



External fusion-bonded epoxy coating for steel pipes



AS 3862:2020

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Preface

This Standard was prepared by the Australian members of the joint Standards Australia/Standards New Zealand Committee ME-038, Petroleum Pipelines, to supersede AS/NZS 3862:2002.

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

The objective of this Standard is to provide purchasers and manufacturers of petroleum pipelines with a Standard for the specification of pipeline coatings using external fusion-bonded epoxy.

The fusion-bonded epoxy coating referred to in this Standard is only intended to be applied to the external surfaces of pipes.

This Standard does not purport to satisfy all requirements for pipelines. The primary change in this revision is the inclusion of coverage for dual- and multi-layer fusion-bonded epoxy systems to supplement the existing single layer product. Some testing requirements were updated to reflect current practice as set out in other Standards.

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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External fusion-bonded epoxy coating for steel pipes

Section 1 Scope and general

1.1 Scope

This Standard specifies requirements and methods of test for external fusion-bonded epoxy (FBE) coating of steel pipes for protection against corrosion. This Standard covers both single-layer and multi-layer coating systems.

NOTE 1 Guidelines to purchasers on information that should be supplied by the purchaser and those variables that should or may be agreed upon at the time of inquiry or order are given in [Appendix A](#).

NOTE 2 Line pipe manufactured in accordance with API 5LW may not be suitable for application of FBE coating without requiring additional surface preparation. Surface imperfections in the form of steel slivers, burrs and laminations can cause excessive holidays, resulting in the need for extra surface cleaning, grinding or filing.

NOTE 3 Line pipe manufactured in accordance with API 5LW may require a more stringent straightness specification to allow coating in accordance with this Standard.

NOTE 4 Consideration should be given to strain ageing when specifying line-pipe for FBE coating. Guidance is given in [Clause 3.1.3](#).

Methods for demonstrating conformance with this Standard are given in [Appendix B](#).

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 1627.4, *Metal finishing—Preparation and pre-treatment of surfaces, Part 4: Abrasive blast cleaning of steel*

AS 3894.1, *Site testing of protective coatings, Part 1: Non-conductive coatings—Continuity testing—High voltage (brush) method*

AS 3894.3, *Site testing of protective coatings, Part 3: Determination of dry film thickness*

AS 3894.5, *Site testing of protective coatings, Part 5: Determination of surface profile*

AS 3894.6, *Site testing of protective coatings, Part 6: Determination of residual contaminants*

AS 4352, *Tests for coating resistance to cathodic disbonding*

ASTM D149, *Standard Tests for Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies*

ASTM D257, *Standard Test Methods for DC Resistance or Conductance of Insulating Materials*

ASTM D1044, *Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion*

ASTM D1653, *Standard Test Methods for Water Vapor Transmission of Organic Coating Films*

ASTM D1921, *Standard Test Methods for Particle Size (Sieve Analysis) of Plastic Materials*

ASTM D2240, *Standard Test Method for Rubber Property—Durometer Hardness*

ASTM D2370, *Standard Test Method for Tensile Properties of Organic Coatings*

ASTM D4060, *Standard Test Method for Abrasion Resistance of Organic Coatings for the Taber Abraser*

ASTM G11, *Standard Test Method for Effects of Outdoor Weathering on Pipeline Coatings*

ASTM G14, *Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)*

ASTM G17, *Standard Test Method for Penetration Resistance of Pipeline Coatings (Blunt Rod)*

API RP 5L1, *Recommended practice for railroad transportation of line pipe*

API RP 5L5, *Recommended practice for marine transportation of line pipe*

1.3 Terms and definitions

For the purpose of this document, the definitions below apply.

1.3.1

abrasion resistant overcoat

ARO

two-layer FBE with an anti-corrosion coating and an abrasion-resistant overcoat

1.3.2

anti-slip overcoat

rough textured outer surface FBE layer applied over a corrosion resistant FBE layer for a variety of service applications, such as a corrosion resistant underlayer for concrete coated pipe, offshore laying, or other handling applications requiring a higher friction coefficient

1.3.3

batch (FBE powder)

quantity of epoxy powder produced using the same formulation and raw materials of the same source during a continuous production run of not more than 24 hours

1.3.4

bolster

support for coated pipes during transport and storage

1.3.5

coating defect

deleterious imperfection in the coating including disbonded areas, areas of low film thickness and holidays

Note 1 to entry: Surface anomalies commonly referred to as “blowholes”, “fish-eyes”, “volcanoes” or “craters” are deleterious to the performance of the FBE coating only if they provide a pathway for water through the coating or significantly reduce the coating thickness. These anomalies should not be considered coating defects if they pass the holiday test and are constrained to the top layer of a multi-layer system. Solid lumps/drops, typically from gun tips, are not considered deleterious.

