

Australian/New Zealand Standard™

**External fusion-bonded epoxy coating
for steel pipes**



AS/NZS 3862:2002

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee ME-038, Petroleum Pipelines. It was approved on behalf of the Council of Standards Australia on 27 July 2001 and on behalf of the Council of Standards New Zealand on 20 February 2002. It was published on 11 March 2002.

The following interests are represented on Committee ME-038:

Australasian Corrosion Association
Australian Institute of Petroleum
Australian Petroleum Production and Exploration Association
Australian Pipeline Industry Association
Bureau of Steel Manufacturers
Cooperative Research Centre for Materials Welding and Joining
Department of Labour New Zealand
Department of Minerals and Energy WA
Department of Mines and Energy NT
Department of Natural Resources and Environment Vic.
Department of Natural Resources and Mines Qld
Gas Association of New Zealand
Ministry of Energy and Utilities NSW
Primary Industries and Resources SA
Australian Gas Association
Welding Technology Institute of Australia

Additional interests participating in the preparation of this Standard:

Cathodic Protection Systems
Tyco Water Pipelines Research
Canusa
Brian Martin and Associates
Bredero Shaw Australia
Socotherm

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about joint Australian/New Zealand Standards can be found by visiting the Standards Australia web site at www.standards.com.au or Standards New Zealand web site at www.standards.co.nz and looking up the relevant Standard in the on-line catalogue.

Alternatively, both organizations publish an annual printed Catalogue with full details of all current Standards. For more frequent listings or notification of revisions, amendments and withdrawals, Standards Australia and Standards New Zealand offer a number of update options. For information about these services, users should contact their respective national Standards organization.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Please address your comments to the Chief Executive of either Standards Australia International or Standards New Zealand at the address shown on the back cover.

This Standard was issued in draft form for comment as DR 00130.

Australian/New Zealand Standard™

External fusion-bonded epoxy coating for steel pipes

Originated as AS 3862—1991.
Second edition jointly revised and designated AS/NZS 3862:2002.

COPYRIGHT

© Standards Australia/Standards New Zealand

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher.

Jointly published by Standards Australia International Ltd, GPO Box 5420, Sydney, NSW 2001 and Standards New Zealand, Private Bag 2439, Wellington 6020

ISBN 0 7337 4089 8

PREFACE

This Standard was prepared by the joint Standards Australia/Standards New Zealand Committee ME-038, Petroleum Pipelines, at the request of manufacturers and users of fusion-bonded epoxy coating for pipes.

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 to be applied only to external surfaces of pipes.

Attention is drawn to the fact that this Standard does not purport to satisfy all requirements for pipelines.

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.

Statements expressed in mandatory terms in notes to figures and tables are deemed to be requirements of this Standard. All other notes are for information and guidance only.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE.....	4
1.2 REFERENCED DOCUMENTS.....	4
1.3 DEFINITIONS.....	5
1.4 PIPE MARKING	6
SECTION 2 MATERIAL REQUIREMENTS	
2.1 FUSION-BONDED EPOXY (FBE) POWDER	7
2.2 ABRASIVE MATERIALS	7
2.3 REPAIR MATERIALS.....	7
SECTION 3 APPLICATION	
3.1 MILL APPLICATION	8
3.2 FIELD APPLICATION	11
SECTION 4 REPAIRS	
4.1 REPAIRS TO COATINGS IN THE MILL	14
4.2 REPAIRS TO FIELD JOINTS AND ADJACENT AREAS.....	14
4.3 REPAIR PROCEDURE.....	14
SECTION 5 STORAGE, HANDLING AND TRANSPORT	
5.1 STORAGE OF POWDER.....	17
5.2 TRANSPORT OF POWDER.....	17
5.3 HANDLING, TRANSPORT AND STORAGE OF PIPES	17
5.4 HEALTH AND SAFETY	19
SECTION 6 TESTING REQUIREMENTS	
6.1 GENERAL.....	20
6.2 FBE POWDER	20
6.3 TESTING OF REPAIRS.....	20
APPENDICES	
A PURCHASING GUIDELINES	21
B MEANS FOR DEMONSTRATING COMPLIANCE WITH THIS STANDARD	23
C CHEMICAL PRETREATMENT	30
D DENSITY OF POWDER.....	31
E GEL TIME OF POWDER	33
F PARTICLE SIZE ANALYSIS OF POWDER.....	34
G VOLATILE CONTENT OF POWDER	35
H DSC ANALYSIS	36
I FOAMING.....	42
J ADHESION OF COATINGS TO STEEL.....	44
K RESISTANCE OF COATING TO IMMERSION IN HOT WATER.....	45
L FLEXIBILITY	46
M UNIFORMITY OF HEATING	48
N HEAT DECAY PERIOD	49
O WATER ABSORPTION OF COATING TEST	50
P THERMAL STABILITY OF COATING TEST	51
Q PREPARATION OF A TEST PANEL AND VISUAL INSPECTION	53
R PREPARATION OF TEST PANELS FOR REPAIR MATERIALS.....	55
S INTERFACIAL CONTAMINATION	57

