welder qualification test welds, NDE for construction in specific materials, NDE of specific purpose construction, forgings and castings; and reports and records.

NDE and testing of pressure equipment constructed of non-metallic or composite materials is not specified in this Standard and should be agreed by the parties concerned.

In this Standard and in other Australian or Australian/New Zealand pressure equipment Standards, ‘examination’ and ‘testing’ are quality control activities carried out by, or for, the manufacturer. ‘Inspection’ refers to those activities of, or for, the owner or user to determine conformity and may include some examination and testing.

1.2 APPLICATION This Standard is intended for use by designers, manufacturers, fabricators, testing bodies, NDE personnel, inspecting bodies, inspectors and all persons concerned with the non-destructive examination of pressure equipment.

This Standard may be applied to plant under pressure that is not covered by AS/NZS 1200.

1.3 REFERENCED DOCUMENTS A list of the documents referred to in this Standard is given in Appendix A.

1.4 DEFINITIONS For the purposes of this Standard, the definitions below apply.

1.4.1 Examination—a detailed review, check or assessment by visual or other non-destructive means of one or more characteristics of a given product, process or service, for conformity with the specified requirements.

NOTE: It includes various NDE methods in this Standard and examination of personnel.

1.4.2 Image quality indicator (IQI)—a device used for judging, from the appearance of its image in a radiograph, the overall quality of that radiograph.

1.4.3 Inspector—a person able to inspect pressure equipment.

1.4.4 Manufacturer—a body corporate, firm or person who manufactures pressure equipment.

NOTE: In this Standard, ‘manufacturer’ includes ‘fabricator’, ‘constructor’, ‘assembler’, ‘installer’ and ‘erector’, and is used to embrace all or some of these terms and is applicable to all locations, on or off site, where pressure equipment may be manufactured. It is recognized that different operations may be carried out by different organizations.

1.4.5 Parties concerned—the purchaser, designer, manufacturer, inspection body, testing body, NDE personnel, inspector and owner as appropriate.

1.4.6 Pressure equipment—boilers, pressure vessels, pressure piping and their components covered by AS/NZS 1200.

1.4.7 Postweld heat treatment (stress relief)—uniform heating of pressure equipment or portion thereof to a sufficient temperature, below the critical range followed by uniform cooling, to relieve the major portion of the residual stresses.

1.4.8 Shall—indicates that a statement is mandatory.

1.4.9 Should—indicates a recommendation.

1.4.10 Spot examination—the examination of samples of welds or components, expressed as a percentage of the summation of the total lengths of all such welds or the total number of components. For example, a 10 percent spot examination may be one of the following:

- (a) 100 percent of the length of each weld in 10 percent of the number of welds.
- (b) 10 percent of the length of each weld in 100 percent of the number of welds.
- (c) An appropriate mix of percentage of each weld or percentage of number of welds so that 10 percent of the total weld length is examined.

1.4.11 Testing—carrying out one or more technical operations that consist of the determination of one or more characteristics of a given product, process or service to a specified procedure.

NOTE: It includes tests which damage or have the potential to damage products such as mechanical and pressure tests in this Standard and trials to determine performance and fitness for purpose.

1.4.12 Testing body—the body, laboratory or firm that provides testing and examination services.

NOTE: Such a body may be independent or the manufacturer.

SECTION 2 MATERIAL GROUPING

This Standard uses the material grouping system given in AS/NZS 3992 and applied throughout the pressure equipment Standards. Table 2.1 lists the material grouping for all materials.

TABLE 2.1
MATERIAL GROUPING

Material group	Material type	Typical nominal compositions or specifications	ANSI/ASME BPV-IX classification	
			P number	Group number
FERROUS MATERIALS (see Note 1)				
Carbon steel				
A1	Carbon and carbon-manganese steel (low strength) (see Note 2)	AS 1548: 7-430, 7-460 AS/NZS 1596: HU300, HA 300/1 ASTM A 106B	1	1
A2	Carbon and carbon-manganese steel (medium strength) (see Note 3)	AS 1548: 5-490, 7-490	1	2
A3	Carbon and carbon-manganese steel (High-yield strength)	API 5L: X52, X60, X65, and X70 all with carbon equivalent ≤ 0.40. AS/NZS 1594: HA350, XF 400 and XF 500.	—	—
Low alloy steel				
B	Alloy steel (alloy <¾)	C-½Mo; ½Cr-½Mo; 1Mn-½Mo	3	1, 2, 3
C	Alloy steel (¾≤ total alloy < 3)	1Cr-½Mo; 1¼Cr-½Mo; ¾Cr-¾Ni-Cu-A1	4	1, 2
D1	Alloy steel (vanadium type)	½Cr-½Mo-¼V	—	—
D2	Alloy steel (3 ≤ total alloy < 10)	2¼Cr-½Mo;	5A	1
		5Cr-½Mo; 9Cr-1Mo 9Cr-1Mo-V	5B	1 1 2
E	3½ nickel steel	3½Ni	9B	1
F	9 nickel steel	9Ni	11A	1
G	Quenched and tempered low alloy steel	ASTM A 517; AS 3597:700 PV	11B	1 to 8
High alloy steel				
H	Martensitic chromium steel	13Cr (Type 410); 15Cr (Type 429) 12Cr-1Mo-V(W)	6 —	1,2, 3, 4 —
J	Ferritic high chromium steel (11–13Cr)	12Cr-Al (Type 405) 13Cr-Low C (Type 410S)	7	1
K	Austenitic chromium-nickel steel	18Cr-8Ni (Type 304) 18Cr-12Ni-2.5Mo (Type 316) 18Cr-10Ni-Ti (Type 321)	8	1
L	High chromium steel (>25Cr)	27 Cr-1Mo (S44627)	10I	1
M	Ferritic-austenitic chromium-nickel steel	22Cr-5Ni-3Mo-N (S31803)	10H	1
NON-FERROUS MATERIALS				
Aluminium and aluminium alloys				
Al 21	Aluminium and its alloys 1000 series and 3003	Al (99.0 min) and Al-1.25Mn	21	—
Al 22	Aluminium alloys 3004 and low - strength 5000 series	Al-2.5Mg; Al-2.75Mg-0.75Mn; Al-1.2, Mn-1.0Mg	22	—
Al 23	Aluminium alloys (selected 6000 series)	Al-Mg-Si-Cr alloys	23	—
Al 25	Aluminium alloys (High strength 5000 series)	Al-4.5Mg-0.75Mn; Al-4Mg-0.5Mn	25	—