1.3.6

coupon

sample of steel pipe coated with fusion bonded epoxy and used for laboratory tests

1.3.7

drop

non-homogeneous or partially cured lump of powder deposited on the surface of the coating

1.3.8

holiday

discontinuity of protective coating that exposes the steel to the outside environment

1.3.9**multi-layer FBE**

system consisting of a base layer of anti-corrosion FBE with an additional layer or layers of specifically formulated FBE

Note 1 to entry: The additional layers are selected to provide additional specific properties to the coating system e.g. improved mechanical protection, resistance to UV and chalking, improved hot-wet resistance and anti-slip (generally for offshore pipe-laying or concrete application).

1.3.10**pinhole**

small discontinuity on the surface of the FBE coating which may or may not extend to the steel surface

1.3.11**pipe diameter length**

length of pipe equating to the diameter of the pipe

1.3.12**run****sag**

visible flow of the coating under gravity to produce a significant local variation in film thickness

1.3.13**rust blooming**

visual detectable colour change on the surface of the pipe due to oxidation, other than as a result of pre-treatment

1.3.14**shelf life**

characteristic of each material formulation, which is related to storage time, temperature and humidity, which may make it unsuitable for use

1.3.15**substrate**

steel pipe surface to which the coating is to be applied

1.3.16**surface crater**

localized surface depression produced during coating application, detectable by normal vision

1.3.17**test panel**

sample of steel plate coated with fusion-bonded epoxy for laboratory tests

1.4 Pipe marking

Each pipe identity shall be accurately preserved throughout the coating process.

NOTE This may involve the transfer of pipe identity from the outside to the inside of each pipe prior to external coating and then from the inside to the outside prior to dispatch. The loss of pipe identity is usually grounds for discard of the pipe.

Unless otherwise specified by the purchaser, the following information shall be marked a minimum of 0.3 m clear of the ends of the pipe, on each length of coated pipe with a permanent weatherproof marking system:

- (a) Date of coating (year, month, day).
- (b) Coating applicator's name or trademark.
- (c) Nominal coating thickness, in micrometres, plus system, FBE, multi-layer FBE, ARO, etc.

- (d) Pipe specification and steel grade.
- (e) Pipe length, diameter and wall thickness.
- (f) Pipe traceability information (e.g. heat number, pipe number).

Section 2 Material requirements

2.1 Fusion-bonded epoxy (FBE) powder

The following requirements apply to the composition and properties of FBE powder:

- (a) FBE powder shall be a pigmented thermosetting material based on cross-linkable epoxy resins as the binder system.
- (b) In case of multi-layer FBE, which utilizes the application of a second (or more) FBE layer over the base FBE anti-corrosion coating, the upper layers may be specially formulated to provide additional mechanical, anti-slip or UV-resistance properties.
- (c) The components of the formulation shall be melt-compounded in an extrusion process prior to being milled to the final powder form.
- (d) The powder shall be free flowing and able to be fluidized and spray-applied using conventional electrostatic guns.
- (e) When applied to a pre-heated pipe, the powder shall fuse to form a continuous uniform film. Cure shall be under the action of the residual heat in the pipe, or through a controlled post cure process.

2.2 Abrasive materials

Abrasive materials shall conform to the requirements of AS 1627.4. They shall be free from contamination and contain less than 100 mg/kg chlorides and less than 0.3 % copper.

Abrasives shall be shot or grit, or both, in accordance with AS 1627.4. The particle size shall be such that the blasted steel pipe surface conforms to [Clause 3.1.2](#).

Abrasives for use in field joints shall be silica-free non-metallic or metallic materials in accordance with AS 1627.4. The particle size shall be such that the blasted steel pipe joint conforms to [Clause 3.2.5](#).