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
External fusion-bonded epoxy coating for steel pipes

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for external fusion-bonded epoxy (FBE) coating of steel pipes for protection against corrosion. It includes coating in the mill and coating in the field.

NOTES:

- 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.
- 2 Line pipe manufactured in accordance with API 5L 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.
- 3 Line pipe manufactured in accordance with API 5L may require a more stringent straightness specification to allow coating in accordance with this Standard.
- 4 Consideration should be given to strain ageing when specifying line-pipe for FBE coating. Guidance is given in Clause 3.1.2, Note 3.

Methods for demonstrating compliance with this Standard are given in Appendix B.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- | | |
|--------|--|
| 1199 | Sampling procedures and tables for inspection by attributes |
| 1399 | Guide to AS 1199—Sampling procedures and tables for inspection by attributes |
| 1627 | Metal finishing—Preparation and pre-treatment of surfaces |
| 1627.4 | Part 4: Abrasive blast cleaning |
| 2490 | Sampling procedures and charts for inspection by variables for percent nonconforming |
| 3894 | Site testing of protective coatings |
| 3894.1 | Part 1: Non-conductive coatings—Continuity testing—High voltage ('brush') method |

AS/NZS

- | | |
|--------|---|
| 2243 | Safety in laboratories |
| 2243.2 | Part 2: Chemical aspects |
| 2990 | Quality systems for engineering and construction projects |
| 3894 | Site testing of protective coatings |
| 3894.6 | Part 6: Determination of residual contaminants |

AS/NZS

- ISO 9001 Quality management systems—Requirements
- ISO 9004 Quality management systems—Guidelines for performance improvement
- HB 18 Guidelines for third-party certification and accreditation
- HB 18.28 General rules for a model third-party certification system for products
- ASTM
- D 149 Tests for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies
- D 257 Tests for D-C resistance or conductance of insulating materials
- D 1044 Test for resistance of transparent plastic materials to surface abrasion
- D 1653 Test for water vapour permeability of organic coating films
- D 1921 Test for particle size (sieve analysis) of plastic materials
- D 2370 Test for tensile properties of organic coatings
- G 11 Test for effects of outdoor weathering on pipeline coatings
- G 14 Test for impact resistance of pipeline coatings (falling weight test)
- G 17 Test for penetration resistance of pipeline coatings
- G 62 Test methods for holiday detection in pipeline coatings
- API RP
- 5L Specification for line pipe
- 5L1 Recommended practice for railroad transportation of line pipe
- 5LW Recommended practice for marine transportation of line pipe

1.3 DEFINITIONS

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

1.3.1 Batch (FBE Powder)

A discrete and continuous manufacturing run.

1.3.2 Bolster

Support for coated pipes during transport and storage.

1.3.3 Coupon

Sample of steel pipe coated with fusion-bonded epoxy and used for laboratory tests.

1.3.4 Drop

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

1.3.5 Holiday

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

1.3.6 Lot

A batch or number of batches manufactured within a limited period of time, typically 24 h or less.

1.3.7 Pinhole

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

1.3.8 Pipe diameter length

Length of pipe measured in diameters of the pipe.

1.3.9 Run or sag

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

1.3.10 Rust blooming

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

1.3.11 Shelf life

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

1.3.12 Strain ageing

A change in the properties of steel associated with ageing at elevated temperature subsequent to cold working.

1.3.13 Substrate

The steel pipe surface to which the coating is to be applied.

1.3.14 Surface crater

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

1.3.15 Test panel

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

1.4 PIPE MARKING

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.
- (d) Pipe specification and steel grade.
- (e) Pipe length, diameter and wall thickness.
- (f) Pipe number (where applicable).

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. It shall not contain tri-mellitic anhydride.
- (b) The components of the formulation shall be melt-compounded in an extrusion process prior to being milled to the final powder form.
- (c) The powder shall be free flowing and able to be fluidized and spray-applied using conventional electrostatic guns.
- (d) When applied to a pre-heated pipe, the powder shall fuse to form a continuous uniform film that will rapidly cure under the action of the residual heat in the pipe.

