

Australian/New Zealand Standard™

Buried corrugated metal structures

Part 4: Helically formed sinusoidal pipes



AS/NZS 2041.4:2010

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee CE-025, Corrugated Metal Drainage Pipes and Arches. It was approved on behalf of the Council of Standards Australia on 23 June 2010 and on behalf of the Council of Standards New Zealand on 28 June 2010.
This Standard was published on 10 August 2010.

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This Standard was issued in draft form for comment as DR 02336.

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Part 4: Helically formed sinusoidal pipes

First published as AS 1761—1979.

Second edition 1985.

AS 1761—1985 jointly revised and redesignated, in part, as AS/NZS 2941.4:2010.

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Jointly published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001 and by Standards New Zealand, Private Bag 2439, Wellington 6140

ISBN 978 0 7337 9654 8

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee CE-025, Corrugated Metal Pipes and Arches, to supersede AS 1761—1985, adopted by Standards New Zealand as NZS 4405 in 1986.

The objective of this Standard is to provide designers, manufacturers and installers of buried helical lock-seamed sinusoidal metal pipes with requirements for the manufacture of such pipe for use in earthworks, primarily as culverts or accessways.

This Standard is Part 4 of the AS/NZS 2041 series, *Buried corrugated metal structures*, which comprises the following parts:

AS/NZS

- 2041 Buried corrugated metal structures
- 2041.1 Part 1: Design methods
- 2041.2 Part 2: Installation
- 2041.4 Part 4: Helically formed sinusoidal pipes (this Standard)
- 2041.6 Part 6: Bolted plate structures

Other parts of the series currently being drafted include the following:

- Part 3: Assessment of existing structures
- Part 5: Helically formed ribbed pipes
- Part 7 Bolted plate structures with transverse stiffeners
- Part 8: Metal box structures

This Edition includes the following changes:

- (a) Design requirements have been moved to AS/NZS 2041.1 *Buried corrugated metal structures* Part 1: *Design methods*, which includes new limit states methods.
- (b) Installation requirements are now referred to AS/NZS 2041.2 *Buried corrugated metal structures*, Part 2: *Installation*.
- (c) Notation is based on ISO 3898, *Bases for design of structures—Notations—General symbols*.
- (d) Materials and fabrication requirements have been updated.
- (e) Materials covered now include galvanized steel, polymer-coated steel, steel with aluminized coating and aluminium strip.
- (f) Reference tables for cover limits have not been included.

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.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	4
1.2 DESIGN AND INSTALLATION	4
1.3 NORMATIVE REFERENCES	5
1.4 DEFINITIONS	5
1.5 NOTATION	6
1.6 MARKING	7
SECTION 2 MATERIALS, TOLERANCES AND MANUFACTURE	
2.1 SCOPE OF SECTION	8
2.2 MATERIALS	8
2.3 TOLERANCES	8
2.4 MANUFACTURE	9
2.5 COUPLING SYSTEMS	12
2.6 MATCH MARKING	14
2.7 DEFECTS AND COATINGS	15
SECTION 3 CORRUGATIONS AND SECTION PROPERTIES FOR DESIGN	
3.1 SCOPE OF SECTION	16
3.2 DIMENSIONS AND TOLERANCES	16
3.3 MATERIAL AND SECTION PROPERTIES	17
APPENDICES	
A DESIGN INFORMATION FOR SUPPLY AND INSTALLATION	23
B MEANS FOR DEMONSTRATING COMPLIANCE WITH THIS STANDARD	27
C LOCK-SEAM STRENGTH TEST	29
D COUPLING BANDS	31
BIBLIOGRAPHY	32

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Australian/New Zealand Standard
Buried corrugated metal structures**Part 4: Helically formed sinusoidal pipes**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies minimum requirements for the materials and manufacture of buried metal pipe formed using sinusoidal profile strip. The pipe is full circular shape formed by a continuous helical lock-seam that runs helically to the longitudinal axis of the pipe.

Pipe diameters up to and including 3600 mm are covered.

Sinusoidal profiles covered include the following:

- (a) S38 (pitch 38 mm).
- (b) S68 (pitch 68 mm).
- (c) S75 (pitch 75 mm).
- (d) S125 (pitch 125 mm).

Helically formed sinusoidal pipe structures are primarily intended for use as culverts in stormwater drainage, detention/retention systems, stockpile and access tunnels. The structures are intended to support roadway and railway and other loadings. They are buried in an embankment or in a trench situation and correct installation in a soil envelope is essential to the performance of the structure.