2.3 Repair materials

The repair material shall be a two-pack epoxy resin or other suitable material that is compatible with the original coating.

Materials that have been subject to environmental conditions that exceed those specified by the manufacturer, including shelf life, shall not be used.

All repair materials shall conform to the requirements of this Standard, including those shown in [Table B.5](#).

Section 3 Application

3.1 Mill application

3.1.1 General

During surface preparation, coating and all handling activities, measures shall be taken to ensure pipe ends are not damaged. Ovality, bevel and bevel landing to remain within the requirements of the bare pipe specification. A quality management system shall be used.

NOTE An example of a suitable quality management system standard is AS/NZS ISO 9001.

3.1.2 Surface preparation

The following requirements apply to surface preparation:

- (a) All oil, grease, soil, organic and other contaminants shall be thoroughly removed prior to abrasive cleaning. After cleaning, the pipe shall be suitably protected from, and maintained free of, all contaminants.
- (b) Prior to the application of the coating, all rust and mill scale shall be removed from the external surface of the pipe by abrasive blast cleaning in accordance with AS 1627.4.
- (c) Any solvents or detergents used in the pre-cleaning of pipe for spot removal of contaminants shall not leave a residue or coating, either before or after heating, which may adversely affect coating application or performance, or degrade pipe properties.
- (d) Any water used in the pre-cleaning of the pipe surface shall be potable. It shall not contain more than 500 mg/L of total dissolved solids. The water shall not be re-used.
- (e) The pipe shall be preheated prior to abrasive cleaning to a temperature at least 10 °C above the dew point. Thermometers used for determination of the dew point shall be calibrated to an accuracy of ± 0.5 °C. All pipe coming from the preheat oven or heating equipment shall be free of all moisture. Damp or wet pipe shall not be abrasive cleaned.
- (f) Where the pipe is coated internally, the internal coating shall be protected from grit blast and impact damage at all times.
- (g) The bevelled end of each pipe shall be preserved in the as-received condition.

NOTE 1 This is ordinarily achieved by the use of special polymer end caps or couplings that protect the bevelled end from impingement of grit and avoids the grinding together of pipe ends.

- (h) Cleaning of the external pipe surface shall be in accordance with AS 1627.4 and be a minimum finish quality of Class Sa 2½.
- (i) After passing through blast cleaning, the pipe surface shall be inspected for slivers, scabs, laminations, burrs or bristles of steel. Such surface features shall be removed by abrading with a flap disc, file or grinding wheel. Where these surface features are removed by use of a grinding wheel, the remaining wall thickness shall —
 - (i) be within the specified limits;
 - (ii) have a smooth profile; and
 - (iii) be re-blasted.

The flap disc, file or grinding wheel used shall not cause contamination of the pipe surface.

NOTE 2 AS/NZS 2885.1 provides requirements for remaining wall thickness for high pressure pipelines.

- (j) Abrading of individual surface areas greater than 4 000 mm² shall not be permitted. All abrading shall be carried out in a manner that produces an even profile on the pipe surface. The surface area treated on any one pipe shall not exceed 0.1 % of the total surface area to be coated.
- (k) After surface preparation, the surface profile shall be within the range of 50 µm to 100 µm peak to trough height measured with replication tape in accordance with Method A of AS 3894.5 or other approved method. The profile shall be angular and not have undercuts.

NOTE 3 Measurement of surface profile using a stylus instrument in accordance with the method of ASTM D7127 is acceptable. If this, or equivalent methods are specified by the purchaser, the acceptance criteria for surface parameters (e.g. R_{pc}, R_t) should be agreed between the applicator and the purchaser.

- (l) Pipe surface shall be monitored for contamination in accordance with AS 3894.6.
- (m) The blast-cleaned surface shall not be contaminated with material that may be detrimental to the coating performance including grit, dust, metal particles, oil, grease, water. In addition, the anchor pattern shall not be scarred or burnished beyond profile limit as specified.
- (n) Tests in accordance with AS 3894.6 shall be carried out prior to coating application to detect the presence and concentration of the following:
 - (i) Chloride contamination in excess of 25 mg/m².
 - (ii) Soluble iron corrosion products.
- (o) Pipes with chloride contamination in excess of 25 mg/m² (see Item (m)(i) above) shall be subject to pre-treatment. The chloride level shall be retested in accordance with Item (m).