2.2 ABRASIVE MATERIALS

Abrasive materials shall comply with 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 complies with Clause 3.1.1.

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 complies with Clause 3.2.5.

2.3 REPAIR MATERIALS

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

All repair materials shall comply with the requirements of this Standard.

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

SECTION 3 APPLICATION

3.1 MILL APPLICATION

3.1.1 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, and shall contain not 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 3°C above the dew point. Thermometers used for determination of the dew point shall be calibrated to an accuracy of $\pm 0.5^\circ\text{C}$. 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) Cleaning of the external pipe surface shall be in accordance with AS 1627.4 and shall be a minimum finish quality of Class 2½ near-white metal.
- (h) After passing through blast cleaning the pipe surface shall be inspected for slivers, scabs, laminations, burrs or bristles of steel, which shall be removed by grinding or filing. The grinding wheel or file used shall not cause contamination of the pipe surface.
- (i) Grinding or filing of individual surface areas greater than 4000 mm² shall not be permitted. All grinding or filing shall be carried out in a manner that produces an even profile on the pipe surface. The total surface area treated on any one pipe shall not exceed 0.1%. The remaining pipe wall thickness shall be not less than 92% of the nominal pipe wall thickness. After surface preparation, the surface profile shall be within the range of 50 µm to 100 µm peak to trough height measured with Press-O-Film replication tape in accordance with Method A of AS 3894.5 or other approved method. The profile shall be slightly angular and not have undercuts.
- (j) Pipe surface shall be monitored for contamination in accordance with AS 3894.6.
- (k) The blast-cleaned surface shall not be contaminated with material that may be detrimental to the coating performance including grit, dust, metal particles, oil, water. In addition, the anchor pattern shall not be scarred or burnished beyond profile limit as specified.

- (l) Tests, in accordance with AS 3894.6 as appropriate, shall be carried out prior to coating application to detect the presence and, where appropriate, concentration of the following:
 - (i) Chloride contamination in excess of 25 mg/m².
 - (ii) Soluble iron corrosion products.
- (m) Pipes with chloride contamination in excess of 25 mg/m² (see Clause 3.1.1(l)(i)) shall be subject to chemical pretreatment and the chloride level shall be retested in accordance with Clause 3.1.1(l).

NOTES:

- 1 Pipes satisfying the requirements of Clause 3.1.1(l) may be subject to chemical pretreatment using either a silicate/chromate conversion coating, a phosphate wash or both.
 - 2 Information on the benefits of chemical pretreatment is provided in Appendix C.
- (n) Where pretreatments are used, deleterious residues shall be removed prior to application of the coating.
 - (o) Any pipe, which is not suitably cleaned in accordance with Clause 3.1.1(l), shall be re-blast cleaned and retested.
 - (p) 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.

3.1.2 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.

NOTES:

- 1 The preferred method of heating is by induction coil or indirect fired oven.
- 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.
- 3 Prior strain and subsequent thermal ageing are prerequisites for the appearance of strain ageing in steel. The extent to which steel properties are ultimately affected depends collectively on—
 - (a) the level of applied strain in pipe forming and cold expansion;
 - (b) the subsequent thermal history of the pipe, i.e. coating temperature and time; and
 - (c) steel composition.

The composition of steel may be adjusted to minimize strain ageing effects. However, where a strain-ageing resistant steel is not chosen, an increase in transition temperature may occur as a result of the strains involved in pipe making with a further increase as a result of the heat treatment involved in the coating process.

The purchaser should consult with the pipe supplier to ensure that the pipe will meet the requisite fracture toughness properties after the heat treatment experienced during coating.

- (b) 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 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 heating operation shall not cause contamination of the prepared surface by combustion products or surface oxidation.

3.1.3 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 film thickness shall be 400 µm min.

NOTES:

- 1 Thicknesses in excess of 600 µm may limit flexibility.
 - 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.
- (b) The heating temperature, the curing temperature and curing time shall be consistent with the powder manufacturer's specification for application procedure.
 - (c) 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.
 - (d) 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%.
 - (e) 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.
 - (f) Powder material on the internal surface of the pipe shall be removed without damaging pipe identification.
NOTE: Powder material should be prevented from entering the inside of the pipe.
 - (g) 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.

3.1.4 Post-curing and cooling

The following applies to post-curing and cooling:

- (a) 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.