(continued)

TABLE 2.1 (continued)

Material group	Material type	Typical nominal compositions or specifications	ANSI/ASME BPV-IX classification	
			P number	Group number
Copper and copper alloys				
Cu 31	Copper (min 99.0Cu)	99.9Cu + Ag	31	—
Cu 32	Copper-zinc alloys	Cu-40Zn	32	—
Cu 33	Copper-silicon alloys	CU-3.3Si	33	—
Cu 34	Copper-nickel alloys	Cu-10Ni	34	—
Cu 35	Aluminium bronze alloys (> 5Al)	Cu-11Al	35	—
Nickel and nickel alloys				
Ni 41	Nickel and low carbon nickel	99.0Ni	41	—
Ni 42	Nickel-copper alloy	67Ni-30Cu only	42	—
Ni 43	Nickel-chromium-iron, nickel-chromium-molybdenum-iron	72Ni-15Cr-8Fe	43	—
Ni 44	Nickel-molybdenum, nickel-molybdenum-chromium-iron	55Ni-21Cr-13Mo	44	—
Ni 45	Nickel-chromium-molybdenum-copper, nickel-iron-chromium-molybdenum-copper, nickel-iron-chromium	25Ni-20Cr-6Mo-Cu	45	—
Ni 46	Nickel-chromium-silicon	35Ni-19Cr-1.3Si	46	—
Titanium and titanium alloys				
Ti 51	Unalloyed and alloyed titanium $R_m \leq 420$ MPa	Unalloyed Ti	51	—
Ti 52	Unalloyed and alloyed titanium $R_m > 420$ MPa	Alloyed 0.3Mo-0.8Ni	52	—
Zirconium				
Zr 61	Unalloyed Zr	99.0 Zr	61	
Zr 62	Alloyed Zr	95.5 Zr - 2.5N _b	62	

LEGEND:

 R_m = specified minimum tensile strength

NOTES:

- 1 For these steels, an upper limit of 580 MPa applies to the actual tensile strength reported on the material certificate.
- 2 For these steels, an upper limit of 620 MPa applies to the actual tensile strength reported on the material certificate.

SECTION 3 NON-DESTRUCTIVE EXAMINATION METHODS — WELDED JOINTS

3.1 GENERAL Where specified by the application Standard, the non-destructive examination of welded joints shall be carried out by one or more of the methods listed in this Section. Such methods may be manual, semi-automatic or automatic. Acceptance or rejection of imperfections detected by non-destructive examination is dependent upon the construction category of the component and the type of joint under examination (see Section 8).

The basis for the selection of an NDE method (either radiographic or ultrasonic examination) should be on providing optimum detection of imperfections that require assessment in accordance with Tables 8.1 and 8.2. Both methods have advantages and disadvantages in the detection, identification and sizing of imperfections. In general, radiography shows a plan view of the imperfection and is very suitable for 'volume' type imperfections such as porosity and inclusions, and for incomplete penetration. Ultrasonic examination can be suitable for detection and sizing the height of planar imperfections such as cracks, lack of fusion and 'tight' incomplete penetration in ferritic steels, particularly in thick sections and in nozzle welds.

The acceptance Standards listed in Tables 8.1 (boilers and pressure vessels) and 8.2 (piping) allow for the above variations, and normally it is expected that only one nominated method (radiographic or ultrasonic) will be used for assessment of weld quality for this Standard. Any variation in the test method nominated shall only be permitted after consultation between the purchaser and manufacturer. However, additional tests to the nominated test method may be used for critical welds.

Abbreviations for NDE methods are as follows:

RT	Radiography.	VT	Visual.
UT	Ultrasonics.	LT	Leak testing.
MT	Magnetic particle.	ET	Eddy Current.
PT	Penetrant.	AE	Acoustic emission.

