

Australian/New Zealand Standard™

Pipelines — Gas and liquid petroleum

Part 2: Welding



AS/NZS 2885.2:2020

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Australian/New Zealand Standard™

Pipelines — Gas and liquid petroleum

Part 2: Welding

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Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME 038, Petroleum Pipelines, to supersede AS/NZS 2885.2:2016.

The inclusion of roles and responsibilities in AS/NZS 2885.2:2020, was approved by the Standards Development Committee on 1 May 2015, as a one-off exemption to the directives of *Standardization Guide 009: Preparation of Standards for Legislative Adoption*.

The objective of this Standard is to provide requirements for the welding of pipelines designed and constructed in accordance with AS 2885.1, *Pipelines—Gas and liquid petroleum, Part 1: Design and construction*.

The objective of this revision is to address the following public comments, which became necessary after the release of the 2016 edition:

- (a) All weld metal chemical analysis for boron content is only required for cellulosic consumables with tensile strength greater than or equal to that of E8010 in [Clause 4.2.1](#).
- (b) Added a note to Table 7.3 (7.4.1 in this edition) to cover scenarios where CVN tests are not practicable.
- (c) Errors in [Table 8.1](#) and [8.2](#) amended.
- (d) Figure 8.1 amended by correcting details for spherical tee and fixing errors.
- (e) Removed the requirement in [Clause 5.6.2](#) to have the long sides of rectangular lugs in the circumferential direction of the pipe.
- (f) Removed the requirement for over-sizing where STRENGTH MATCHING between run pipe and filler metal does not occur in circumferential fillet welds in [Clause 5.6.3](#).
- (g) [Clause 6.4.3](#) has been amended to limit qualification of pipeline assembly welding to alternative standards only for grades below X65.
- (h) Removed the requirement for electrode brand name as an ESSENTIAL VARIABLE for root runs performed with E6010 consumable in [Table 6.1\(B\)](#).
- (i) The wording in [Clause 16.9](#) has been reverted to the 2007 revision, due to changes that contradicted the statement that ESSENTIAL VARIABLES do not apply to in-service welds.
- (j) Changed wording in [Clause 16.14](#) to remove restriction of leak testing hot tap COMPONENTS above the pipeline pressure.
- (k) Errors in Table 17.1 (17.2.1 in this edition) have been corrected.
- (l) [Clauses 17.2.3](#) and [17.2.5](#) (17.2.4 and 17.2.6 in this edition) have been revised to account for the difference in severity between surface breaking and embedded flaws. Limits for inadequate penetration due to high/low have been instated in line with API 1104, *Welding of pipelines and related facilities, Spec 5L, Specification for line pipe*.
- (m) A new defect acceptance table ([Table 17.3.1](#)) has been produced for sentencing to Tier 1 using UT for improved usability of this Standard. Introduced requirement for individual indications with a vertical height (through-wall) dimension determined to be greater than 25 % of the t_N to be deemed as defects when sentencing to Tier 1 using UT, this is based on API 1104.
- (n) ENGINEERING CRITICAL ASSESSMENT in [Clause 17.5](#) has been revised to take into account the different toughness testing requirements of the ECA standard used and additional items have been added to input assumptions.
- (o) A new defect acceptance table ([Table 18.4.1](#)) has been produced for sentencing to Tier 1 using visual inspection, MPT and DPI.

- (p) Appendix H has been removed and instead reference has been made to DNV-RP-F118 where required.

The above list of changes is not intended to be complete. Users of this Standard should not rely on the list in order to ascertain whether there have been changes made to the previous version of the Standard.

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

Small caps have been used throughout this document to indicate terms that are defined in [Clause 1.5](#), e.g. AUTOMATIC WELDING.

The terms “may”, “should” and “shall” are not in small caps but are defined terms that are used in this Standard to indicate an option (may), a recommendation (should) or a mandatory statement (shall).

The terms “normative” and “informative” are used in Standards to define the application of the appendices 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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Australian/New Zealand Standard

Pipelines — Gas and liquid petroleum

Part 2: Welding

Section 1 Scope and general

1.1 Scope

This Standard specifies minimum requirements for safety, welding consumables, weld preparations, welding processes, qualifications of welding procedures and personnel, and fabrication and inspection requirements for the construction and maintenance welding of carbon and carbon-manganese steel pipelines down to 3.2 mm wall thickness designed and constructed in accordance with AS/NZS 2885.1. The welding of corrosion-resistant alloy steel pipelines, or pipelines with NOMINAL THICKNESSES less than 3.2 mm, is not precluded, but is not expressly covered by this Standard. The welding of such pipelines has to be given special consideration.

The following types of welds are covered by this Standard:

- (a) MAINLINE PIPE.
- (b) Tie-in.
- (c) Special class (e.g. golden weld).
- (d) Repair welds (see [Section 25](#)).
- (e) Welds on or between COMPONENTS.
- (f) Temporary welds used in construction (e.g. test headers).
- (g) Structural attachments.
- (h) Aluminothermic or brazing welds for electrical attachments.
- (i) In-service welds.
- (j) Welds made in accordance with other standards.
- (k) PIPELINE ASSEMBLIES.

The welding may be done by a manual metal arc, submerged arc, gas tungsten arc, gas metal arc, flux cored arc or by a combination of these using a manual, semi-automatic, or AUTOMATIC WELDING technique or a combination of these techniques. The welds may be produced by position or roll welding, or by a combination of position and roll welding.

This Standard is applicable to the welding of joints in or on pipelines, and the welding of PIPELINE ASSEMBLIES manufactured from pipes and COMPONENTS.

NOTE 1 For examples of welding of assemblies that are covered by this Standard, see [Figure 1.1](#).

NOTE 2 The welding of COMPONENTS may present special difficulties when using typical pipeline welding procedures (see [Appendix B](#)).

It is not intended that this Standard be applied to the following:

- (i) STATION pipework as defined in AS/NZS 2885.1.
- (ii) Longitudinal welds or spiral welds made during the manufacture of a pipe or a COMPONENT.
- (iii) Underwater welding.

(iv) Hyperbaric welding.

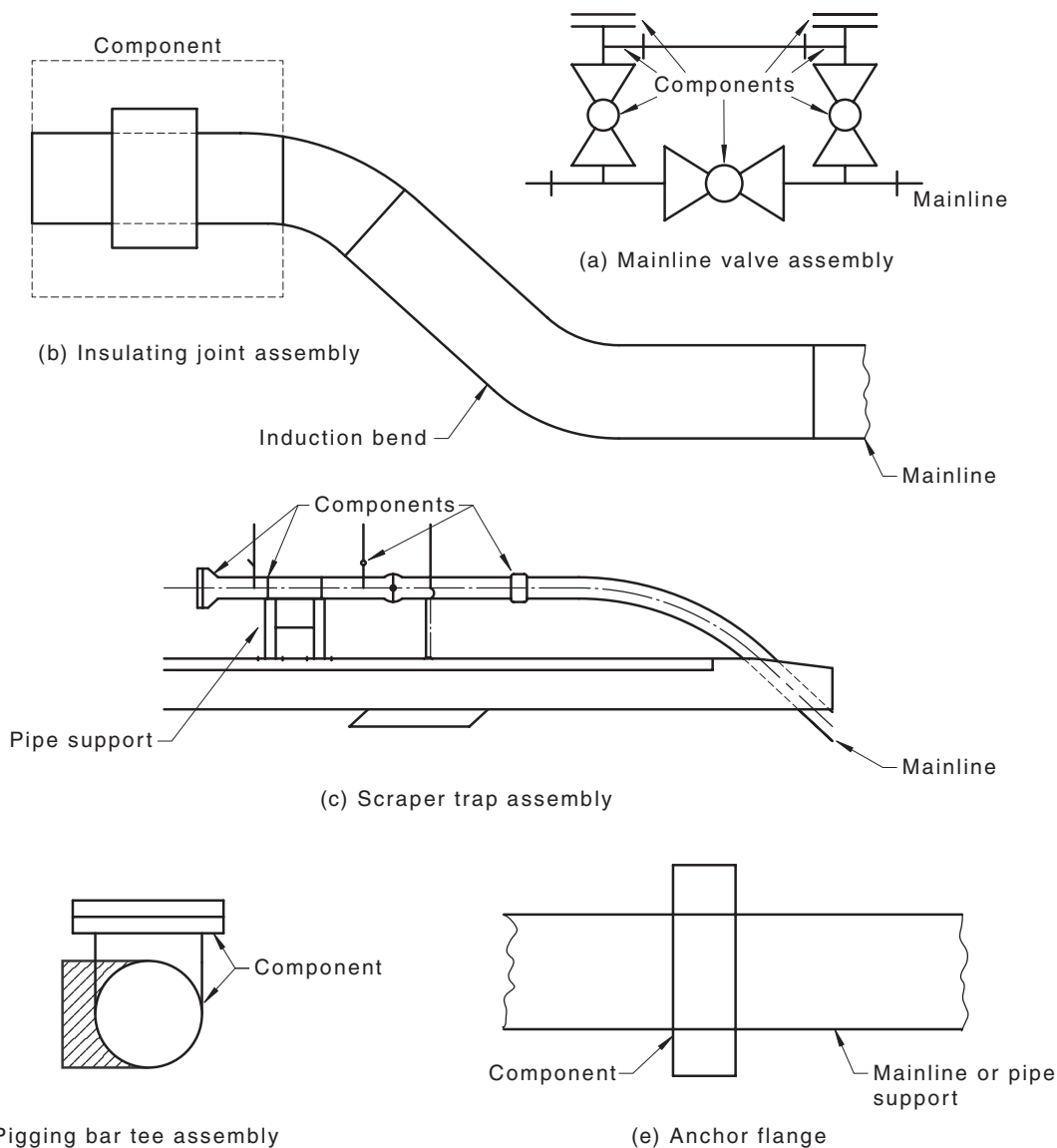


Figure 1.1 — Examples of welding of assemblies covered by this Standard

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 1171, *Non-destructive testing — Magnetic particle testing of ferromagnetic products, components and structures*