NOTE 4 High pressure water wash with deionized or reverse osmosis water or a phosphoric acid wash and rinse pre-treatment with deionized water are accepted methods to reduce or eliminate chloride contamination and soluble iron corrosion products.

NOTE 5 Information on the benefits of pre-treatment is provided in [Appendix C](#).

- (p) Where pre-treatments are used, deleterious residues shall be removed prior to application of the coating. Any water used in the pre-treatment process shall have a maximum conductivity of 10 µS/cm.
- (q) Any pipe which is not suitably cleaned in accordance with [Clause 3.1.2\(m\)](#) shall be re-blast cleaned and retested.
- (r) All pipes shall be coated within 4 h of blast cleaning. Any pipe which is not coated within 4 h or where rust blooming has occurred shall be completely re-blast cleaned. Temperatures shall be monitored on entry to the coating line and be at minimum 3 °C above dew point.

3.1.3 Pre-application heating

The following applies to pre-application heating:

- (a) Pipe for coating shall be uniformly heated in accordance with the manufacturer's specified temperature limits but shall not exceed 260 °C.

NOTE 1 The method of heating should be by induction coil or indirect fired oven.

NOTE 2 The optimum range of application temperature depends on the particular powder used and may be narrower than the broad range indicated above. Below the minimum application temperature, adhesion, after the hot water test ([Appendix K](#)), and cathodic disbondment resistance (AS 4352) may be reduced.

The coating plant may be required to cut samples for mechanical testing by others. See AS/NZS 2885.1.

- (b) The prior strain of pipe forming with subsequent heating for FBE coating will result in thermal strain ageing of the pipe. The purchaser should consult with the pipe supplier to ensure that the pipe will meet the requisite mechanical properties after the heat treatment experienced during coating. The extent to which steel strength and toughness are ultimately affected depends collectively on —
- (i) the level of applied strain in pipe forming and cold expansion;
 - (ii) the subsequent thermal history of the pipe, i.e. coating temperature and time; and
 - (iii) steel composition.

The composition of steel may be adjusted to minimize strain ageing effects but is unlikely to eliminate them. Pipeline owners often require the increase in strength and change in toughness to be characterised by tests on coated pipe for comparison with as-rolled test results from the pipe mill.

Where strain-aging is of concern, it is customary to require the coating plant to cut many samples for mechanical testing by others, refer to AS 2885.1:2018 Section 5.12. As post-coated steel properties are heat sensitive, the sample cutting process must not heat the pipe above 60 °C. This ordinarily precludes flame cutting within 200 mm of the region of coated pipe to be tested.

- (c) The pipe surface temperature shall be checked and recorded using temperature-indicating crayons or other suitable means. Crayons used to mark the pipe surface shall not cause deleterious effects. The use of crayons shall be kept to a minimum. The nominal temperature value of the temperature-indicating crayons shall be checked prior to use. The designated melting range for each batch of temperature-measuring crayons shall be checked, by determining the actual melting range of the crayon using differential scanning calorimetry (DSC). Immediately prior to entry into the powder booth, the surface temperature shall be continuously monitored with infrared pyrometer or similar device. As a minimum, this shall have a visual display, showing the temperature. The equipment should include a recorder and over/under alarms.
- (d) The heating operation shall not cause contamination of the prepared surface by combustion products or surface oxidation.
- (e) Residual magnetism shall be measured on selected separated pipes following the completion of the coating process and before removal from the outgoing racks in the coating facility. The longitudinal magnetic field shall be measured at the root face using a Hall-effect magnetic flux density meter or similar calibrated instrument, in accordance with the manufacturer's procedures. The average value of four readings should not exceed 30 gauss, with a maximum single reading not exceeding 35 gauss. Measurements shall be made at least once every 4 h. In the event of a high reading, pipes either side should be tested until three consecutive pipes meet the requirement. Defective coated pipes shall be segregated, demagnetized and remeasured.