3.2 VISUAL EXAMINATION

3.2.1 Materials During construction, any material or component showing surface imperfections which exceed the allowable imperfections of the product Standard shall be rejected by the manufacturer.

3.2.2 Welds All welds shall be examined to ensure compliance with design size. The entire weld surface of all joints shall, where practicable, be visually examined for compliance with Tables 8.3 (boilers and pressure vessels) and 8.4 (piping) prior to any other non-destructive examination. Unacceptable surface imperfections shall be repaired prior to such examination (see Clauses 3.3.2 and 3.3.3).

3.2.3 Facilities Aids to visual examinations and dimensional checks, such as weld dimension gauges, templates, magnifiers (up to 10×) and lamps, shall be used where necessary. For guidance refer to AS 3978. All surfaces shall be sufficiently clean to permit adequate examination.

3.3 RADIOGRAPHIC EXAMINATION OF WELDED JOINTS

3.3.1 Application Where non-destructive examination is required and the radiographic method is selected, the extent shall be in accordance with Table 7.1, Table 7.2 or Table 7.3, as applicable.

The use of either X-ray or gamma-ray radiography is permitted, provided that each method is used under the conditions stated in this Clause (3.3).

Where it is not practicable (e.g. because of limited accessibility or special configurations) to radiograph welds completely in accordance with this Clause, the weld reinforcement limitations in Clause 3.3.2 and the requirement for film quality over the whole length of the weld may be varied, provided that the specified film density, contrast and image quality indicator (IQI) sensitivity are achieved over an approved percentage of the weld length.

Radiography may be used above the maximum thickness of 60 mm specified in Table 7.1 where this method is preferable to ultrasonic examination, e.g. welds in very thick austenitic castings.

3.3.2 Preparation of welds All welded joints to be radiographed shall comply with the following:

- (a) Weld ripples or other weld surface irregularities on both the inside and outside of the weld which would mask or be confused with images of imperfections shall be dressed to an extent which permits satisfactory interpretation of the radiograph. Dressing shall be by a suitable mechanical process. (For toe dressing, gas tungsten-arc welding (GTAW) dressing may be used.) The weld surface shall merge smoothly into the parent metal for groups D1, D2, F, G, H, J and L steel components and for construction requiring detailed fatigue analysis for service conditions.
- (b) The maximum height of weld reinforcement and thickness through the welded joint shall not exceed the limits given in Table 3.1.
- (c) Butt joints utilizing backing strips not to be retained in service shall have the backing strips removed before radiographic testing.

3.3.3 Methods of radiographic examination Visual examination of the weld surfaces shall be carried out prior to radiographic examination to assist in the interpretation of radiographs. Radiographic examination shall be in accordance with AS 2177.1 using XR1, XR2, XR3, GR1, or GR2 methods (each for single image (S), double-wall single image (DWS), or double-wall double image (DWD)), and the following additional or specific requirements apply:

- (a) *Radiographic density* The minimum radiographic density shall be 1.8 for X-ray technique or 2.0 for gamma-ray technique including a fog density of 0.3 maximum. The maximum radiographic density shall be 4.2 for all areas of the weld including parent material or to the limit of viewing facilities if density up to this value cannot give satisfactory interpretation of radiographs.
- (b) *Contrast* For high-sensitivity type radiography RT(H) using gamma-rays, the contrast shall be assessed by a plaque/hole or step/hole IQI or the contrast meter (or equivalent) detailed in JIS Z3104. Adequate contrast shall be achieved by visual assessment of the IQI outline or where the JIS contrast meter is used, the requirements for special cases as specified in JIS Z3104.
- (c) *Tube voltage* In X-ray techniques, the tube voltage shall not exceed the specified value given in AS 2177.1 for the weld thickness under examination.
- (d) *Use of gamma-rays* Gamma-ray sources may be used provided that the Ug levels specified in AS 2177.1 are maintained and the sensitivity levels required by Figure 3.1 are achieved except as modified by Clause 3.3.4.
- (e) *Additional requirements for crack-sensitive steel* Radiographic examination of welds in crack sensitive ferrous material groups D1, D2, F, G, H, J and L, (i.e. listed in Table 7.2 and materials in Table 7.3) shall be examined by XR1, XR2, or GR1 radiographic methods with the following exception: the GR2 radiographic method may be used for circumferential welds in 2.25 percent chromium, 1 percent molybdenum material in pipework up to 20 mm in thickness.

TABLE 3.1
PERMISSIBLE WELD REINFORCEMENT
OF RADIOGRAPHED JOINTS

millimetres		
Nominal thickness of thinner parent metal at weld (<i>t</i>)	Maximum height of weld reinforcement on either inside or outside (see Notes 1 and 2)	Maximum total thickness through weld (see Note 1)
≤3	1	$t + 2$
>3 ≤12	1.5	$t + 3$
>12 ≤25	2.5	$t + 5$
>25 ≤50	3.0	$t + 6$
>50	4.0	$t + 8$

NOTES:

- 1 These reinforcement limits may need to be reduced, particularly for parent metal thickness below 12 mm, to enable the radiographic density limits of Clause 3.3.3 to be satisfied.
- 2 For butt welds in Group G steels used in transportable pressure vessels the maximum reinforcement on each side of the joint shall be the lesser of 3 mm or 10 percent of the parent plate thickness.