AS 1674.2, *Safety in welding and allied processes, Part 2: Electrical*

AS 1710, *Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification*

AS 1796, *Certification of welders and welding supervisors*

- AS 1817.1, *Metallic materials—Vickers hardness test, Method 1: Test method (ISO 6507 1:1997, MOD)*
- AS 1929, *Non-destructive testing—Glossary of terms*
- AS 2062, *Non-destructive testing—Penetrant testing of products and components*
- AS 2177, *Non-destructive testing—Radiography of welded butt joints in metal*
- AS 2205.2.1, *Methods for destructive testing of welds in metal, Method 2.1: Transverse butt tensile tests*
- AS 2205.3.1, *Methods for destructive testing of welds in metal, Method 3.1: Transverse guided bend test*
- AS 2205.5.1, *Methods for destructive testing of welds in metal, Method 5.1: Macro metallographic test for cross-section examination*
- AS 2205.6.1, *Methods for destructive testing of welds in metal, Method 6.1: Weld joint hardness test*
- AS 2205.7.1, *Methods for destructive testing of welds in metal, Method 7.1: Charpy V-notch impact fracture toughness test*
- AS 2205.7.3, *Methods for destructive testing of welds in metal, Method 7.3: Fracture mechanics toughness tests (K_{IC}, critical CTOD and critical J values)*
- AS 2207, *Methods for destructive testing of welds in metal, Non-destructive testing—Ultrasonic testing of fusion welded joints in carbon and low alloy steel*
- AS 2314, *Methods for destructive testing of welds in metal, Radiography of metals—Image quality indicators (IQI) and recommendations for their use*
- AS 2812, *Methods for destructive testing of welds in metal, Welding, brazing and cutting of metals—Glossary of terms*
- AS 2832.1, *Cathodic protection of metals, Part 1: Pipes and cables*
- AS 2885.0, *Pipelines—Gas and liquid petroleum, Part 0: General requirements*
- AS 2885.1, *Pipelines—Gas and liquid petroleum, Part 1: Design and construction*
- AS 3992, *Pressure equipment—Welding and brazing qualification*
- AS 4041, *Pressure piping*
- AS 4458, *Pressure equipment—Manufacture*
- AS 4564, *Specification for general purpose natural gas*
- AS 4749, *Non-destructive testing—Terminology of and abbreviations for fusion weld imperfections as revealed by radiography*
- AS 4882, *Shielding gases for welding*
- AS/NZS 1167.2, *Welding and brazing—Filler metals, Part 2: Filler metal for welding*
- AS/NZS 2885.5, *Pipelines—Gas and liquid petroleum, Part 5: Field pressure testing*
- AS/NZS 4855, *Welding consumables—Covered electrodes for manual metal arc welding of non-alloy and fine grain steels—Classification*
- AS/NZS 4857, *Welding consumables—Covered electrodes for manual metal arc welding of high-strength steels—Classification*
- AS/NZS 14341, *Welding consumables—Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels—Classification (ISO 14341:2010, MOD)*

AS/NZS 16834, *Welding consumables—Wire electrodes, wires, rods and deposits for gas shielded arc welding of high strength steels—Classification (ISO 16834:2012, MOD)*

AS ISO 9712, *Non-destructive testing—Qualification and certification of NDT personnel—General procedures*

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

AS/NZS ISO 14171, *Welding consumables—Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels—Classification*

AS/NZS ISO 17632, *Welding consumables—Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels—Classification (ISO 17632:2004, MOD)*

AS/NZS ISO 18276, *Welding consumables—Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of high-strength steels—Classification (ISO 18276:2005, MOD)*

AS/NZS ISO 26304, *Welding consumables—Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels—Classification*

ISO 636, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels — Classification*

ISO 2560, *Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification*

ISO 13588, *Non-destructive testing of welds — Ultrasonic testing — Use of automated phased array technology*

ISO 14096-2, *Non-destructive testing — Qualification of radiographic film digitisation systems — Part 2: Minimum requirements*

ISO 17332, *Cinematography — Manufacturer-printed latent image identification information for 35 mm motion-picture colour-print film — Specifications*

ISO 16828, *Non-destructive testing — Ultrasonic testing — Time-of-flight diffraction technique as a method for detection and sizing of discontinuities*

ISO 17636-2, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors*

ISO 18275, *Welding consumables — Covered electrodes for manual metal arc welding of high-strength steels — Classification*

ASME B31.3, *Process Piping*

AWS A5.1, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*

AWS A5.5, *Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding*

AWS A5.17, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*

AWS A5.18, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*

AWS A5.20, *Carbon Steel Electrodes for Flux Cored Arc Welding*

AWS A5.23, *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*

AWS A5.28, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*

AWS A5.29, *Specification for Low-Alloy Steel Electrodes for Flux Cored Arc Welding*

AWS A5.36, Specification for Carbon and Low-Alloy Steel Flux Cored Electrodes for Flux Cored Arc Welding and Metal Cored Electrodes for Gas Metal Arc Welding

AUSTRALIA Weld (formerly WTIA), TN 01, The Weldability of Steels

AUSTRALIA Weld (formerly WTIA), TN 3, Care and Conditioning of Arc Welding Consumables

DNVGL-RP-F118. Pipe girth weld automated ultrasonic testing system qualification and project specific procedure validation

DNVGL-ST-F101-2017, Submarine Pipeline Systems

MSS SP-97, Integrally Reinforced Forged Branch Outlet Fittings—Socket Welding, Threaded and Buttwelding Ends

1.3 Terms and definitions

For the purpose of this Standard, the definitions given in AS 1929, AS 2812, AS 2832.1 and those below, apply.

1.3.1

approved and approval

as defined in AS 2885.0

1.3.2

automated ultrasonic testing

AUT

mechanized ultrasonic inspection for pipe girth welds using a technique based on zonal discrimination whereby the weld is divided into approximately equal vertical examination sections (zones) each being assessed by a pair of ultrasonic search units

1.3.3

automatic welding

welding in which all operations are preset and performed automatically during the process

Note 1 to entry: The welding operator is not able to change or adjust any weld parameters or variables once the welding operation has commenced.

1.3.4

burn-off rate

ratio of electrode length consumed to the length of weld pass deposited, which is proportional to the HEAT INPUT, divided by the square of the electrode core wire diameter

Note 1 to entry: Weld Australia (formerly WTIA) publication TN 01 provides information relating to BURN-OFF RATE TO HEAT INPUT.

1.3.5

buttering

surface 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)

Note 1 to entry: The BUTTERING provides a suitable transition weld deposit for subsequent completion of the butt joint.

1.3.6

cellulosic welding

arc welding with a high hydrogen welding consumable

1.3.7

competent person

as defined in AS 2885.0

1.3.8**component**

as defined in AS 2885.0

Note 1 to entry: COMPONENTS made from API 5L PSL2 pipe and that meet the mechanical properties of the pipe material in the welded condition can be treated as pipe in relation to welding procedure qualification.

1.3.9**crack tip opening displacement (CTOD) test**

destructive test that provides a quantitative fracture mechanics based measure of the fracture toughness of the weld metal in girth welds

Note 1 to entry: See [Clause 7.4.7.2](#), CRACK TIP OPENING DISPLACEMENT (CTOD) test.

1.3.10**computerized radiography****CR**

two-step radiographic imaging process; first an image plate is exposed by penetrating radiation; secondly, the luminescence from the image plate is stimulated, detected, digitized and displayed

1.3.11**defect**

as defined in AS 2885.0

1.3.12**design temperatures**

range of the metal temperatures to be expected in construction, testing and operation including consideration of depressurization and repressurization

Note 1 to entry: See AS/NZS 2885.1 for details.

1.3.13**diameter**

outside DIAMETER nominated in the material order, ignoring the manufacturing tolerance provided in the specification under which the pipe was manufactured

1.3.14**discontinuity**

generic term for IMPERFECTIONS (see [Clause 1.3.31](#)), which includes DEFECTS (see [Clause 1.3.31](#)) and non-rejectable irregularities

1.3.15**digital radiography****DR**

one step radiography technique using an electronic device that converts penetrating radiation into a discrete array of analogue signals, which are subsequently digitized and transferred to a computer for display as a digital image

1.3.16**dye-penetrant inspection****DPI**

widely applied low-cost inspection method used to locate surface-breaking DEFECTS in all non-porous materials (e.g. metals, plastics, or ceramics)

Note 1 to entry: Also known as liquid penetrant inspection (LPI) or penetrant testing (PT).

1.3.17**electrical discharge machining (EDM)**

manufacturing process whereby a desired shape is obtained using electrical discharges (sparks), which remove material from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage

Note 1 to entry: Also known as spark machining, spark eroding, burning, die sinking, wire burning or wire erosion.

1.3.18**engineering critical assessment****ECA**

formal process for the assessment of structures containing DISCONTINUITIES, in order to determine whether the structure is fit for purpose

Note 1 to entry: The process involves the use of fracture mechanics and requires consideration of the DISCONTINUITY, the stress, and the material properties for the likelihood of failure arising from fracture, plastic collapse, fatigue, buckling, creep, corrosion/erosion, and leakage.

1.3.19**engineering design**

detailed design of a pipeline system, developed from process and mechanical requirements, including all necessary specifications, drawings, and supporting documents

1.3.20**essential variable**

variable in which a change outside specified limits requires requalification of welding

1.3.21**focal law**

phased array operational file that defines the search unit elements and their time delays, for both the transmitter and receiver function

1.3.22**finite element analysis****FEA**

numerical technique that encompasses methods for connecting many simple element equations over many small subdomains, named finite elements, to approximate a more complex equation over a larger domain

1.3.23**flux core arc welding****FCAW**

arc welding using a consumable continuous flux cored electrode that provides the filler metal, and shielding is provided by the flux contained within the electrode

Note 1 to entry: Additional shielding may be obtained from an externally supplied gas or gas mixture.