3.1.4 Application of FBE powder

The following requirements apply to the application of FBE powder:

- (a) The powder shall be applied to the pipe surface by an electrostatic spray. The resulting cured coating thickness shall be 400 µm min.
- (b) For a multilayer system, the minimum anti-corrosion base layer shall have a minimum dry film thickness (DFT) of 300 microns. An overcoat may be applied as an integrated process with chemical bonding during the same process to increase the thickness to provide improved abrasion resistant or protective properties. The dwell time between the powder application of the layers shall be in accordance with the manufacturer's requirements. An anti-slip overcoat

may additionally be applied to both single and dual layer systems. FBE overcoat shall not be applied directly to steel.

NOTE 1 Thicknesses in excess of 600 μm may limit flexibility.

NOTE 2 The minimum thickness required will depend on the performance of the particular powder being used, pipeline operating conditions, pipeline route terrain and many other factors. Accordingly, minimum coating thickness should be that specified by the purchaser for the particular end use being considered.

- (c) The heating temperature, the curing temperature and curing time shall be consistent with the powder manufacturer's specification for application procedure.
- (d) The coating shall be applied to the external surface of the full length of each pipe except for a cutback of 75 mm to 120 mm at each end. The cutback shall be measured from the bevel shoulder. Any coating applied to the cutback shall be removed without metal damage. This includes avoiding loss of wall thickness and damage to the pipe end to values below the bare pipe specification.
- (e) Recycled powder is permitted only when collected and processed through a closed system, which controls the ratio of recycled to virgin powder. Sieving equipment of 350 μm or finer and a magnetic particle separator shall be used. The ratio of recycled powder to virgin powder shall not exceed 20 %. All recycled powder shall be applied as a central layer between the base and the outer layer of a dual layer system. A maximum of 10 % cross mixing of base coat with topcoat is permitted. Where base and topcoat are applied in separate booths all the topcoat recycled powder may be used. Recycling of a sinter layer requires an additional booth and closed system, for re-use in the last few guns. Particle sizing shall be verified before use.
- (f) Recycled powder shall be tested before use and conform to the requirements of [Table B.2](#) for volatile content, gel time and DSC.
- (g) When coating application on a pipe length is discontinuous, the pipe shall be rejected, stripped of its coating and prepared for recoating in accordance with [Clause 5.1](#).
- (h) During coating application, curing and handling, the pipe (including bevelled ends), the coating, and the internal lining shall be protected against physical damage and any contamination that could be deleterious to the coating or internal lining.
- (i) Powder material on the internal surface of the pipe shall be removed without damaging pipe identification.

NOTE 3 Powder material should be prevented from entering the inside of the pipe.

- (j) During the entire coating application, curing and handling, the coating and internal lining shall be protected against physical damage and any contamination that could be deleterious to the coating or internal lining.
- (k) Measurement of DFT shall be in accordance with AS 3894.3—2002, Method B. All measurements shall be recorded.

NOTE 4 For production testing, the total system thickness should be measured on each pipe at five locations.

NOTE 5 For QC testing, the total system thickness should be tested at seven locations along the pipe, at start-up and at a frequency of every 30 min.

- (l) To measure the individual layer thicknesses, first measure the total system thickness, then the topcoat is removed in the test area using either grinding or router to expose the surface of the base layer, for the second measurement.

NOTE 6 This should be carried out at start-up, on one of the first 5–10 pipes, at five locations, then every 2 h at one location.

3.1.5 Post-curing

Post-application heating may be used to complete the curing of the coating. The pipe temperature reached during this process shall not exceed the powder application temperature.

The coated pipe shall not be subjected to a curing temperature in excess of 260 °C, as described in [Clause 3.1.3](#) Note 2.

3.1.6 Cooling

After completing cure in accordance with the powder manufacturer's recommendations, the pipe may be quenched with running water or forced air cooling to facilitate coating handling, inspection and repairs. The time to quench shall be monitored to ensure conformance to the manufacturer's minimum curing requirements.

The pipe shall cool in such a manner as to avoid damage to the newly applied coating.

3.2 Field application

3.2.1 General

The field applied coating shall consist of either mono layer or two layer FBE.

3.2.2 Protection of mill-applied coating during pipe welding and cutting operations

Mill-applied coatings shall be protected from welding and flame cutting processes.