3.3.4 Assessment of radiographic sensitivity Radiographic sensitivity shall be assessed by the image quality indicator (IQI) using the smallest wire, step/hole or plaque/hole visible on the film, expressed as a percentage of the weld metal thickness (see Foreword of AS 2177.2 for limitation of use of IQIs).

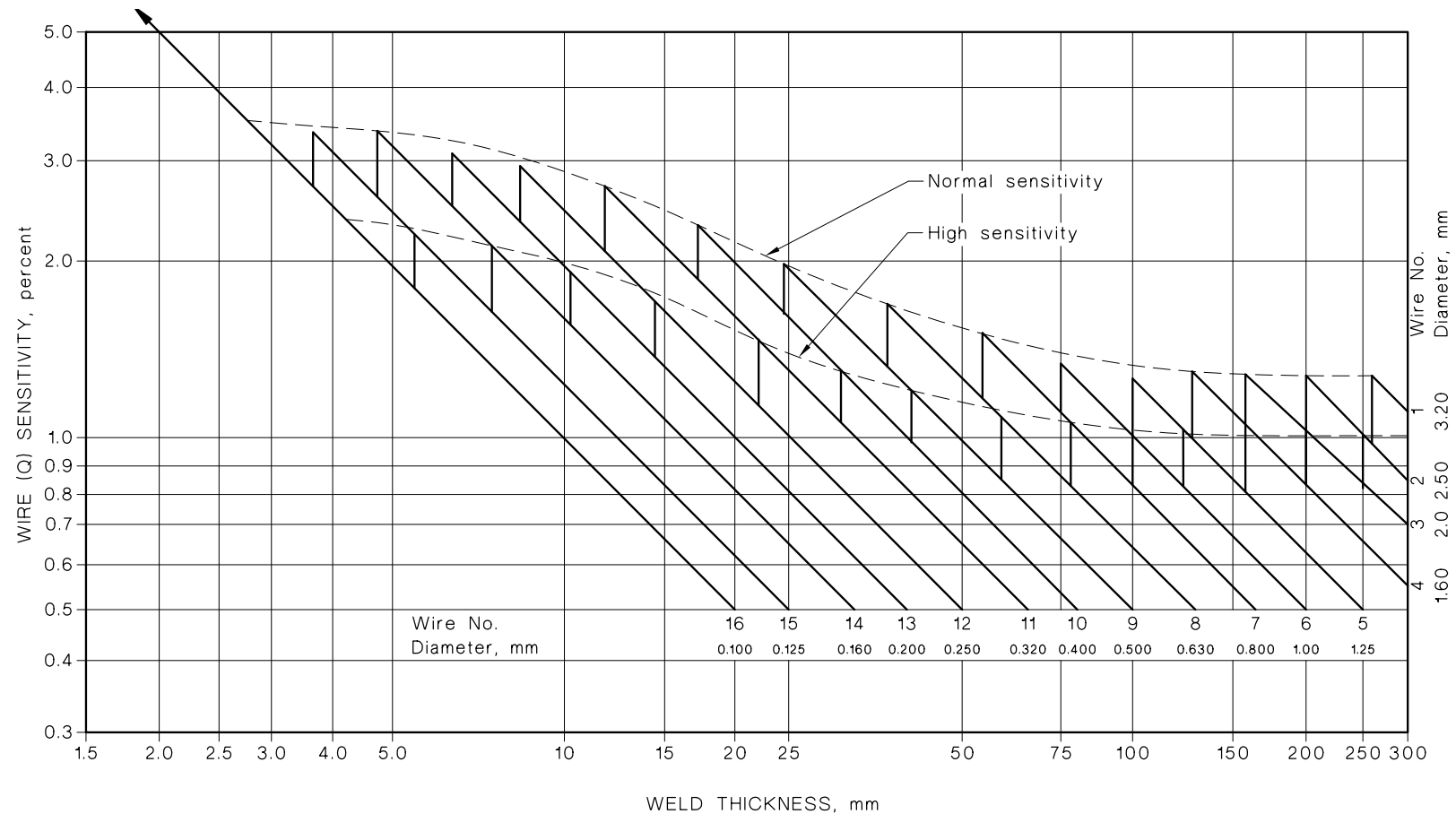
The radiographic sensitivity shall not be greater than the wire sensitivity expressed as a percentage or the wire size specified in Figure 3.1, except for the relaxations detailed in Items (a) and (b) as follows:

- (a) The use of GR1 and GR2 methods using the radioisotope iridium-192 is permitted for weld metal thickness below 20 mm in material groups as covered by Table 7.1 for circumferential joints only, provided that radiographs produced by these methods give the sensitivities from IQIs located in accordance with techniques specified in Table 3.2. For weld metal thickness above 20 mm and for longitudinal seams (Type A joints) the radiographic sensitivity using the above techniques shall comply with the requirements of Figure 3.1.

For all joints in components in materials covered by Table 7.2, the IQI sensitivity shall comply with the requirements of Figure 3.1 for the weld thickness under examination and GR2 techniques shall not be used except as permitted by Clause 3.3.3(e).