1.3.24**full screen height****FSH**

height of the display on a conventional ultrasonic flaw detector screen

1.3.25**gamma radiography**

non-destructive method for detecting DISCONTINUITIES in materials and COMPONENTS using electromagnetic radiation emitted by radioactive isotope (such as Ir-192 or Se-75)

Note 1 to entry: Energies of gamma rays are usually between 0.010 and 10 MeV. X-rays also occur in this energy range, but are of non-nuclear origin. Gamma radiation usually accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best attenuated by dense materials like lead and depleted uranium.

1.3.26**gas metal arc welding****GMAW**

arc welding using a consumable continuous solid electrode that provides the filler metal and shielding is provided entirely from an externally supplied gas or gas mixture

1.3.27**golden weld**

weld that will not be subject to a hydrostatic strength test

1.3.28**hot repair**

repair welding on a pipeline containing hydrocarbon gas under controlled conditions with a burning gaseous atmosphere present due to escape of the pipeline contents

1.3.29**hydrogen assisted cold cracking****HACC**

as defined in AS 2885.0

1.3.30**image plate****IP**

photostimulable luminescent material capable of storing a latent radiographic image of a material being examined and, upon stimulation by a source of red light of appropriate wavelength, generates luminescence proportional to radiation absorbed

Note 1 to entry: When performing CR, an IP is used in lieu of a film.

1.3.31**imperfection**

material DISCONTINUITY or irregularity that is detectable by inspection in accordance with this Standard

1.3.32**in-service welding**

welding onto a product-filled pipeline

1.3.33**interpass temperature**

temperature in a multi-run weld and adjacent parent metal immediately prior to the application of the next run, which is normally expressed as a maximum temperature

1.3.34**lamellar tearing**

cracking in the parent metal adjacent to the weld and arising from weld stresses in the through thickness direction of the plate, which occurs in a stepped configuration, associated with lamellar non-metallic inclusions in the plate, parallel to the fusion boundary

1.3.35**licensee**

as defined in AS 2885.0

1.3.36**magnetic particle testing****MPT**

non-destructive method of inspection for determining the existence and extent of possible DEFECTS in ferromagnetic materials, wherein finely divided magnetic particles, applied to the magnetized part, are attracted to and outline the pattern of any magnetic-leakage fields created by surface and subsurface DISCONTINUITIES

1.3.37**mainline pipe**

as defined in AS 2885.0

1.3.38**manual metal arc welding****MMAW**

arc welding with a covered electrode manually applied by the welder, without automatic or semi-automatic replacement of the electrode and shielding is provided only by decomposition of the electrode covering

1.3.39**matching**

ability of a girth weld, containing DISCONTINUITIES at the limit of the acceptance criteria, to match the strength of the pipe and to ensure that under displacement controlled loading plastic strain is transferred to at least one adjoining pipe before the weld breaks

Note 1 to entry: Weld strength MATCHING includes weld reinforcement, pipe wall thickness and work hardening characteristics as defined by yield to tensile ratio.

Note 2 to entry: Overmatching is when the girth weld has greater strength than the pipe. Undermatching is when the girth weld strength is lower than the pipe.

1.3.40**mechanized welding**

welding in which the welding parameters are maintained within a suitable tolerance by mechanical or electronic means

Note 1 to entry: The welding operator is able to change or adjust some parameters or variables but only within a limited and controlled range.

1.3.41**nominal thickness** **t_N**

as defined in AS 2885.0 (wall thickness, nominal)

1.3.42**non-destructive testing****NDT**

as defined in AS 2885.0

1.3.43**NDT technician**

personnel involved in NON-DESTRUCTIVE TESTING (NDT) and qualified to a minimum Level 2 of an APPROVED NDT qualification program

1.3.44**non-essential variable**

variable in which a change outside specified limits does not require requalification of the welding procedure

Note 1 to entry: NON-ESSENTIAL VARIABLES are those Items in [Table 6.1\(A\)](#) that do not appear in the list of ESSENTIAL VARIABLES in [Table 6.1\(B\)](#).

1.3.45**non-planar discontinuity**

weld DISCONTINUITIES not included in the planar category, including volumetric DISCONTINUITIES such as porosity, root concavity, burn-through, hollow bead, and slag inclusions

Note 1 to entry: Also known as non-planar volumetric indication.

1.3.46**o-let**

integrally reinforced forged branch outlet COMPONENT that is designed and manufactured according to MSS SP-97

Note 1 to entry: "O-LET" also refers to similar integrally reinforced branch COMPONENTS, e.g. threadolet, sockolet, latrolet, elbowlet, nipolet, sweepolet.

1.3.47**peening**

mechanical working of weld metal by means of hammer blows or the like, or bombardment with shot or similar pellets

1.3.48**phased array ultrasonic testing****PAUT**

ultrasonic testing technique using probes containing a number of array elements each of which can be activated for transmission and/or reception individually thereby providing electronic beam shaping

1.3.49**pig**

device inserted in a pipeline for operation or inspection, and transported through it by the flow of the fluid in the pipeline

1.3.50**pipeline assemblies**

as defined in AS 2885.0

1.3.51**planar defect**

category of unacceptable weld DISCONTINUITIES that are assumed to have only two dimensions and which, in fracture mechanics terms, are considered to be equivalent in behaviour to a crack

Note 1 to entry: The fitness for purpose based acceptance criteria in Tier 2 of this Standard classifies the various DISCONTINUITY types into planar and non-planar categories. The workmanship based acceptance criteria in Tier 1 does not require classification of DISCONTINUITIES according to whether they are planar or non-planar.

1.3.52**probability of detection****PoD**

statistical method used to determine the probability of detecting minimum flaw sizes by the NON-DESTRUCTIVE TESTING method being evaluated

1.3.53**post-weld heat treatment****PWHT**

method for reducing and redistributing the residual stresses in the material that have been introduced by welding, which involves a controlled heating of the material, holding for a period of time, and then controlled cooling

1.3.54**preheat temperature**

temperature of the work piece in the weld zone immediately prior to any welding operation

Note 1 to entry: PREHEAT TEMPERATURE is normally expressed as a minimum and is usually equal to the minimum INTERPASS TEMPERATURE.

Note 2 to entry: A minimum PREHEAT TEMPERATURE may be required, e.g. to avoid hydrogen cracking in the weld metal or heat-affected zone. A maximum value may also be specified in order to achieve particular levels of toughness and/or strength. It is recommended that preheat be measured at least 75 mm from the weld line.

1.3.55**pretested**

as defined in AS 2885.0

1.3.56**procedure qualification record****PQR**

record of welding variables used to produce a test weldment and the results of tests conducted on the weldment to qualify a WELDING PROCEDURE SPECIFICATION

1.3.57**proposed welding procedure specification****pWPS**

document that specifies a nominal proposed range of welding ESSENTIAL VARIABLES, which is used as the basis for producing a test weldment for the purpose of qualifying a weld procedure in accordance with this Standard

1.3.58**radiographic testing****RT**

process of making a radiograph via electromagnetic radiation (X-rays or gamma rays) penetrating photographic film, IMAGE PLATE or a digital detector

Note 1 to entry: The preferred method of radiography is X-ray.

1.3.59**safety management study**

as defined in AS 2885.0

1.3.60**sour environment**

piping normally conveying crude oil or a natural gas containing hydrogen sulfide together with an aqueous liquid phase in a concentration that may affect materials

Note 1 to entry: The limits defined in NACE MR0175/ISO 15156 are deemed, for the purposes of this Standard, to constitute sour service.

1.3.61**specified minimum yield strength****SMYS**

as defined in AS 2885.0

1.3.62**station**

as defined in AS 2885.0

1.3.63**time of flight diffraction****ToFD**

ultrasonic inspection method which differs from the traditional pulse echo technique in that it processes diffracted signals from the edges of features which then directly relate to the true position and size of the feature, as opposed to the magnitude of the reflection from the feature as compared to a reference reflector

1.3.64**undercutting adjacent to the cover pass****SUC(ext)**

groove melted into the base metal adjacent to the cover pass and left unfilled by weld metal

1.3.65**undercutting adjacent to the root pass****SUC(int)**

groove melted into the base metal adjacent to the root pass and left unfilled by weld metal

1.3.66**ultrasonic testing****UT**

NDT process that uses high frequency sound energy to conduct examinations and make measurements

Note 1 to entry: Ultrasonic inspection is used for flaw detection/evaluation, dimensional measurements, material characterization, and more. To illustrate the general inspection principle, a typical pulse/echo inspection configuration will be used.

1.3.67**weld metal deposition repair**

repair method for loss of NOMINAL THICKNESS

Note 1 to entry: For example, repairing corrosion DEFECTS by surfacing with deposited weld metal while the pipeline is in service.

1.3.68**welding procedure specification****WPS**

document given to a welder/operator, which specifies the required range of welding variables within which the welder/operator may weld so as to ensure the weld will be sound when undertaken within the range of variables specified

Note 1 to entry: The variables specified on the WELDING PROCEDURE SPECIFICATION are those recorded on the PROCEDURE QUALIFICATION RECORD (PQR) to which the ESSENTIAL VARIABLES has been applied.

1.3.69**weldability**

ability of a metal to be welded under given fabrication conditions in a specific weldment, resulting in satisfactory service performance

1.3.70**x-ray radiography**

imaging technique that uses X-rays to view the internal structure of a non-uniformly composed and opaque object (i.e. a non-transparent object of varying density and composition) such as weld metal

Note 1 to entry: To create the image, a heterogeneous beam of X-rays is produced by an X-ray generator and is projected toward the object. A certain amount of X-ray is absorbed by the weld metal, which is dependent on the particular density and composition of that weld. The X-rays that pass through the weld are captured behind the weld by a detector (either photographic film, IMAGE PLATE or a digital detector). The detector can then provide a superimposed 2D representation of all the weld's internal composition.

Note 2 to entry: X-ray is the preferred method of test where radiography is to be used.

1.3.71 yield strength σ_y

SPECIFIED MINIMUM YIELD STRENGTH (SMYS) specified in the Standard with which the pipe or COMPONENT conforms

Note 1 to entry: The preferred method for determining the tensile properties of the line pipe conforming to API Spec 5L is given in AS/NZS 2885.1, Appendix A, preferred method for tensile testing of welded line pipe during manufacture.