During pipe welding, cutting and blast cleaning it is necessary to protect the adjacent coating for a distance of approximately 750 mm each side of the welded joint or cut. This can be achieved by the use of blankets made of fire-resistant material, which will prevent sparks and globules of molten metal from contacting the surface of the mill-applied coating. These blankets shall be secured to the pipe throughout adjacent welding, grinding and cutting operations.

3.2.3 Protection of mill-applied coating during pipe pre-heating for welding

In many cases it is necessary to pre heat the pipeline prior to welding. Damage to the mill-applied coating can occur during this process. The application of flame heating outside the cutback area shall be avoided. Steel temperatures, adjacent to the mill-applied coating, shall not exceed 260 °C.

3.2.4 Pipe weld profile

The profile of the weld capping pass should not contain any irregularities or discontinuities (including surface undercut and lack of fusion on cap) which could affect the integrity of the joint coating.

3.2.5 Procedure trials

Prior to commencement of field coating, procedure trials shall be carried out to determine the following parameters:

- (a) Heating rate.
- (b) Heat profile — Temperature variation around the circumference.
- (c) Maximum and minimum temperatures.
- (d) Temperature decay rate.
- (e) Powder application method.
- (f) Powder application rate.

- (g) Number of passes to achieve required thickness.

The above tests shall be carried out under field conditions using field equipment on each diameter and thickness of pipe to be used.

NOTE 1 Where the heating procedure is controlled by time and heat input, the procedure should establish the impact of the substrate temperature on the heating time for situations including the following:

- (a) Early morning.
- (b) Wet conditions.
- (c) Conditions where there is a significant difference between the top and the underside of the pipe that is exposed to full sun.

NOTE 2 The maximum heat input rate should be established to minimize bubbling of the overlap coating.

3.2.6 Surface preparation

All discontinuities, sharp edges, points and slag shall be ground off the weld cap prior to field coating. Surface preparation shall be as follows:

- (a) Prior to abrasive cleaning remove all visible oil, grease, soil, organic and other contaminants in accordance with AS 1627.4.
- (b) Either before or after heating, ensure that solvents or detergents used do not leave an undesirable residue or coating on the pipe.
- (c) If water is used in the precleaning of the pipe surface prior to abrasive blast cleaning, the water shall be potable and not contain more than 500 mg/L of total dissolved solids.
- (d) The surface to be coated and the adjacent coating shall be dry prior to the commencement of dry blasting. Direct-flame drying shall not be used for powder application purposes. Direct-flame drying may be used prior to abrasive blast cleaning to bring cold areas around the joint to a similar steel temperature as the adjacent pipe.
- (e) Cleaning of the external pipe surface shall be abrasively blast cleaned in accordance with AS 1627.4 and be a minimum finish quality of Class Sa 2½.
- (f) The profile on the pipe steel after blasting shall be angular, between 50 µm and 100 µm as measured in accordance with AS 3894.5, and conform to the powder manufacturer's specification.
- (g) Blast-cleaning abrasives shall conform to the requirements of AS 1627.4. Abrasives shall be free of moisture and any other deleterious materials. Abrasives shall contain less than 100 mg/kg chlorides and less than 0.3 % copper. Abrasives shall be stored in a clean, dry area.
- (h) The mill-applied coating, adjoining the field joint, shall be abraded for a minimum distance of 50 mm from the edge of the field joint. In the case of a chamfered cutback edge, the minimum distance shall be 30 mm as measured from the top edge of the chamfer (i.e. at the position of full coating thickness).
- (i) After cleaning, each joint shall be visually inspected for surface defects and surface imperfections that might cause holidays in the coating. Such surface imperfections shall be removed by an approved method of grinding or filing. The remaining wall thickness shall be within the specified limits.

NOTE AS/NZS 2885.1 provides requirements for remaining wall thickness for high pressure pipelines.

- (j) All field joints shall be coated within 4 h of blast cleaning, subject to the steel temperature remaining at least 5 °C above the dew point. Any field joint that is not coated within 4 h of blast cleaning or where rust blooming or other contamination has occurred shall be completely reblasted.

- (k) The blast-cleaned surface shall be monitored for contamination in accordance with AS 3894.6 and the requirements of [Clause 3.1.2\(k\)](#) of this Standard. Where air is used for the removal of contaminants, it shall not further contaminate the surface.