This Standard does not consider the additional design requirements for internally pressurized applications.

NOTES:

- 1 For helically formed pipes greater than 3600 mm diameter, the design methods in AS/NZS 2041.1 may not apply.
- 2 Guidelines on requirements that may need to be specified at the time of calling for tenders or quotations and information to be supplied by the manufacturer are detailed in Appendix A.
- 3 Information on means of demonstrating compliance with this Standard is given in Appendix B.
- 4 When intended for use in internally pressurized applications, specialist advice should be obtained.

1.2 DESIGN AND INSTALLATION

Design shall be carried out in accordance with AS/NZS 2041.1 using the section properties given in Section 3 of this Standard. Installation shall be carried out in accordance with AS/NZS 2041.2.

NOTE: This Standard includes the product requirements and design properties. AS/NZS 2041.1 gives information on design issues and requirements for structural design of the metal structure. Performance of the structure depends on correct installation (particularly adequate compaction of appropriate fill material around the metal structure) for which AS/NZS 2041.2 gives the requirements.

1.3 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

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

AS

- 1111 ISO metric hexagon commercial bolts and screws (all parts)
- 1112 ISO metric hexagon nuts including thin nuts, slotted nuts and castle nuts (all parts)
- 1214 Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
- 1397 Steel sheet and strip—Hot-dip zinc-coated or aluminium/zinc-coated
- 1789 Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch precast)
- 2205 Methods of destructive testing of welds in metal
- 2205.3.1 Part 3.1: Transverse guided bend test

AS/NZS

- 1365 Tolerances for flat-rolled steel products
- 1554 Structural steel welding
- 1554.1 Part 1: Welding of steel structures
- 1665 Welding of aluminium structures
- 1734 Aluminium and aluminium alloys—Flat sheet, coiled sheet and plate
- 2041 Buried corrugated metal structures
- 2041.1 Part 1: Design methods
- 2041.2 Part 2: Installation

- 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

ISO

- 3898 Bases for design of structures—Notations—General symbols

ASTM

- A742 Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
- A929 Standard Specification for Sheet, Metallic Coated by Hot-dip Process for Corrugated Steel Pipe
- B744 Standard specification for aluminium alloy sheet for corrugated aluminium pipe

1.4 DEFINITIONS

For the purpose of this Standard, the definitions in AS/NZS 2041.1 and AS/NZS 2041.2 and those below apply.

1.4.1 Corrugation

Sinusoidal profile section shapes.

1.4.2 Cover

The vertical distance between the neutral axis of the structure's corrugation profile at the top of the structure and—

- (a) pavement surface of road;
- (b) base of sleepers for railway traffic loads and surface of track formation for heavy vehicles or equipment running on the track formation;

- (c) top of trench or embankment where Items (a) and (b) are not applicable; or
- (d) base of a stockpile.

1.4.3 Diameter, internal

The minimum clear dimension measured from internal crest to internal crest.

1.4.4 Depth of corrugation

Measured as the vertical distance from a straightedge resting on the corrugation crests parallel to the axis of the pipe, to the bottom of the intervening valley (see to Figure 3.1).

1.4.5 Flexibility factor

A measure of wall flexibility of the corrugated metal pipe for the purpose of achieving handling and installation without permanent deformation of the metal structure.

1.4.6 Lock-seam

A seam formed by folding over the edges of adjacent sheets so that they interlock with each other to form a tight joint.

1.4.7 Pitch of corrugation

The distance, measured from crest to crest of corrugations, at 90° to the direction of the corrugation.

1.4.8 Protective coating

A coating designed to isolate the substrate from the environment.

NOTE: Types of protective coating include aluminized, galvanized, polymer, bituminized and epoxy coatings and similar.

1.4.9 Skew number

A number denoting the angle between the centre-line of the road, railway or other embankment and the centre-line of the pipe, measured in a clockwise direction.