1.4 Approval

Each document prepared for a pipeline in accordance with this Standard shall be APPROVED, as required by AS 2885.0.

NOTE [Appendix A](#) lists the documents that require APPROVAL in this Standard.

1.5 Qualification

Welding shall be performed by qualified personnel as described in [Section 3](#) of this Standard and in accordance with documented qualified and APPROVED welding procedures.

1.6 Retrospectivity

It is not intended that this Standard be applied retrospectively to existing installations. Welding procedures and welder qualifications conforming to appropriate previous editions of this Standard may continue to be used for the maintenance of existing installations. New welding procedures and qualifications shall be in accordance with this Standard.

1.7 Carbon equivalent (CE)

For the purpose of this Standard, the CARBON EQUIVALENT (CE) calculated in accordance with the International Institute of Welding (IIW) formula, as follows:

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15} \quad 1.7$$

NOTE Where CE is reported on a test certificate using another formula, it should be re-calculated using the formula above for application within this Standard.

1.8 Heat input (arc energy)

A weld pass for HEAT INPUT shall be calculated as follows:

$$Q = \frac{EI}{V} \times \frac{60}{1000} \quad 1.8$$

where

- Q = welding energy input, in kilojoules per millimetre of a pass of a weld
- E = arc voltage, in volts (RMS value for a.c.)
- I = welding current, in amperes (RMS value for a.c.)
- V = welding speed, in millimetres per minute

NOTE 1 Both the arc voltage and welding current have to be measured accurately with voltage measured close to the arc as possible between the electrode holder or contact tube and the work piece.

NOTE 2 For waveform power sources, see [Clause 6.7.2](#) for an alternative method to determine HEAT INPUT.

Section 2 Safety

2.1 Production welding

2.1.1 General

Production welding shall be considered in the construction safety plan that is required in accordance with AS/NZS 2885.1.

NOTE The guidance in Weld Australia (formerly WTIA) publication TN 7 should also be considered.

2.1.2 Electrical safety during welding

Production welding shall be in accordance with AS 1674.2.

NOTE The guidance in Weld Australia (formerly WTIA) publication TN 7 should also be considered.

2.1.3 Welding environment

A thorough check shall be made in and around the welding site in accordance with AS 1674.2 to ensure welder safety and confirm that there are no substances that could constitute a risk of fire or explosion.

2.1.4 Equipment and compressed gases

Arc welding equipment shall be of a size and type suitable for the work and shall be maintained in a condition that ensures acceptable welds, continuity of operation, and safety of personnel. Arc-welding equipment shall be operated within parameter ranges given in the qualified welding procedure. Equipment that does not meet these requirements shall be repaired or replaced.

Equipment used with compressed gases, including regulators, shall be properly maintained to prevent hazards such as gas leaks.

NOTE Equipment used with compressed gases should be frequently checked for whether cylinders and regulators are visibly damaged or corroded, and whether they are within test date. Gas pipes, COMPONENTS, hoses and tubing can easily become damaged over time so these should also be inspected regularly.

2.1.5 Electric and magnetic fields (EMF)

Electric current flowing through any conductor causes localized electric and magnetic fields (EMF). Welding current creates EMF around welding cables and welding machines.

WARNING — EMF MAY INTERFERE WITH SOME PACEMAKERS, AND WELDERS HAVING A PACEMAKER SHOULD CONSULT THEIR PHYSICIAN BEFORE WELDING.

2.2 Welding or cutting on a pipeline after commissioning

2.2.1 General

All of the activities associated with welding or cutting on pipelines containing flammable and/or pressurized substances have a potential high risk.

The procedures that are qualified in accordance with [Sections 15](#) and [16](#) shall include a thorough risk assessment. The risk assessment shall include the safety of the public, operations personnel and the suitability of equipment. The risk assessment shall be APPROVED.

WARNING — SPECIFIC ATTENTION SHOULD BE PAID TO THE RISK OF IGNITION OR ELECTROCUTION DUE TO THE PIPELINE BEING AT AN ELEVATED POTENTIAL WITH RESPECT TO EARTH, AND THE LIKELIHOOD THAT IT MAY CARRY SUBSTANTIAL CURRENTS.



NOTE 1 IN-SERVICE WELDING risk assessment guidance in Weld Australia (formerly WTIA) publication TN 20 should be considered.

NOTE 2 Bonding cables should be installed prior to cutting, to effectively bypass any current that may be flowing in the pipeline, especially if the methods of cutting employed are not expected to cause ignition.

NOTE 3 Consideration should be given for earthing the pipeline prior to the commencement of welding or cutting. Due to the potentially hazardous nature of the earthing procedure, the earthing procedure shall be APPROVED.

The formation of mixtures of flammable vapour, including gas and air, shall be prevented, unless work is to be carried out in line with [Clause 15.3](#).

2.2.2 Risk assessment

Welding or cutting on a pipeline that is operational or during construction activity involves increased risk to public safety and operating personnel.

A project-specific risk assessment for the activities involved shall be undertaken. The risk assessment shall consider, as a minimum, the following:

- (a) Qualification of the welding to simulate the field installation.
- (b) Failure of equipment including the power supply.
- (c) Failure of valves to isolate.
- (d) Confirmation of the mechanical properties of the operational pipeline and the COMPONENTS to be used in the completed assembly.
- (e) Leak and strength testing of the completed assembly.
- (f) Competency of supervision, technicians, welders and NDT TECHNICIANS used in the process.
- (g) Emergency shutdown and depressurization.
- (h) Loss of supply as a result of an incident.

2.3 Safety and protection from ionizing radiation

All RADIOGRAPHIC TESTING shall be carried out in accordance with statutory State and Commonwealth health and safety regulations.

Section 3 Qualifications

3.1 General

Personnel involved in pipeline welding activities in accordance with this Standard shall be COMPETENT PERSONS.

[Clauses 3.2](#) to [3.5](#) specify the key welding tasks and the qualification required to demonstrate competence to undertake those tasks.

3.2 Welding engineering

The following tasks shall be undertaken by a COMPETENT welding engineer:

- (a) Review of design data including —
 - (i) a material summary listing pipe grade, NOMINAL THICKNESS, DIAMETER, CARBON EQUIVALENT (CE) and specification for all COMPONENTS;
 - (ii) the boundary limits between STATIONS and MAINLINE PIPE;
 - (iii) the SAFETY MANAGEMENT STUDY information related to NDT and welding including GOLDEN WELDS;
 - (iv) the design minimum temperature; and
 - (v) for IN-SERVICE WELDING, the pipeline operating pressure range and velocity range.
- (b) Design of all welding procedure qualification test welds and specification of the requirements for examination and testing.
- (c) Development of a weld map that shows where each welding procedure is to be used.
- (d) Selection and APPROVAL of welding procedure specifications.
- (e) APPROVAL of an alternate welding Standard in accordance with [Clause 6.4.3](#).
- (f) Direct supervision of any weld being qualified by the method of engineering in accordance with [Clause 6.4.5](#).
- (g) APPROVAL of the number and location of production cut-out welds.
- (h) Specification of the non-destructive and mechanical test requirements for production welds.
- (i) Specification of acceptance criteria and DEFECT assessment in accordance with [Sections 17](#) and [19](#).
- (j) APPROVAL of any repair to a repair weld in accordance with [Section 25](#).
- (k) The specification of requirements for welder or operator qualification test welds and examination and testing.
- (l) APPROVAL of the qualifications of the welding supervisor and inspector in accordance with [Clauses 3.3\(v\)](#) and [3.4\(vi\)](#).
- (m) APPROVAL of the qualification program for NDT personnel and approval of NDT procedures.
- (n) APPROVAL of any proposed PWHT activities.

Tasks that require APPROVAL shall only be undertaken by a welding engineer (see Note 3).

NOTE 1 One or more welding engineers may be engaged to undertake welding engineering tasks on a pipeline and welding engineers may be engaged from different organizations to undertake different tasks.

NOTE 2 For guidance on the responsibilities of personnel involved in welding-related tasks, refer to ISO 14731.

NOTE 3 For the APPROVAL process, refer to AS 2885.0.

A COMPETENT welding engineer shall have one or more of the following qualifications:

- (i) Hold an International Institute of Welding (IIW) qualification at the level of International Welding Engineer (IWE) diploma.
- (ii) Hold postgraduate diploma or degree in welding engineering from a recognized university or a registered training organization.
- (iii) Have other APPROVED qualifications or experience acceptable to the LICENSEE, including specific technical knowledge and experience in the welding of pipelines.

In addition to the requirements above, a welding engineer shall be qualified by previous experience and specific training if they are involved in the following tasks:

- (A) Welding onto a pipeline that has been hydrostatically tested or commissioned, where the pipeline will not be subjected to another pressure test before it is returned to service.
- (B) Welding onto a pipeline that has contained hydrocarbons.
- (C) IN-SERVICE WELDING on pipelines.

A welding engineer shall approve both the weld procedure and risk assessment for these activities.

3.3 Welding supervision

The welding supervisor shall be responsible for planning, execution and supervision of weld procedure qualification test welds and production welds.

The following tasks shall be undertaken by a COMPETENT welding supervisor:

- (a) The planning, execution, supervision and recording of all welding procedure qualification test welds and their examination and testing.
- (b) The planning, execution, supervision and recording of all welder or operator qualification test welds and their examination and testing.
- (c) The coordination of all production welding.
- (d) The coordination of all production NDT.
- (e) Producing and maintaining reports and records as required.

NOTE 1 One or more welding supervisors may be engaged to undertake welding supervision tasks on a pipeline and supervisors may be engaged from different organizations or work teams to perform different tasks.

NOTE 2 For guidance on the responsibilities of personnel involved in welding-related activities, refer to ISO 14731.

Where APPROVED by the LICENSEE, a welding supervisor may also perform the role of the welding inspector.

The welding supervisor shall have a minimum of three years' experience in welding pipelines and have one or more of the following qualifications:

- (i) A welding supervisor certificate in accordance with AS 1796 Certificate No. 10, or a New Zealand Institute of Welding supervisor certificate.