- (b) For joggle joints using DWS techniques on materials as listed in Table 7.1 with single weld thickness equal to or less than 6.3 mm, the sensitivities to be achieved shall be not greater than one wire size smaller than the appropriate wire size shown in Figure 3.1.

The weld thickness for use in Figure 3.1 shall be the single weld thickness at the joint which shall be equal to the nominal wall thickness plus the thickness of the allowable reinforcement on each side of the weld and shall not include the thickness of any backing ring or joggle.



NOTES:

- 1 The sensitivity and wire sizes shown are based on IQIs located on the source side. Where an IQI is located on the film side, the required IQI sensitivity is that given by the wire of one numerical number lower e.g. for film side wire No. 12, use wire No. 11 for determination of IQI sensitivity.
- 2 For step/hole and plaque/hole type IQIs, the equivalent wire type IQI sensitivity is to be determined in accordance with AS 2177.2 and is not to exceed the values shown in the above figure.

FIGURE 3.1 IQI SENSITIVITY

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TABLE 3.2
IQI SENSITIVITY FOR WELD THICKNESS BELOW 20 mm

Weld thickness mm	Radiographic exposure technique	IQI location	IQI sensitivity required
> 3 ≤ 6	DWD	Source side	Wire No. 12 or thinner
> 6 ≤ 9	DWD	Source side	Wire No. 11 or thinner
> 9 ≤ 20	DWD	Source side	Wire No. 10 or thinner
> 3 ≤ 6	DWS	Film side	Wire No. 13 or thinner
> 6 ≤ 9	DWS	Film side	Wire No. 12 or thinner
> 9 ≤ 20	DWS	Film side	Wire No. 11 or thinner

LEGEND:

DWD = Double wall, double image technique

DWS = Double wall, single image technique

3.4 ULTRASONIC EXAMINATION OF WELDED JOINTS

3.4.1 Application Where non-destructive examination is required and the ultrasonic method is selected, the extent of examination shall be in accordance with Table 7.1, Table 7.2 or Table 7.3 as applicable and the following conditions shall apply:

- (a) Where ultrasonic examination of group K steel weldments or weldments of thickness below 10 mm is required, the procedure shall be qualified to prove that it can detect unacceptable imperfections as listed in Tables 8.1 and 8.2.
- (b) The welded joint shall be subjected to magnetic particle examination, or penetrant examination for non-magnetic materials, in accordance with Clause 3.5 or Clause 3.6 as well as the ultrasonic examination.

3.4.2 Surface preparation Surfaces over which probes are to be traversed shall comply with the requirements for preparation of surfaces specified in AS 2207. The appropriate surface preparation category (see AS 2207) shall be chosen to suit the scanning mode required.

Where scanning of butt welds can be carried out from one surface only due to joint geometry, and the reinforcement precludes full examination of the weld, the butt weld surface shall be dressed flush (AS 2207 Category SP4). The location of the dressed weld shall be marked on the surface prior to testing.

Welds shall be dressed flat (AS 2207, Category SP3) on one or both surfaces as necessary for groups D1, D2, F, G, H, J, and L steels and for electroslag welds.

3.4.3 Method of examination Examination shall be in accordance with AS 2207, methods UMA, UMB, UMC, UMD, UME, UMF, and UMG at Levels 1 or 2 for double preparation and single preparation butt welds, tee butt welds, cruciform joints and set-in and set-on branches respectively.

Option B of the variations given in AS 2207 shall apply for Level 2 examination.

Examination at Level 1 sensitivity shall be used where required in Tables 7.2 and 7.3 for welds in steel groups D1, D2, F, G, H, J and L and for electroslag welds.

As an alternative to AS 2207 and Clause 3.4.1(b) above, time of flight diffraction (ToF) ultrasonic examination may be used provided the equipment, procedure and calibration methods comply with BS 7706 and the parties concerned agree.

NOTE: ToFD examination was recognized in the above British Standard in 1993 as a reliable and accurate means of assessment for imperfections. This method could be readily automated producing a hard copy record. It provides a longitudinal cross-sectional representation of imperfections and identifies surface-breaking imperfections. This method is currently in use in Australia.

3.5 MAGNETIC PARTICLE EXAMINATION OF WELDED JOINTS

3.5.1 Application The extent of magnetic particle examination shall be in accordance with Table 7.1, Table 7.2 or Table 7.3, as applicable.

Penetrant examination in accordance with Clause 3.6 is permissible as an alternative to magnetic particle examination, only if access restrictions preclude the use of magnetic particle method.

3.5.2 Method of examination The preparation of surfaces and the procedure for magnetic particle examination shall be in accordance with AS 1171.

Arcing at the prod contact and local overheating or burning of the surface being examined shall be avoided (see also Section 12).

3.6 PENETRANT EXAMINATION OF WELDED JOINTS

3.6.1 Application The extent of penetrant examination shall be in accordance with Table 7.1, Table 7.2 or Table 7.3, as applicable.

3.6.2 Method of examination The preparation of surfaces and the method for examination shall be in accordance with AS 2062.

3.7 OTHER METHODS Examination methods other than those listed in this Section may be more suitable for special constructions and may be used as alternatives provided that—

- (a) the procedure is in accordance with a national Standard;
- (b) the method is shown to be no less capable of detecting imperfections; and
- (c) the parties concerned agree.