3.2.7 Pre-application heating

The following requirements apply to pre-application heating:

- (a) Field joints before coating shall be uniformly heated in accordance with the manufacturer's specified temperature limits but not exceed 260 °C. Uniformity of heating shall be in accordance with [Appendix M](#).

NOTE 1 The method of heating should be by induction coil or indirect fired oven.

NOTE 2 See [Clause 3.1.3](#) Notes 1 and 2.

- (b) The pipe surface temperature shall be checked using temperature-indicating crayons, surface thermometers or other suitable means and recorded. Crayons used to mark the pipe surface shall not cause deleterious effects and their use shall be kept to a minimum. The nominal temperature value of the temperature-indicating crayons shall be checked prior to use. The designated melting range for each batch of temperature-measuring crayons shall be checked, by determining the actual melting range of the crayon using differential scanning calorimetry (DSC).
- (c) The period of heat-decay between maximum and minimum application temperatures on the field joint surface, prior to completion of coating, shall be checked at least three times per production day or whenever ambient weather conditions change significantly or whenever there is a change in pipe wall thickness or diameter. The application of the coating shall be completed within the heat-decay period as determined by [Appendix N](#).
- (d) Care shall be taken during the heating operation to prevent contamination of the prepared surface by combustion products or excessive oxidation.
- (e) Any mill-applied coating or repaired coating adjacent to the field joint that is damaged or blistered during the heating process shall be repaired. If blistering occurs in the parent coating, a modified heating rate, which does not promote the blistering, shall be determined and used.

NOTE 3 Blistering may occur in the parent coating if it is heated too rapidly. The problem is intermittent, and is not related to particular FBE powder types, coating thickness, or pipe properties. The cause of the problem is thought to be the rapid escape of absorbed water from the parent coating. A slow rate of heating can be used to control the rate of moisture release from the parent coating and greatly reduce the possibility of blistering.

3.2.8 Application of FBE powder

The following applies to the application of FBE powder:

- (a) The powder shall be applied to the pipe surface by spray. The resulting cured film thickness shall be not less than 400 µm and not less than the specified minimum thickness of the factory-applied coating.

NOTE The minimum and maximum thickness required will depend on the performance of the particular powder being used, pipeline operating conditions, pipeline route terrain and many other factors. Accordingly, minimum and maximum coating thicknesses should be that specified by the purchaser for the particular end use being considered.

- (b) The coating shall be applied over the entire bare steel area and with a minimum overlap of 50 mm on the adjacent mill-applied coating. The field-applied coating shall completely cover all mill coating abraded during surface preparation with a minimum overlap of 5 mm on untouched mill-applied coating. The overlap coating shall fuse with the substrate coating for

a minimum of 40 mm, when tested with a knife. Additional controls may need to be applied to the preheating rate and duration to achieve this condition.

- (c) When inspected visually, the applied coating shall be homogenous across the entire field joint. In particular, no surface imperfections detrimental to the quality of the coating (embedded grit, foreign particles, pitting, blisters etc.) shall be allowed.
- (d) Powder application equipment shall be completely cleaned before and after each day's work.

3.2.9 Post-application heating

Post-application heating may be used to complete the curing of the coating.

The coated joint shall not be subject to a curing temperature in excess of 260 °C. It shall conform to the powder manufacturers' specifications or written instructions.

NOTE Prolonged elevated temperatures over 220 °C and exceeding 300 seconds may result in degradation of the coating.

Section 4 Repairs

4.1 Repairs to coatings in the mill

The following applies to repairs to pipe coating in the coating mill:

- (a) All coating defects defined in [Clause 1.3](#) detected during inspection or in the course of handling the coated pipe shall be repaired using materials qualified in accordance with [Clause 6.2.3](#).
- (b) The maximum single area to be repaired shall be 0.01 m².
- (c) The maximum total area to be repaired on any individual pipe shall be 0.1 % of the total external surface area of the coated length of pipe.
- (d) For any individual pipe length, the number of coating defects shall not exceed the rate of 1 per metre of pipe length.
- (e) There shall be no more than 50 repairs on any 10 consecutive pipes.
- (f) Repairs shall be carried out in accordance with [Clause 4.3](#).
- (g) If any of the criteria described in Item (b), (c) or (d) is exceeded, the length of pipe shall be stripped and recoated.
- (h) The repaired area shall be subject to a holiday test in accordance with AS 3894.1.