1.5 NOTATION

The notation in this Standard is based on the notation and principles given in ISO 3898 and AS/NZS 2041.1. The notation used is as follows:

A	= cross-sectional area of wall of the metal structure per unit length (based on structural base metal thickness), in millimetres squared per millimetre
d_c	= depth of sinusoidal corrugation, in millimetres
d_h	= effective horizontal diameter (to the neutral axis of the corrugation), in millimetres
d_v	= effective vertical diameter (to the neutral axis of the corrugation), in millimetres
$F_{f,max}$	= maximum flexibility factor, in millimetres per newton
f_u	= minimum ultimate tensile strength, in megapascals
f_y	= minimum yield strength, in megapascals
I	= second moment of area of the corrugated section (based on structural base metal thickness), in millimetres to the fourth power per millimetre
i	= radius of gyration of corrugated section (based on structural base metal thickness), in millimetres
p	= pitch of corrugation, in millimetres
R_c	= inside radius of sinusoidal corrugation, in millimetres

- S_s = clear internal diameter of pipe, measured to internal crests, in millimetres
- t = structural base metal wall thickness without coatings, in millimetres
- W_{el} = elastic section modulus of the corrugated section (based on structural base metal thickness), in millimetres to the third power per millimetre
- W_{pl} = plastic section modulus of the corrugated section (based on structural base metal thickness), in millimetres to the third power per millimetre

1.6 MARKING

The information shall be marked on the product. The marking shall be permanent, and applied in a conspicuous position that is visible after installation and shall include the following:

- (a) Name of the manufacturer.
- (b) Date of manufacture including the month and year.
- (c) Plate thickness and profile to AS/NZS 2041.4.

NOTES:

- 1 For example, XXX, 2010/09, 2.5 S68 to AS/NZS 2041.4.
- 2 Manufacturers making a statement of compliance with this Australian/New Zealand Standard on product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

SECTION 2 MATERIALS, TOLERANCES AND MANUFACTURE

2.1 SCOPE OF SECTION

This Section specifies the materials to be used, method of manufacture, and dimensional requirements to be observed in the manufacture of helically formed sinusoidal pipes.

2.2 MATERIALS

2.2.1 Base material

The base material consisting of the base metal and a protective coating shall be—

- (a) galvanized steel strip complying with the requirements of AS 1397 for steel base grade G250 and galvanized to Z600;
- (b) aluminium cladding aluminium substrate strip classification Alclad 3004-H34 (7072 cladding and 3004 core) in accordance with AS/NZS 1734 and ASTM B744;
- (c) steel strip of grade G230 minimum with an aluminized (Type II) coating in accordance with ASTM A929; or
- (d) galvanized steel strip of grade G230 minimum and galvanized to Z600 with a polymer coating in accordance with ASTM A742.

The materials specified in Items (a) to (d) are appropriate for the design methods specified in AS/NZS 2041.1.

Standard thicknesses for these materials are given in Table 2.4.2.2(A) to Table 2.4.2.2(D). Specified thickness is the thickness quoted when ordering minimum wall thickness includes coatings and minimum base metal tolerance. Structural base metal wall thickness (t) is the thickness used in design and defined as follows:

Structural base metal wall thickness (t) = (nominal base metal thickness – base metal tolerance)/0.95 but not greater than the nominal base metal thickness, where the nominal base metal thickness = total specified coated thickness – coating thickness.

2.2.2 Additional coatings

In abnormally corrosive or abrasive conditions, a second coating or wear-resistant coating shall be applied over the base material (see AS/NZS 2041.1).

2.3 TOLERANCES

2.3.1 Internal diameter and corrugations

The internal diameter and type of corrugation of the pipe shall be as specified and subject to the tolerances given in Clauses 2.3.2 and 2.3.3.

2.3.2 Pipe tolerances

The actual dimensions shall not differ from the specified dimensions by more than the following:

- (a) Length.....±1%.

- (b) Clear internal diameter (S_s):
- (i) Average internal diameter, measured as the mean of a pair of internal measurements taken mutually at right angles to internal crests ± 6.0 mm;
or
 $\pm 1\%$ whichever is greater of the specified diameter.
 - (ii) In all cases where special ends are being manufactured, diameter of pipe at the joint $\pm 1\%$.
 - (iii) A pipe shall be round such that the major axis diameter does not exceed the minor axis diameter by more than 2% .
NOTE: When large diameter pipes are transported, hold-down straps can cause pipe out-of-round to exceed the above tolerance. This elastic deformation will rebound to normal self-weight deflection after unstrapping.
- (c) End squareness (variation from the perpendicular to the main axis of the pipe):
- (i) For pipes up to 1500 mm across the pipe (out of squareness) 15 mm.
 - (ii) For match-marked pipes, maximum difference across the pipe (out of squareness) the lesser of 50 mm or $S_s/50$.