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

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. This time to quench shall be monitored to ensure compliance with the manufacturer's minimum curing requirements.

3.2 FIELD APPLICATION

3.2.1 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 are to be secured to the pipe throughout welding, grinding and cutting operations.

3.2.2 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.

3.2.3 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.

3.2.4 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.

NOTES:

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

3.2.5 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 shall 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.
- (e) Cleaning of the external pipe surface shall be in accordance with AS 1627.4 and shall be a minimum finish quality of Class 2½ near-white metal, with a surface profile after blasting of between 50 µm and 100 µm as measured in accordance with AS 1627.4.
- (f) Blast-cleaning abrasives shall comply with the requirements of AS 1627.4. Abrasives shall be free of moisture, and any other deleterious materials, and shall contain less than 100 mg/kg chlorides and less than 0.3% copper. Abrasives shall be stored in a clean, dry area.
- (g) The mill-applied coating adjoining the field joint shall be abraded for a minimum distance of 20 mm from the edge of the field joint.
- (h) All field joints shall be coated within 4 h of blast cleaning. Any field joint, which is not coated within 4 h of blast cleaning or where rust blooming has occurred, shall be completely reblasted.
- (i) The blast-cleaned surface shall be monitored for contamination in accordance with AS 3894.6 and the requirements of Clause 3.1.1(k) of this Standard. Where air is used for the removal of contaminants, it shall not further contaminate the surface.

3.2.6 Pre-application heating

The following requirements apply to pre-application heating:

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

NOTES:

- 1 The preferred method of heating is by induction coil.
- 2 See also Notes to Clause 3.1.2(a).

- (b) The pipe surface temperature shall be checked using temperature-indicating crayons, surface thermometers or other suitable means, and shall be 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: 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.

3.2.7 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 400 µm min.

NOTE: 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.

- (b) The coating shall be applied over the entire bare steel area and with a minimum overlap of 25 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 20 mm, when tested with a knife. Additional controls may need to be applied to the preheating rate and duration to achieve this condition.
- (c) Powder application equipment shall be completely cleaned before and after each day's work.

3.2.8 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 and shall be in accordance with the powder manufacturers' specifications or written instructions.

NOTE: Prolonged elevated temperatures will 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 holidays defined in Clause 1.3 detected during final bench testing and in the course of handling the coated pipe in the pipe mill yard shall be repaired in accordance with this Standard, using materials qualified in accordance with Clause 6.2.3 and Table A1, Appendix A.
- (b) The maximum single area to be repaired shall be 0.01 m².
- (c) The maximum total area to be repaired on one joined 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 holidays shall not exceed the rate of 1 m 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 7.3. Visible coating discontinuities not detected electrically shall also be repaired in accordance with this Standard.
- (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 qualified in accordance with Clause 6.2.3; or a fusion bonded epoxy applied in accordance with Clause 3.1.3 for major repairs.

4.3.2 Surface preparation

Surface preparation shall be as follows:

- (a) *Defects of maximum dimension in any direction less than 100 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 shall 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 approximately 10 mm to 20 mm wide, adjacent to the area to be repaired, shall be abraded with the 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 100 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. The steel surface shall be cleaned by dry blast cleaning in accordance with AS 1627, Class 2½.

A region of the parent coating approximately 20 mm to 30 mm wide adjacent to the area to be repaired shall be roughened by blasting.

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 contents of one component shall be added to the other component and mixed. The mixing shall render each of the two components completely homogeneous. The mixing shall be carried out with a clean mixer and clean container. 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 shall 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 following applies to the application of repair materials:

- (a) To facilitate curing the surface may be heated to 50°C prior to application and after application of the coating. Heating may be with hot air, radiant heaters, or propane torch. The surface temperature shall not exceed 50°C. The temperature shall be monitored using temperature-indicating crayons.

NOTE: 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.
- (d) The material shall be applied to a minimum dry film thickness of 1000 µm for any single reading.

4.3.5 Curing of repair materials

The following requirements apply to the curing of repair materials:

- (a) The material shall be allowed to cure to a Durometer D hardness of at least 65 before testing and handling.
- (b) The material shall be free of runs, sags, drips, voids, pinholes, blistering, peeling, loss of adhesion, inadequate film thickness and inadequate cure.
- (c) Any material, that fails any one of the tests in this Section or any one of the tests listed in Table B5 of Appendix B, shall be removed, the surface re-prepared and the coating reapplied.