See also Sections 23 and 24.

SECTION 4 QUALIFICATION OF NON-DESTRUCTIVE EXAMINATION PERSONNEL

4.1 RADIOGRAPHIC AND ULTRASONIC EXAMINATION Radiographic and ultrasonic examination, interpretation, evaluation for compliance, and reporting shall be made by personnel having qualifications and experience for their job function acceptable to the testing body, the manufacturer and where required by the purchaser.

Operators shall have the qualifications detailed below or shall carry out their duties under the supervision of persons responsible for the examination.

NOTES: Qualifications normally acceptable for the examination of components include the following:

- 1 Certification by the Australian Institute of Non-Destructive Testing (AINDT) or Certification Board for Inspection Personnel (CBIP), New Zealand, in accordance with AS 3998 in the relevant non-destructive testing category together with adequate experience in the examination of welds by the relevant non-destructive examination method.
- 2 Acceptance as a signatory for a laboratory approved by National Association of Testing Authorities (NATA), Australia and International Accreditation New Zealand (IANZ), New Zealand, for the relevant non-destructive testing category.
- 3 Equivalent qualification.

4.2 VISUAL, MAGNETIC PARTICLE, DYE PENETRANT, EDDY CURRENT AND ACOUSTIC EMISSION EXAMINATION Visual, magnetic particle, dye penetrant, eddy current and acoustic emission examination shall be carried out by personnel having adequate experience and qualifications to carry out their duties.

See Section 23 for AE testing.

NOTE: Certification of personnel for some of these examination methods are available through AINDT and CBIP.

4.3 EXAMINATION OF IMPORTED COMPONENTS For equipment and components manufactured outside Australia, the manufacturer shall ensure that the quality of non-destructive examination and the qualification of the personnel carrying out the examination is comparable with the requirements of this Standard.

SECTION 5 NON-DESTRUCTIVE EXAMINATION SCHEDULE

For all pressure equipment fabrication, where non-destructive examination is a requirement of the design, a non-destructive examination schedule should be prepared by the manufacturer. Such a schedule should identify the following:

- (a) The stages of manufacture of components or fabrication at which non-destructive examination, as required by this Standard, is undertaken.
- (b) The amount of non-destructive testing in relation to material type thickness, welding process and type of welded joint (see Tables 7.1, 7.2 and 7.3).
- (c) The method of examination and the test sensitivity level required (see Tables 7.1, 7.2 and 7.3).

NOTE: Some typical examples of non-destructive examination schedules as applied to pressure vessels and pressure piping are given in Appendix E.

SECTION 6 STAGE OF NON-DESTRUCTIVE EXAMINATION

Non-destructive examination may be carried out before or after postweld heat treatment or hydrostatic test, except as modified by the following:

- (a) For F and G group steels, 100 percent magnetic particle examination (or where this is not practicable, 100 percent penetrant examination) of all welds shall be carried out after the hydrostatic test and not less than seven days after welding or postweld heat treatment, whichever is the later operation, except that for those surfaces not accessible after the hydrostatic test, the examination shall be carried out at the last possible stage of fabrication.
- (b) For D1, H, J, K, and L group steels, non-destructive examination shall be carried out after postweld heat treatment.
- (c) For welds made by the electroslag process, non-destructive examination shall be carried out after normalizing.

It is recommended that in-process NDE be carried out during fabrication to ensure that all obvious fabrication imperfections are removed prior to postweld heat treatment.

SECTION 7 EXTENT OF NON-DESTRUCTIVE EXAMINATION OF WELDED JOINTS

7.1 GENERAL The extent of non-destructive examination is dependent upon—

- (a) class of construction;
- (b) type of welded joint;
- (c) parent material used in construction; and
- (d) method of welding of joint under examination.

The percentage of weld to be examined for each type of joint in the construction is set out as follows:

- (i) Tables 7.1 and 7.2 for boilers and pressure vessels of Classes 1, 2, 2A, 1H, 2HA and 2HB construction. The non-destructive examination for other construction classes are referred to in Clause 8.1.
- (ii) Table 7.3 for piping Classes 1 and 2. Class 3 piping is exempt from all non-destructive examination except for visual.

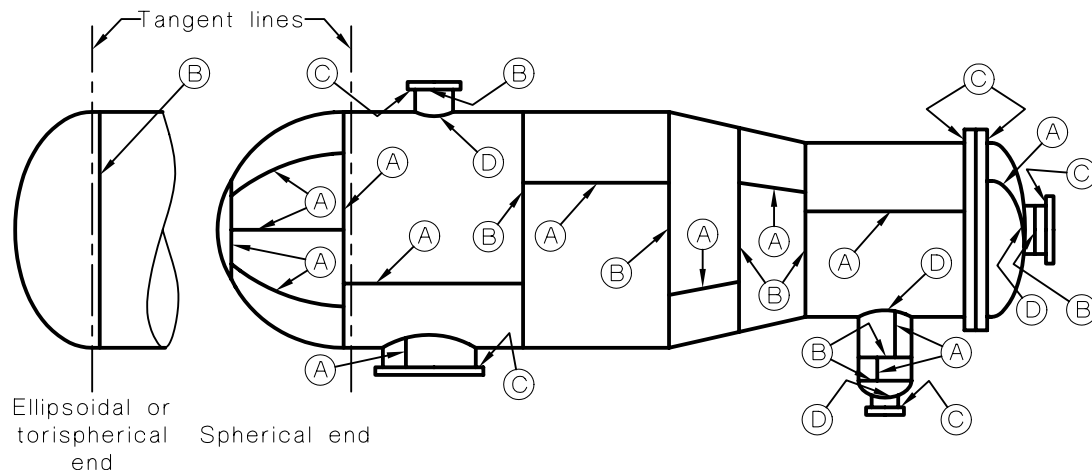
7.2 TYPES OF WELDED JOINTS For the purposes of this Standard, welded joints are classified as one of the following Types 'A', 'B', 'C' and 'D', according to their position as indicated in Figure 7.1 for typical joint types in vessels and as indicated in Table 7.3 for piping:

- (a) *Type A joints*—are longitudinal welded joints in main cylindrical shells, transitions in diameter, or in branches; or joints in positions requiring equivalent welds. This includes circumferential or any other welded joints within spherical shells, within formed or flat ends, or welds connecting spherical ends to main shells or within flat plates forming integral parts of pressure vessels.
- (b) *Type B joints*—in boilers and pressure vessels are circumferential welded joints within main cylindrical shells, within transitions of diameter, welds connecting diameter transition pieces to main cylindrical shells, welds connecting formed ends (other than spherical) to main cylindrical shells and circumferential welds in branches. See Tables 7.1 and 7.2 as appropriate.

In piping, Type B joints are circumferential butt welds in pipes, tubes and attachment welds of pipe fittings such as caps, reducers, tees and weldneck flanges. Some fillet welds in piping are included as Type B. See Table 7.3.

- (c) *Type C joints*—are peripheral welded joints with the weld located at a corner between pressure-retaining part as in the joints connecting flanges, tube plates, or flat ends to main shells, to formed ends, to transitions in diameter, or to branches.
- (d) *Type D joints*—are welded joints, connecting branches to main shells, to spheres, to transitions in diameter, to ends or to piping.

7.3 100 PERCENT EXAMINATION Where 100 percent examination is specified in Tables 7.1 to 7.3, the weld shall be subjected to the specified non-destructive testing method over its full length. Where magnetic particle or penetrant testing are specified they shall be applied to all accessible surfaces of the weld, include both sides and the heat affected zone.



NOTE: For explanation of points A to D see Clause 7.2.

FIGURE 7.1 WELDED JOINT TYPE BASED ON LOCATION

7.4 SPOT EXAMINATION When examination of less than 100 percent is specified in Tables 7.1 to 7.3, spot examination (refer definition 1.4.10) is applied.

Spot examinations are an effective method for inspection and quality control provided that the portions selected for examination are representative of the overall weld or batch of welds. Examination in accordance with this Standard will ensure with a high probability that any weld is of the specified quality. Where a higher level of confidence is required, an increased percentage examination should be employed.

The extent of the specified spot examination shall comply with the following:

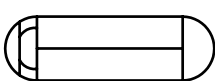
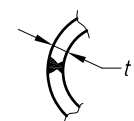
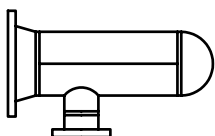
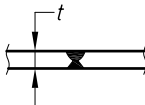
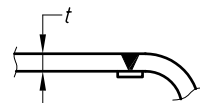
- The percentage of weld length or welds, for the relevant welding methods nominated in Table 7.1, Table 7.2 and Table 7.3, shall be examined by the non-destructive examination method specified.
- At least 50 percent of the spot examinations shall include, where applicable, 'T-junctions' of circumferential and longitudinal welds.
- Additional spots or joints shall be examined, so that the examination includes welding produced by each welder and with each welding procedure.

NOTE: Where more than one welder or welding procedure is used on a double-welded butt joint, a single spot examination may represent the work of such welders or welding procedures.

- The minimum length of spot examination shall be 300 mm when applied to a percentage of a weld length or the examination of one joint when applied as percentage of a batch of welds.
- The areas shall be representative of all processes employed in the manufacture.

TABLE 7.1

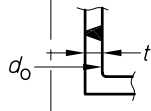
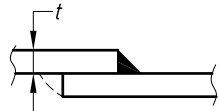
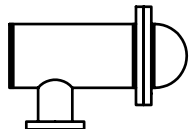
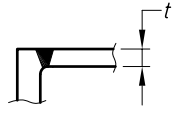
NON-DESTRUCTIVE EXAMINATION OF WELDED JOINTS—BOILERS AND PRESSURE VESSELS (See Notes 1 and 2)*—STEEL GROUPS A1, A2, A3, B, C, E, K, AND M (See Note 3)* AND NON-FERROUS METALS