- (ii) An International Institute of Welding (IIW) diploma at the level of International Welding Specialist (IWS), International Welding Technologist (IWT) or International Welding Engineer (IWE).
- (iii) A New Zealand Institute of Welding certificate in welding engineering.
- (iv) A postgraduate certificate, diploma or degree in welding engineering from a recognized university or a registered training organization.
- (v) Have other APPROVED qualifications or experience acceptable to the LICENSEE, including specific technical knowledge and experience in the welding of pipelines.

For welding supervision of welding onto a pipeline that has been hydrostatically tested or commissioned, the welding supervisor shall also be qualified by experience and training in the welding or cutting of pipelines containing, or having contained, hydrocarbons.

For IN-SERVICE WELDING the welding supervisor shall also be qualified by experience and training specifically related to IN-SERVICE WELDING on pipelines.

3.4 Welding inspection

The following tasks shall be undertaken by a competent welding inspector:

- (a) The witnessing of all welding procedure qualification test welds and the subsequent removal of test samples.
- (b) The witnessing of all welder or operator qualification test welds and the subsequent removal of test samples.
- (c) The examination of all production welds including visual inspection.
- (d) Ensuring that all reports and records are prepared as required.

NOTE 1 One or more welding inspectors may be engaged to undertake welding inspection tasks on a pipeline and welding inspectors may be engaged from different organizations or work teams to perform different tasks.

NOTE 2 Guidance on welding inspection activities is provided in ISO 14731.

Welding inspectors shall have qualifications, training and experience in the inspection of pipeline welding. A welding inspector shall have one or more of the following qualifications:

- (i) An International Institute of Welding (IIW) diploma as a welding inspector.
- (ii) A Weld Australia (formerly WTIA) certificate as a welding inspector.
- (iii) A New Zealand Institute of Welding certificate as a welding supervisor or a welding supervisor's certificate in accordance with AS 1796 Certificate No. 10.
- (iv) A Certification Board of Inspection Personnel (CBIP) New Zealand Welding Inspector.
- (v) A CSWIP Certificate as a welding inspector, at the required level.
- (vi) Other APPROVED qualifications and experience.

3.5 Welders and welding operators

Welders and welding operators shall be qualified in accordance with [Section 9](#) of this Standard.

Section 4 Materials

4.1 Scope of section

This Section sets out requirements for the welding of materials that conform to AS/NZS 2885.1.

NOTE Changes to the weld consumable classification system are described in [Tables D.1](#) and [D.2](#) of [Appendix D](#).

4.2 Consumables

4.2.1 General

Consumables shall conform to the Standards listed in [Table 4.2.1](#), as appropriate.

All-weld metal chemical analysis for boron shall be analysed and reported for cellulosic consumables with tensile strength greater than or equal to that of E8010. All weld metal boron content greater than 0.0010 % shall be subject to an engineering assessment (see Note 1).

Consumables that do not conform to the listed Standards may be used, provided their chemical and mechanical properties are equivalent to those specified in the listed Standards and meet the boron requirements of this Section (see Note 2).

NOTE 1 For discussions on boron in cellulosic welding of high strength line pipe, see list of references in Bibliography.

NOTE 2 The following should be taken into account for manual arc welding electrodes:

- (a) Lower strength electrodes (see welding process column in [Table 4.2.1](#)) should be used for welding of all passes for pipe and components in material with SPECIFIED MINIMUM YIELD STRENGTH (SMYS) up to and including 360 MPa.
- (b) Unless it can be shown that it is difficult to meet the required mechanical properties [see [Clause 17.4.1\(c\)](#)], lower strength electrodes should be used for the first pass, when welding pipe and COMPONENTS of material with SMYS greater than 360 MP.
- (c) Electrodes for cellulosic manual metal-arc welding should be selected and specified in accordance with [Appendix C](#).

NOTE 3 The selection of wires for AUTOMATIC WELDING should take into account the information given in [Appendix E](#).

4.2.2 Storage and handling of consumables

Consumables shall be stored and handled as follows:

- (a) Electrodes — in accordance with one or more of the following:
 - (i) Specifications of the manufacturer.
 - (ii) Requirements of the relevant Standard.
 - (iii) Weld Australia (formerly WTIA) publication TN 3.
- (b) Filler rods and fluxes — in accordance with one or both of the following:
 - (i) Specifications of the manufacturer.
 - (ii) Requirements of the relevant Standard.

Table 4.2.1 — Welding consumables

Welding process	Standard	Consumable type
Manual metal-arc welding using lower strength cellulose electrodes	AS/NZS 4855-B ISO 2560-B AWS A5.1	Cellulose MMA
Manual metal-arc welding using medium strength cellulose electrodes	AS/NZS 4857-B ISO 18275-B AWS A5.5	Cellulose MMA
Manual metal-arc welding using lower strength hydrogen-controlled electrodes	AS/NZS 4855-B ISO 2560-B AWS A5.1	Basic coated MMA
Manual metal-arc welding using medium strength hydrogen-controlled electrodes	AS/NZS 4857-B ISO 18275-B AWS A5.5	Basic coated MMA
Submerged-arc welding ^a	AS/NZS 14171 AWS A5.17 AS/NZS ISO 26304-B AWS A5.23	Fused or bonded flux Solid wire
Gas tungsten-arc welding ^b	AS/NZS 1167.2 AWS A5.18 AS/NZS ISO 26304-B IAWS A5.28 ISO 636-B	Solid wire
Gas metal-arc welding ^b	AS/NZS 14341-B AWS A5.18 AS/NZS 16834-B AWS A5.28	Solid wire
Gas metal-arc welding ^b	AS 4882	Shielding gas
Flux cored arc welding ^{c, d}	AS/NZS ISO 17632 ISO 17632-B AWS A5.20 AS/NZS ISO 18276-B ISO 18276-B AWS A5.29 AWS A5.36	Gas- or self-shielded flux-cored wire

^a Any combination of electrodes and fluxes may be used to qualify a procedure. Each combination shall be identified by its complete classification number, e.g. F6A2-EM12K or F7A1-EL12 as specified in AWS A5.17, B-S49A2 AB SU32 as specified in AS/NZS ISO 14171-B.

^b Any combination of electrodes and gases may be used to qualify a procedure. Each combination shall be identified by its complete classification number, e.g. ER 70S-6 as specified in AWS A5.18 with each shielding gas to be specified by brand name or mix analysis, B-G 49A 6 M S3, SG-ACO-16/2.75 as specified in AS/NZS 14341-B and AS 4882.

^c Any combination of electrodes (with or without gas) may be used to qualify a procedure. Consumables shall be identified by the complete classification number, e.g. B-T492T8-1NA-UH15 as specified in ISO 17332-B. Where a shielding gas is used, this shall be specified by brand name or mix analysis.

^d Any combination of electrodes may be used to qualify a procedure. Consumables shall be identified by the complete classification number (e.g. root pass E71T-GS, other passes E71T8-K2).

Section 5 Design of a welded joint

5.1 General

A welded joint shall be designed to be capable of withstanding the design forces, and strains presented by AS/NZS 2885.1; for pressure-containing COMPONENTS it shall be leak tight in accordance with AS/NZS 2885.5.

Details of the weld preparations shall be in accordance with those shown in the qualified WELDING PROCEDURE SPECIFICATION. The WELDING PROCEDURE SPECIFICATION shall include tolerances for all of the specified dimensions.

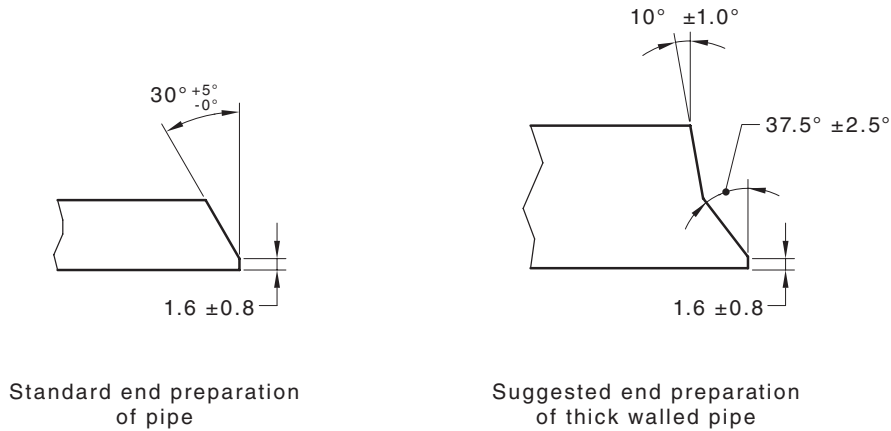
5.2 Butt welds between components of equal nominal thickness

The weld preparation for a butt weld between COMPONENTS of equal NOMINAL THICKNESS shall be single V type, double V type, or an APPROVED preparation.

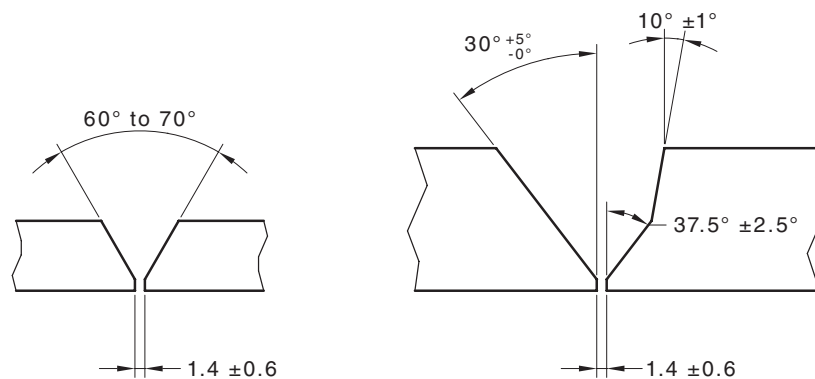
For a manual metal-arc welding process, joints using the combination of weld preparations shown in [Figure 5.2](#) may be used.

For other welding processes, the weld preparation shall have been shown to be satisfactory by being qualified in the welding procedure test.