SECTION 5 STORAGE, HANDLING AND TRANSPORT

5.1 STORAGE OF POWDER

5.1.1 General

The manufacturer's recommendation of storage conditions of the powder shall be followed.

Powders that have been stored beyond the manufacturer's expiry date are considered suitable for use, provided the characteristics remain in accord with Table B1, subject to recertification by the powder manufacturer.

5.1.2 Containers

Prior to use the powder shall be stored in the manufacturer's original container, which shall be marked with the manufacturer's name, batch number, type of powder, storage condition and expiry date.

5.2 TRANSPORT OF POWDER

5.2.1 Containers

Powder shall be transported in sealed containers, which will prevent ingress of water. Where necessary, containers shall be refrigerated to maintain the temperature so that no deterioration of the powder occurs.

Temperature-indicating tags shall be indicative of the manufacturer's recommended storage conditions. The minimum number of temperature-indicating tags that are affixed to powder containers shall be as follows:

- (a) 1 per batch as manufactured.
- (b) 4 per container.
- (c) 1 per truckload, if less than 1 batch.

5.2.2 Damaged containers

The contents of any container that has been damaged to the point where the epoxy resin powder has been exposed to the atmosphere shall be tested for gel time, moisture content and DSC analysis and shall be within specification for each property. Out-of-specification powder shall not be used for coating.

5.3 HANDLING, TRANSPORT AND STORAGE OF PIPES

5.3.1 Handling

Pipes shall be protected from damage to the pipe material, coating and lining during handling. At all times during handling, coated pipes shall be prevented from contacting each other.

NOTE: Where forklifts are used to handle coated pipe, the tynes should be covered with a suitable padding material. Where cranes are used to lift and handle the pipe, tail lines should be secured to each end of the pipe to prevent it coming into contact with obstructions and other pipes, which might cause damage.

Where end hooks are used, they shall not be copper faced. End hooks shall provide bearing on a minimum of one-eighth of the circumference (12.5%). If end hooks are used, a spreader bar shall also be used. The spreader bar and length of sling used with the end-hooks shall be such that the included angle of the slings above the spreader of the crane bar is not more than 120°.

5.3.2 Storage of uncoated pipes

All uncoated pipes shall be stored a minimum of 150 mm clear of the ground in such a manner as will prevent water and dirt from accumulating in the pipe.

When pipes are supported on timbers, the pipe supports shall be placed nominally within 1.5 m of each end of the pipe and at intervals not greater than 5.5 m measured along the pipe.

The bottom layer of pipe in any stack shall be supported on wooden bearers or windrows. Timber bearers shall be nominally 200mm wide, and the ends of each row shall be securely chocked to prevent movement of the pipes in the stack. When pipes are supported on windrows covered with suitable plastic sheeting, the pipe supports shall be placed nominally within 2.5 m of each end of the pipe. For pipes in excess of 12 m length, additional windrows may be required.

The second and subsequent layers of uncoated pipes may be 'nested' on top of the previous layers or alternatively may be stripped with non-padded timber.

The height of pipe stacks shall not exceed requirements of Table 5.1.

TABLE 5.1
PIPE STACK HEIGHT

Outside diameter of pipe, mm	Maximum No. of layers
Up to 219.1	10
273.1 to 323.9	7
355.6 to 508.0	5
589.0 to 864.0	4
Bundled pipe (Bundles separated with timbers)	Maximum No. of bundled layers
Up to 114.3	5
168.3	4

NOTE: Subject to agreement of the purchaser and compliance with API 5LW, greater stacking heights may be permitted for bare pipe.

5.3.3 Storage of coated pipes

Coated pipes shall be stored a minimum of 150 mm clear of the ground in such a manner as to minimize corrosion to the uncoated parts of the pipe and prevent damage to the pipe and the coating. No uncoated section of pipe shall be in contact with the soil.

When pipes are supported on timbers, the pipe supports shall be placed nominally within 1.5 m of each end of the pipe and at intervals not greater than 5.5 m measured along the pipe.

The bottom layer of pipe in any stack shall be supported on wooden bearers or wind-rows. Timber bearers shall be nominally 200 mm wide padded with rubber, felt or similar material, and the ends of each row shall be securely chocked to prevent movement of the pipes in the stack. When pipes are supported on wind-rows covered with suitable plastic sheeting, the pipe supports shall be placed nominally within 2.5 m of each end of the pipe. For pipes in excess of 12 m length, additional wind-rows may be required. Pipe separators shall be used to prevent contact between the coated pipes. A minimum of three separators shall be used for double random pipes, and 5 separators shall be used for triple random lengths.