Type of joint (see Figure 7.1)	Type of weld	Nominal wall thickness (t) mm	Nominal outside diameter (d _o) or (D _o) mm	Notes*	Extent of non-destructive examination, percent (see Note 4)*							Examination method and sensitivity (see Note 21)*
					Construction Standard and class of construction							
					AS 1210					AS 1228		
					Class 1H	Class 2HA	Class 2HB	Class 1	Class 2A	Class 1	Class 2	
Type A 	1 Double-welded butt; or equivalent 	All	All	5, 6, 7, 8	100	100	10(AU) 25(M) Note 9	100	2(AU) 10(M)	100	10(AU) 25(M)	Wall thickness t mm: t ≤ 10: RT (N) 10<t≤32: RT(N); or UT(2) + MT 32<t≤60: RT(H); or UT(2) + MT t > 60: UT(2) + MT (preferred) or RT(H)
Type B 	1 As above 	≤32	All	6, 7, 8,	100	10(AU) 25(M) Notes 5, 9	10(AU) 25(M) Notes 5, 9	10(AU) 25(M) Notes 5, 9, 27	2(AU) 10(M)	100	10(AU) 25(M)	
		>32	All	6, 8	100	10(AU) 25(M) Notes 5, 9	10(AU) 25(M) Notes 5, 9	100	N.A.	100	N.A.	
	2 Single-welded butt with retained backing strip 	All	All	6, 7, 8	N.A.	N.A.	N.A.	100	2(AU) 10(M)	100	N.A.	
	3 Single-welded jogged butt 	≤16	All	6, 7, 8	N.A.	N.A.	N.A.	100	2(AU) 10(M)	N.A.	N.A.	

See end of Table 7.3 for Notes and Legend.

(continued)

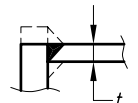
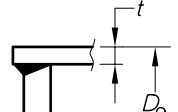
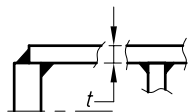
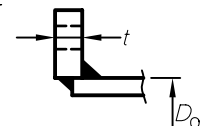
TABLE 7.1 (continued)

Type of joint (see Figure 7.1)	Type of weld	Nominal wall thickness (t) mm	Nominal outside diameter (d _o) or (D _o) mm	Notes*	Extent of non-destructive examination, percent (see Note 4)*							Examination method and sensitivity (see Note 21)*
					Construction Standard and class of construction							
					AS 1210					AS 1228		
					Class 1H	Class 2HA	Class 2HB	Class 1	Class 2A	Class 1	Class 2	
Type B (continued)	4 Circum. butt weld in branch, pipe and tube 	≤20	All	6, 7, 8, 22	10	5	5	0	0	As per Table 7.3 for Class 1 piping	As per Table 7.3 for Class 1 piping	As per Table 7.3
		>20	≤275	6, 7, 8, 22	100	20	20	10	0			
		>20	>275	6, 7, 8	100	100	100	100	0			
	5 Circum. fillet weld in shell branch, pipe and tube 	All	All	NA	NA	NA	NA	NA	NA	NA	NA	Note: Joint only applies to Class 3 vessels.
Type C (see Note 10) 	1 Butt 	≤32	All	6, 7, 8	100	10(AU) 25(M) Note 9	10(AU) 25(M) Note 9	10(AU) 25(M) Notes 5, 9	2(AU) 10(M)	100	2(AU) 10(M)	As for A and B above
		>32	All	6, 8	100	10(AU) 25(M) Notes 5, 9	10(AU) 25(M) Notes 5, 9	100	N.A.	100	N.A.	

See end of Table 7.3 for Notes and Legend.

(continued)

TABLE 7.1 (continued)

Type of joint (see Figure 7.1)	Type of weld	Nominal wall thickness (t) mm	Nominal outside diameter (d _o) or (D _o) mm	Notes*	Extent of non-destructive examination, percent (see Note 4)*							Examination method and sensitivity (see Note 21)*
					Construction Standard and class of construction							
					AS 1210					AS 1228		
					Class 1H	Class 2HA	Class 2HB	Class 1	Class 2A	Class 1	Class 2	
Type C (see Note 10) (continued)	2 Full penetration-shell 	≤32	All	6, 11, 22	0	0	0	0	0	0	0	MT
		>32	All	6, 11, 12	100	10(AU) 25(M) Notes 5 & 9	10(AU) 25(M) Notes 5 & 9	100	N.A.	100	N.A.	UT for lamellar tearing only
	3 Full penetration-end 	≤32	All	6, 11, 12, 13, 22	10	10	10	0	0	10	0	MT
		>32	≥1500	6, 11, 12, 13, 22	10	10 Note 9	10 Note 9	0	N.A.	10	N.A.	
		>32	>1500	6, 11, 12, 13	100	100 Note 9	100 Note 9	100	N.A.	100	N.A.	UT for lamellar tearing only
	4 Partial penetration or fillet 	≤60	All	6, 11, 22	0	0	0	0	0	0	0	MT
		>60	All	6, 11, 22	10	N.A.	N.A.	10	N.A.	10	N.A.	
		All	Weld throat >15	6, 11, 22	10	10	N.A.	10	N.A.	10	10	
	5 Circum. weld to loose or slip-on flange 	≤20	All	6, 11, 22	0	0	0	0	0	0	0	MT
		>20	≤300	6, 11, 22	100	100	100	10	0	100	0	
		>20	>300	6, 11, 22	100	100	100	100	10	100	10	

See end of Table 7.3 for Notes and Legend.

(continued)