The weld preparation selected shall take into consideration the proposed production NDT method.



(a) End preparations



(b) Acceptable combinations of end preparations

NOTE The standard root face dimension is 1.6 mm ± 0.8 mm.

Figure 5.2 — End preparations and acceptable combinations of end preparations

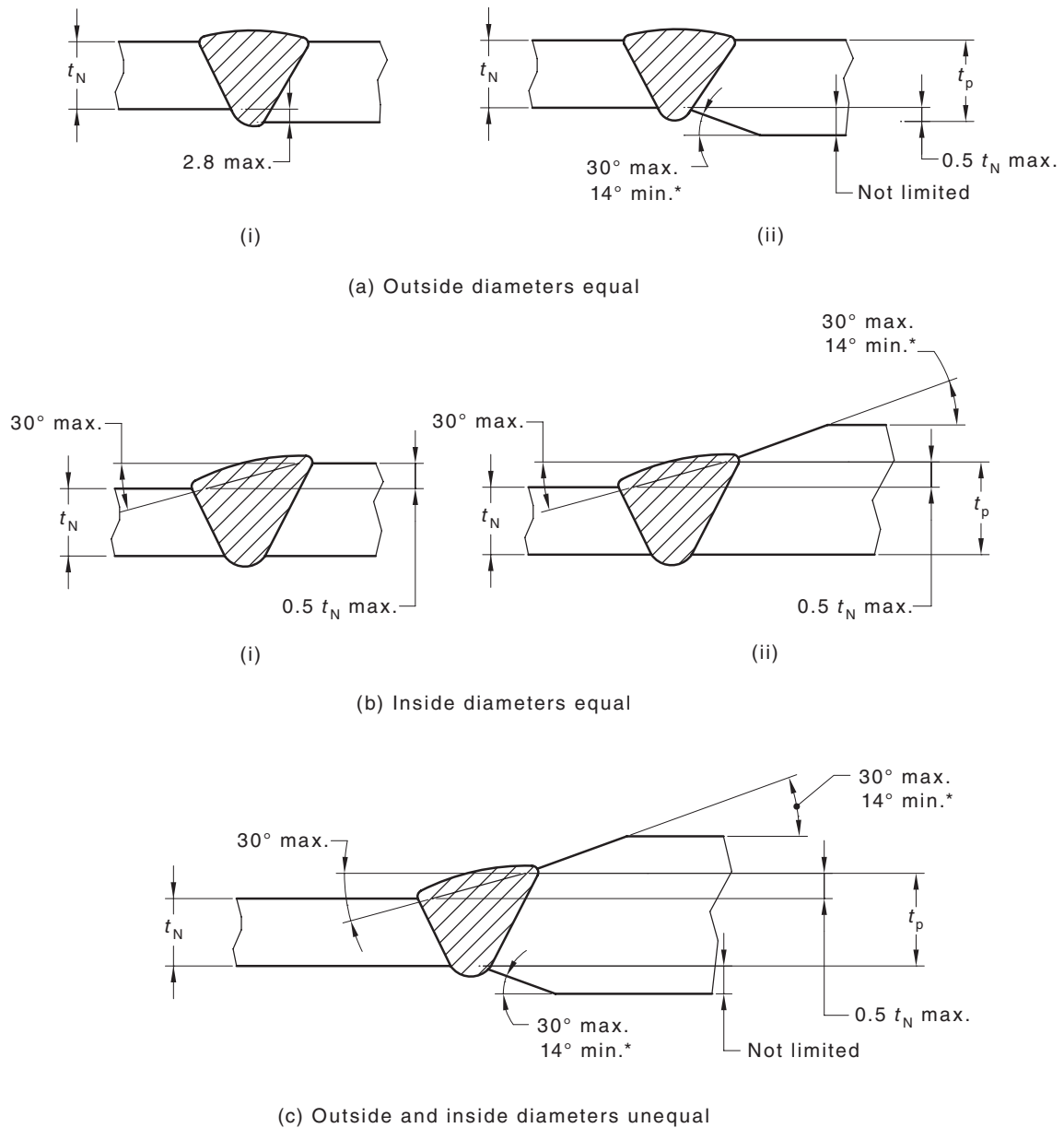
5.3 Butt welds between components of unequal nominal thickness

The weld preparations on a butt weld between COMPONENTS of unequal NOMINAL THICKNESS shall be as shown in [Figure 5.3](#).

When the SPECIFIED MINIMUM YIELD STRENGTH (SMYS) of the COMPONENTS to be jointed are unequal, the joint shall have measured tensile strength at least equal to that of the lower strength COMPONENT as demonstrated by carrying out a transverse butt tensile strength test in accordance with [Clause 7.4.2](#). This may be demonstrated by a joint using the thinner material only. In the case of the thicker COMPONENT, the thickness for design internal pressure shall be not greater than 1.5 times the NOMINAL THICKNESS of the thinner COMPONENT unless additional analysis is undertaken. Grade ratios greater

than 1.5 may be used provided that stress analysis shows the axial stresses are between 10 % and 60 % of SPECIFIED MINIMUM YIELD STRENGTH (SMYS).

NOTE Care should be taken analysing stresses on transitions near bends, in pipelines with large tie-in stresses or thermal variation, or where ground movement may occur as these situations are likely to increase axial loadings.



*No minimum where the parent metals have the same SMYS

LEGEND:

t_N = nominal wall thickness of the thinner pipe
 t_p = thickness for design internal pressure

NOTE 1 The standard root face dimension is $1.6 \text{ mm} \pm 0.8 \text{ mm}$. Other joint preparations are acceptable subject to qualification.

NOTE 2 In joints of unequal thickness and/or grade, where local allowable hoop stress may be exceeded, an option is to demonstrate fitness for purpose using FINITE ELEMENT ANALYSIS (FEA).

NOTE 3 Match boring may be required with wall thickness changes if AUT is used.

Figure 5.3 — Weld preparations for butt welds — Unequal nominal thickness or grade

5.4 Reinforcement of a butt weld

The height of the weld reinforcement of a butt weld shall be in accordance with [Clause 18.4.2](#), and with any requirements specified in the weld joint design.

NOTE Unless otherwise specified in the design, this Standard does not specify minimum levels of weld reinforcement beyond filling the joint flush with the parent metal.

5.5 Longitudinal butt welds

Longitudinal butt welds on sleeves shall be attached using a procedure that does not allow penetration of the weld into the carrier pipe.

NOTE One method is to use a backing bar.

5.6 Fillet weld

5.6.1 Dimensions of a fillet weld

A fillet weld may be slightly convex or slightly concave and shall have the specified leg length or throat thickness. The size of fillet weld shall be the leg length of the largest isosceles triangle that can be inscribed in the weld section. The size, convexity or concavity and leg lengths shall be measured to the nearest 0.5 mm on a section scribed with lines as shown in [Figure 5.6.1](#). The depth of the concavity or the height of the convexity shall be equal to or less than 2 mm. For production welds, any gap between the two parts being joined shall be subtracted from the fillet leg length and throat thickness.

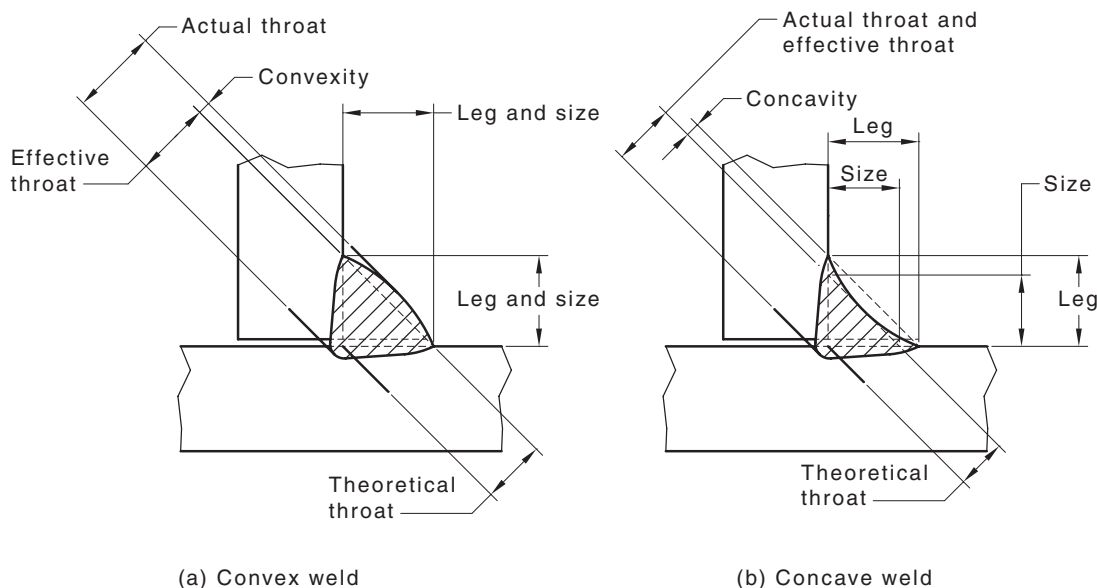


Figure 5.6.1 — Cross-section of a fillet weld

5.6.2 Fillet welding a lug, boss, pig bar or pad

A fillet-welded lug, boss, pig bar or pad shall conform to the following:

- (a) *Dimensions* — The length of a lug shall be not less than 50 mm (see Notes 1 and 2).
- (b) *Surface preparation* — The area of the pipe to which the connection is to be made shall be clean and be free from oil, scale, and surface-connected DEFECTS.

- (c) *Fit up* — The attachment shall fit up to the circumference of the pipe or pressure-containing COMPONENT.
- (d) *PIG bars* — The bars shall not be welded directly to the high stress areas around the extrusion neck (see Note 3).

NOTE 1 A boss should be circular with a DIAMETER not less than 50 mm.

NOTE 2 Rectangular or square pads may be used, provided the corners of the pad are rounded.

NOTE 3 The bars transverse to the flow direction should be welded to a pup piece and the bars parallel to the flow direction should be welded to the transverse bars only. In situations where this is impracticable, alternative designs should be considered in order to avoid peak stresses at the ends.