2.3.3 Corrugation tolerances

The tolerances for pitch, depth and radius of the corrugations shall be as given in Section 3.

2.4 MANUFACTURE

2.4.1 General

All pipe lengths shall be manufactured from welded metal strip coils with a corrugated section and helical lock-seam formed by cold-working the metal strip.

2.4.2 Lock-seams

2.4.2.1 General

Lock-seams shall comply with the following requirements:

- (a) The edges of the strip forming the pipe shall be jointed with a continuous lock-seam formed by folding over the edges of adjacent edges so that they interlock with each other to form a tight joint (see Figure 2.4.2.1).
- (b) There shall be no significant roller indentations on the 180° fold, or beyond the lapped area. Roller indentations shall not cause seam cracking or a loss of contact within the seam. Significant indentations are those that injure or disfigure the lock-seam or those that show such obvious metal working as would present potential seam failure by fracture under load.
- (c) The 180° fold of metal at the lock-seam shall have a smooth curvature inside and outside with no angularity of the interior of the fold.
- (d) A section of sufficient width to show the complete seam profile, including the offset and the corrugations, may be cut from the pipe normal to the seam (as specified in Paragraph C2, Appendix C) and measured to verify the following:
 - (i) The total sum of the retaining offsets on both sides shall be a minimum of one strip thickness. The retaining offset, as shown in Figure 2.4.2.1, is that portion of the strip profile adjacent to the lock-seam and in tight contact with the 180° fold.

- (ii) The gaps formed within the internal fold shall be approximately equal. Each gap shall be not less than half the strip thickness, and shall not exceed 1.5 times the strip thickness.
- (iii) The minimum lap shall be as given in Table 2.4.2.1.

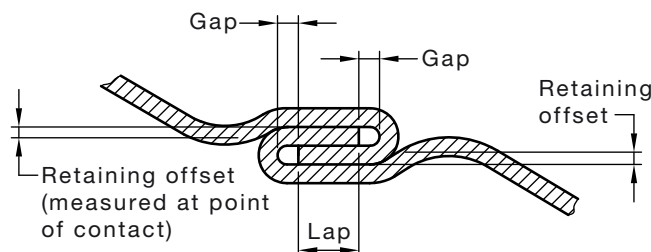


FIGURE 2.4.2.1 SINUSOIDAL LOCK-SEAM CROSS-SECTION

TABLE 2.4.2.1
MINIMUM LAP

Corrugation	Minimum seam lap, mm
S38	4
S68	6.5
S75	8
S125	8

2.4.2.2 Lock-seam strength test

When tested in accordance with Appendix C, lock-seams shall be capable of the minimum strength values given in Tables 2.4.2.2(A) and 2.4.2.2(B). Where coatings are applied before the formation of the lock-seam other than those covered in Tables 2.4.2.2(A) to 2.4.2.2(D), the required minimum seam strength shall be evaluated by testing to ensure equal or better performance.

NOTE: Structural design does not include a check of the seam strength as the seam is tested during manufacture in accordance with this Standard.

TABLE 2.4.2.2(A)
STRUCTURAL BASE METAL WALL THICKNESS AND MINIMUM LATERAL LOCK-SEAM STRENGTH—AS 1397 G250 Z600 GALVANIZED STEEL

Specified (uncoated) wall thickness mm	Nominal coated wall thickness mm	Minimum coated wall thickness mm	Structural base metal wall thickness (<i>t</i>) mm	Lateral lock-seam strength kN/m
1.20	1.29	1.24 (1.13)	1.20 (1.09)	47
1.60	1.69	1.63 (1.53)	1.60 (1.52)	67
2.00	2.09	2.02 (1.91)	2.00 (1.92)	88
2.50	2.60	2.52 (2.41)	2.50 (2.43)	117
3.00	3.10	3.01 (2.89)	3.00 (2.94)	148
3.50	3.60	3.50 (3.37)	3.50 (3.44)	182
4.00	4.10	4.00 (3.87)	4.00 (3.97)	218

NOTE: Specified AS 1397 wall thickness is uncoated. AS/NZS 1365 strip tolerance assumes cold-rolled section properties in Tables 3.3(B) to 3.3(E) and assumes cold-rolled strip tolerances. Hot-rolled values are shown in brackets and their section properties may be calculated using Note 3 of Tables 3.3(B) to 3.3(E).