4.2 Repairs to field joints and adjacent areas

Field joints and adjacent areas shall be subject to repairs as follows:

- (a) All holidays defined in [Clause 3](#) detected on coated field joints shall be repaired in accordance with [Clause 4.3](#). Visible coating discontinuities not detected electrically shall also be repaired.
- (b) The maximum number of holidays permitted to be repaired in the field joint coating and within 150 mm beyond the junctions of the field joint coating and the original coating shall be —
 - (i) 5 for pipe whose diameter is 273 mm or larger; or
 - (ii) 3 for pipe whose diameter is less than 273 mm.
- (c) If the criterion described in Item (b) is exceeded, the field joint shall be stripped and re-coated in accordance with the requirements of this Standard.
- (d) Repairs shall be carried out in accordance with [Clause 4.3](#).

4.3 Repair procedure

4.3.1 General

Repairs shall be carried out using a two-part epoxy resin material that is tested in accordance with [Clause 6.2.3](#); or, for major repairs, using stripping and recoating with a fusion bonded epoxy applied in accordance with [Clause 3.1.4](#).

4.3.2 Surface preparation

Surface preparation shall be as follows:

- (a) *Defects of maximum dimension in any direction less than 10 mm* — Dimension shall be measured after removal of all loose and disbonded coating. All visible oil, grease, organic and other contaminants shall be removed prior to further cleaning.

All holidays shall be abraded back to a clean steel surface using a coarse hand file or abrasive blast cleaning. Preparation shall leave a profile of not less than 50 µm and remove all FBE from the surface. All other defects shall be abraded back to sound coating with a minimum of sound parent material being removed.

The edges of the parent or field joint coating shall be feathered. A region of the parent coating at least 10 mm wide, adjacent to the area to be repaired, shall be abraded with a minimum amount of sound parent material being removed.

All contamination shall be removed from the surface prior to application of repair materials.

- (b) *Defects over 10 mm in any direction* — Dimension shall be measured after removal of all loose and disbonded coating. All loose and disbonded coating shall be cut back to sound material. For defects over 100 mm, the steel surface shall be cleaned by dry blast cleaning in accordance with AS 1627.4, Class Sa 2½.

A region of the parent coating approximately 25 mm wide adjacent to the area to be repaired shall be roughened.

All contamination shall be removed from the surface prior to the application of repair materials.

4.3.3 Mixing of repair materials

The following applies to the mixing of repair materials:

- (a) Each mixing shall include the complete components of a kit provided by the coating manufacturer. There shall be no mixing of part kits.

NOTE Mixing of components using a dual cartridge gun supplied by the coating manufacturer for this purpose is permitted.
- (b) If required to facilitate curing the two components may be heated to 50 °C in a hot water bath prior to mixing.
- (c) The mixing shall be carried out in accordance with the manufacturer's instructions. The mixing shall render the mixture completely homogeneous. Under no circumstances shall mixing be carried out with a mixer or container on which there are traces of semi-cured material.
- (d) All mixed material shall be used within its pot life as defined by the manufacturer or be discarded. Any increase in viscosity of the material is evidence that the material has exceeded its pot life.

4.3.4 Application of repair materials

The application shall be in accordance with the manufacturer's instructions. The following applies to the application of repair materials:

- (a) To facilitate curing, the surface may be heated in accordance with manufacturer's requirements prior to application. Heating shall not exceed 85 °C. Heating may be with hot air, radiant heaters, or propane torch. The temperature shall be monitored. Any coating damaged by excessive heat shall be removed and repaired. No discoloration of the FBE coating nor the repair material is permitted. There shall be no direct flame impingement onto the repair material.
- (b) The surface to be coated shall remain dry from the commencement of surface preparation until the completion of the application of the coating. Any rust bloom that occurs during the initial or subsequent phases of flame heating shall be removed.
- (c) The repair material shall be applied evenly over the exposed steel surface and onto all profiled FBE linepipe coating. It may be applied by brush, roller or spatula.