The lugs, bosses, PIG bars or pads shall be welded to the pipe or pressure-containing COMPONENT using an APPROVED WPS.

5.6.3 Sleeve fillet welds

The fillet welds for sleeve COMPONENTS shall be sized according to [Figure 5.6.3](#).

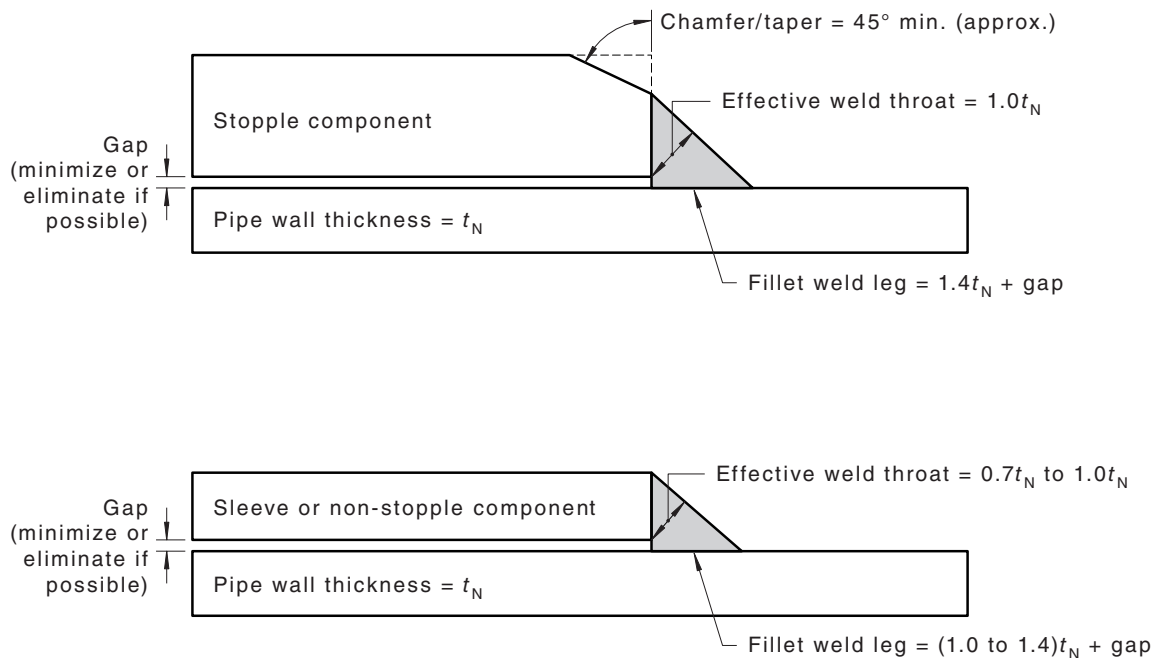


Figure 5.6.3 — Cross-section of sleeve and stopple component fillet weld

5.6.4 Flanges and forged socket components

The size of fillet welds for flanges and forged socket COMPONENTS shall be as specified in AS 4041.

5.7 Welding of threaded joints

Welding shall not be carried out on threaded joints for any purpose, including sealing against leakage unless APPROVED by an engineering assessment.

5.8 Reinforcement of a welded branch connection

The design of welds involving pipe to pipe branch connections (whether sit-on or set-in) shall be in accordance with Appendix L of AS/NZS 2885.1.

5.9 Reinforcement of multiple openings

The reinforcement of multiple openings shall be determined from Appendix L of AS/NZS 2885.1.

5.10 Forged branch component

A forged branch COMPONENT with integral reinforcement shall be designated sit-on or set-in.

The weld between a set-in branch COMPONENT and a pipe shall be designated a tee-butt weld.

The weld between a sit-on branch COMPONENT and a pipe shall be designated a single bevel butt weld.

The weld joint design shall be in accordance with AS/NZS 2885.1. The weld toe detail at branches shall meet the requirements of AS 4041.

NOTE The welding of forged branch type COMPONENTS with integral reinforcement, such as weldolets, is shown in AS 4041.

5.11 Effect of components on PIG passage

The method of welding COMPONENTS into pipelines, which may require pigging during their design life, shall —

- (a) allow free passage of PIGs in the main pipeline; and
- (b) prevent entry of main pipeline PIGs into any branch line.

5.12 Offset of longitudinal welds

Longitudinal welds on the opposite sides of a girth weld shall be staggered circumferentially. The minimum circumferential offset distance between longitudinal welds shall be not less than six times the pipe wall NOMINAL THICKNESS.

5.13 Distance between welds

A weld for any branch connection (whether integrally reinforced or not) or any welded attachment to the pipe shall be located a minimum distance of approximately six times the pipe NOMINAL THICKNESS from any circumferential weld in the pipe.

NOTE: The minimum distance between girth welds should be 1.5 times the pipe diameter.

5.14 Location of aluminothermic welds and brazing connections

Aluminothermic welds and brazing connections shall be located at a distance greater than 6 times the pipe wall thickness from an existing pipeline longitudinal or circumferential weld. Where multiple cable connections are required, the spacing between them shall be greater than 75 mm.

5.15 Attachment of electrical conductors

Conductors shall be attached to pipelines using aluminothermic welding, brazing or by fillet welding a lug, boss or pad.

5.16 Golden welds

The number and location of GOLDEN WELDS shall be assessed in accordance with a SAFETY MANAGEMENT STUDY and shall be APPROVED.

NOTE For information on a SAFETY MANAGEMENT STUDY, see AS/NZS 2885.6

Section 6 Qualification of a welding procedure specification

6.1 Welding procedure specification (WPS)

The purpose of a WELDING PROCEDURE SPECIFICATION is to document the nominal and, where appropriate, average values of the ESSENTIAL VARIABLES and NON-ESSENTIAL VARIABLES of the welding procedure, and the limits of these variables.

The WPS constitutes the work instruction for the weld. [Table 6.1\(A\)](#) lists the items that shall be defined for each welding procedure.

The ESSENTIAL VARIABLES for qualified welding procedure specifications shall be in accordance with [Table 6.1\(B\)](#).

Table 6.1(A) — Items for qualified procedures

Item [see Note 1 of Table 6.1(B)]		Remarks
PIPE		
1	(a) Material specification (b) Material manufacturer (c) Material CARBON EQUIVALENT (CE)	Pipe and COMPONENTS conforming to the AS(/NZS) 2885 series of Standards, another relevant Australian Standard, or another APPROVED Standard Where material grade SMYS $\geq$ 480 MPa $CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15}$
2	NOMINAL THICKNESS (t_N)	NOMINAL THICKNESS of each component of the joint
3	DIAMETER group	Applicable to the DIAMETER of each pipe, branch pipe or component
PROCESS		
4	Welding process	The arc welding process (e.g. MMAW, automatic GMAW, GTAW, SAW, FCAW or a nominated combination)
DESIGN		
5	Preparation	Joint preparation (e.g. type and details of bevel, root face, and gap) and the dimensional tolerances upon the preparation. For high-low limits, see Clause 18.4.3
6	Weld shape and size	Shape and size of welds
7	Backing	Type of backing or consumable insert (if used)
8	Passes	Number and sequence of passes (including stripper passes)
9	Position	Positions qualified in Table 8.2
10	Direction of welding	Vertical up or vertical down
FILLER		
11	Filler metal	DIAMETER and classification of electrode for each pass. For mechanized GMAW and FCAW, electrode brand name
SHIELDING		
12	Shielding gas	(a) Type, composition and flow rate of gas or gas mixtures used for shielding or backing (b) Nozzle or cup size
13	Shielding flux	Type, size, classification, make and brand number

Table 6.1(A) *(continued)*

Item [see Note 1 of Table 6.1(B)]		Remarks
ELECTRICAL		
14	Electrical characteristics	Arc type (globular, spray, pulsed, short circuit), current, polarity, voltage and wave form for each size and type of electrode
15	Waveform power sources	A change in the welding machine model
16	Contact to work distance	A change in the distance
PROCEDURE		
17	Number of welders	Minimum number of root and hot pass welders
18	Type of line-up clamp	Internal clamp, external clamp, no clamp
19	Removal of line-up clamp, and/or type of lift [see Note 8, 9 and 10 of Table 6.1(B)]	Minimum percentage of root pass to be completed before release of clamp. Where less than 100 %, the location of the completed proportion shall be specified [see Notes 8, 9 and 10 of Table 6.1(B)]. The type of lift shall also be specified
20	Tack welding (if used)	Number and size of tacks employed
21	Time lapse between individual passes [see Table 6.1(B)]	Maximum time lapse — (a) between the start of the root pass and the start of the hot pass; and (b) between subsequent passes
22	PREHEAT TEMPERATURE and INTERPASS TEMPERATURE	Heating method, width heated, PREHEAT TEMPERATURE and INTERPASS TEMPERATURE
23	PWHT and post-weld cooling	(a) For PWHT, the heating method, width heated, minimum and maximum temperature, time at temperature, method of temperature measurement, and control of maximum and minimum cooling rates (b) For deliberate accelerated post-weld cooling above 100 °C, the method or the rate of cooling
24	HEAT INPUT or BURN-OFF RATE [see Note 6 of Table 6.1(B)]	HEAT INPUT or BURN-OFF RATE for each pass
CLEANING		
25	Cleaning	Equipment and method used
METHOD OF QUALIFICATION		
26	The method of qualification as listed in Clause 6.4	Nominate the method of qualification
NOTE Item indicates the specification topic.		

Table 6.1(B) — Essential variables for qualified welding procedures

Item and ESSENTIAL VARIABLE (see Note 1)	Welding process				
	Cellulosic MMAW	Low hydrogen MMAW	GMAW and FCAW	SAW	GTAW
1. Material					
(a) Where SPECIFIED MINIMUM YIELD STRENGTH (SMYS) > 480 MPa, an increase of SMYS of 45 MPa	X	X	X	X	X
(b) Where material SMYS ≥ 480 MPa — Steel manufacturer (combinations between different steel manufacturers do not require separate qualification [see Clause 6.6.3(b)])	X	—	—	—	—
(c) For actual CE values of < 0.35, an increase of CARBON EQUIVALENT of > 0.05 above that used for the procedure test weld	X	—	—	—	—
(d) For actual CE values of ≥ 0.35, an increase of CARBON EQUIVALENT of > 0.03 above that used for the procedure test weld	X	—	—	—	—
(e) For actual CE, an increase of CARBON EQUIVALENT of > 0.10 above that used for procedure test weld	—	X	X	X	X
(f) For material that is to be PWHT, a change to or from quenched and tempered or thermo-mechanically processed condition	X	X	X	X	X
2. Wall thickness					
Tier 1: Change of material NOMINAL THICKNESS in a COMPONENT of a joint	0.5t–1.2t	0.5t–1.5t	0.5t–1.5t	0.5t–1.5t	0.5t–1.5t
Tier 2: Change of material NOMINAL THICKNESS in a joint	t–1.2t	t–1.2t	t–1.2t	t–1.2t	t–1.2t
Tier 3: Change of material NOMINAL THICKNESS in a joint	t	t	t	t	t
3. DIAMETER group					
Change in DIAMETER outside the DIAMETER groups qualified as follows:	X	X	X	X	X
(a) $D \leq 60.3$ mm					
(b) 60.3 mm < $D \leq 508$ mm					
(c) $D > 508$ mm where D is the DIAMETER of the test weld					
Or, as an alternative to the DIAMETER groups given above, where there is a change in DIAMETER from a qualified procedure of more than 50 % of the DIAMETER	X	X	X	X	X

Table 6.1(B) (continued)

Item and ESSENTIAL VARIABLE (see Note 1)		Welding process				
Pipe		Cellulosic MMAW	Low hydrogen MMAW	GMAW and FCAW	SAW	GTAW
PROCESS						
4. Welding process						
(a)	A change from one welding process or combination to another	X	X	X	X	X
(b)	Change from a manual operation to semi-automatic or automatic operation, or vice versa	—	—	X	X	X
(c)	Change of AUTOMATIC WELDING system used (see Note 4)	—	—	X	X	X
(d)	Change of bug manufacturer or model	—	—	X	X	X
DESIGN						
5. Preparation						
(a)	Any change to the nominal dimensions of the weld preparation and their tolerances	X	X	X	X	X
(b)	An increase in the specified level of high-low beyond the limits of Clause 18.4.3	X	X	X	X	X
6. Weld shape and size						
Change beyond that specified by joint design tolerances (see Section 5)		X	X	X	X	X
7. Backing						
Deletion or addition or change of a backing material or consumable insert		—	X	X	X	X
8. Passes						
Reduction in number of passes to less than 4		X	—	—	—	—
9. Position						
Change in position other than as specified in Table 8.2		X	X	X	X	X
Change in lead angle beyond range qualified		—	—	X	X	X
10. Direction of welding						
Change between vertical up and vertical down		X	X	X	—	X



Table 6.1(B) (continued)

Item and ESSENTIAL VARIABLE (see Note 1)	Welding process				
	Cellulosic MMAW	Low hydrogen MMAW	GMAW and FCAW	SAW	GTAW
FILLER					
11. Filler metal (electrodes, filler wire)					
(a) Any change in welding consumable classification, as defined within a nominated standard (Table 4.2.1.)	X	X	X	X	X
(b) Change in electrode DIAMETER used for the root pass of electrode, filler wire or rod	X	X	X	X	X
(c) For cellulose or cellulosic electrodes a change in manufacturer and factory of origin	X	—	—	—	—
SHIELDING					
12. Shielding gas					
(a) Change between one gas or mixture and another gas or mixture	—	—	X	—	X
(b) Decrease in shielding gas flow rate by more than 10 % or decrease in the nozzle or cup size	—	—	X	—	X
(c) Change of gas backing type, composition or flowrate	—	—	X	—	X
13. Shielding flux					
(a) Change in flux, type, classification or make number	—	—	—	X	—
(b) Change in flux/electrode combination resulting in different classification number	—	—	—	X	—
ELECTRICAL					
14. Electrical characteristics					
(a) Change of polarity of the electrode	X	X	X	X	X
(b) Change of electrical current between a.c. and d.c.	X	X	X	X	X
(c) Change of arc type between spray arc, globular arc, pulsed arc, and short-circuiting (dip transfer) arc or between the use of a conventional power source and a controlled waveform power source	—	—	X	X	X
(d) Change in the welding machine model	—	—	X	X	—
(e) Change of more than 25 % in contact tip-to-work distance	—	—	X	X	—
PROCEDURE					
15. Number of welders					
Decrease in number of welders used on any root pass, or hot pass, in the procedure test field	X	—	X	—	—

Table 6.1(B) (continued)

Item and ESSENTIAL VARIABLE (see Note 1)	Pipe	Welding process				
		Cellulosic MMAW	Low hydrogen MMAW	GMAW and FCAW	SAW	GTAW
16. Removal of line-up clamp (see Note 9)						
(a) A reduction in the proportion of root pass welded before the line-up clamp is released		X	X	X	X	X
(b) A change from normal to extreme lift (see Appendix B)		X	—	—	—	—
17. Tack welding						
A reduction in the number or size of tack welds or both		X	X	X	X	X
18. Time between individual passes (see Note 5)						
(a) Increase in time lapse beyond the qualified range for the root to hot pass		X	—	—	—	—
(b) Increase in time lapse between other passes		X	—	—	—	—
19. Preheat and INTERPASS TEMPERATURES (see Note 11)						
(a) For material grades of SMYS < 480 MPa a decrease in material temperature of more than 25 °C below or an increase of more than 75 °C above that used in the procedure test weld		X	X	X	X	X
(b) For material grades of SMYS > 480 MPa a decrease in material temperature of more than 10 °C below or an increase of more than 75 °C above that used in the procedure test weld (see Note 11)		X	X	X	X	X
20. PWHT and/or cooling						
(a) Change in PWHT		X	X	X	X	X
(b) Change in post-weld cooling method and intensity, or rate of cooling (see Clause 13.2)		X	X	X	X	X
21. HEAT INPUT or BURN-OFF RATE (see Note 6)						
(a) For each individual pass of mechanized or AUTOMATIC WELDING, a change of HEAT INPUT of more than 15 % from the average determined using data associated with corresponding weld pass from the procedure test weld		—	—	X	X	—
(b) For manual welding, a change of HEAT INPUT or BURN-OFF RATE of more than 15 % above and below the range used in the procedure test weld. At the LICENSEE's discretion, extreme high or low HEAT INPUT outliers may be deleted from the range		X	X	X	—	X
22. Cleaning equipment and method used		X	X	X	X	X

NOTES TO [TABLE 6.1\(B\)](#):

NOTE 1 "X" indicates applicability.

NOTE 2 The ESSENTIAL VARIABLE specifies the limits outside which requalification is required. Changes in NON-ESSENTIAL VARIABLES require documentation but do not require requalification.

NOTE 3 In tapered joints or branch welds the NOMINAL THICKNESS to be considered shall be the effective thickness on the thicker side of the joint. The effective thickness shall be as defined in Weld Australia (formerly WTIA) publication TN 01.

NOTE 4 Guidance for welding systems, Item 4(c), are referenced in [Appendix E](#).

NOTE 5 **Applies to cellulosic MMAW only.** The method of defining time lapse shall be the same for production welds as is used for procedure qualification welds. It is recommended that the time lapse from start of root pass to start of hot pass be the defined method to avoid uncertainties associated with root repairs.

NOTE 6 **Applies to MMAW only.** BURN-OFF RATE is defined as the ratio of length of electrode consumed to the length of weld pass deposited. Weld Australia publication TN 01 provides information relating BURN-OFF RATE to HEAT INPUT.

NOTE 7 **Applies to cellulosic MMAW only.** The ESSENTIAL VARIABLES in [Table 6.1\(B\)](#) primarily address the risk of HACC. This is clearly evident by the latitude extended to the range of NOMINAL THICKNESS (Item 2). Tier 2, however, permits increased DEFECT limits based on demonstrated mechanical properties, i.e. weld metal strength MATCHING and fracture toughness. Although Tier 2 DEFECT limits are proportional to NOMINAL THICKNESS, variations in NOMINAL THICKNESS can strongly influence DEFECT tolerance. This is principally a consequence of the fact that PLANAR DEFECTS are assumed to be one weld pass deep (i.e. 3 mm). Such an assumed DEFECT depth in thin-walled pipe can significantly change the requirement of weld strength MATCHING (despite the proportional decrease in DEFECT limit). For this reason the Tier 2 and Tier 3 lower limit multiplier for NOMINAL THICKNESS range is more restrictive than that for Tier 1.

NOTE 8 **Applies to cellulosic MMAW only.** Research work carried out by the CRC for welded structures (CRC-WS) has shown that for normal lifts (see [Appendix B, Clause B.9.2.1](#)) the additional strains over and above the weld contraction strains, caused by lifting and lowering, are small for pipe DIAMETERS less than DN 500. It has also shown that providing due attention is paid to the other factors governing the risk of HACC, the removal of the line-up clamp after at least 50 % of the root pass is completed, does not by itself cause cracking.

NOTE 9 **Applies to cellulosic MMAW only.** The proportion of the root pass completed before clamp release shall be ≥ 50 %.

NOTE 10 **Applies to cellulosic MMAW only.** Where the proportion of the root pass completed before the line-up clamp is released is < 100 %, then at least 80 % of both the top and bottom quadrants shall be completed before clamp release.

NOTE 11 Refer to [Clause 6.6.5](#) which requires the test weld to be made under conditions that simulate the worst case to be encountered in production.

6.2 Purpose of qualifying a welding procedure

A welding procedure shall be qualified to demonstrate that the production welds made in accordance with the welding procedure —

- (a) have the required mechanical properties such as strength, toughness, ductility and hardness;
- (b) produce sound result, that is free from cracks, unacceptable porosity or other DEFECTS; and
- (c) are free from the risk of HYDROGEN ASSISTED COLD CRACKING (HACC).