

Australian/New Zealand Standard™

# **Zinc and zinc/aluminium-alloy coatings on steel wire**



## **AS/NZS 4534:2006**

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee MT-009, Metal Finishing. It was approved on behalf of the Council of Standards Australia on 8 June 2006 and on behalf of the Council of Standards New Zealand on 16 June 2006.

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The following are represented on Committee MT-009:

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Australian Aluminium Council  
Australian Industry Group  
Australian Paint Manufacturers' Federation  
Department of Defence  
Galvanizers Association of Australia  
Institution of Materials Engineering Australia  
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# Australian/New Zealand Standard™

## **Zinc and zinc/aluminium-alloy coatings on steel wire**

Originated, in part, as part of AS K53.1—1934 and AS K53.2—1935.  
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## PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee MT-009, Metal Finishing, to supersede AS/NZS 4534:1998, *Zinc and zinc/aluminium-alloy coatings on steel wire*.

The objective of this Standard is to specify requirements for zinc/aluminium-alloy coatings on steel wire and on fabricated wire products. The coatings are formed by the application of molten metal by hot dipping using a specialized continuous process, or by electroplating. However, in this revision of the Standard, a further range of coatings, specifically of high coating mass, has been added. The purpose of these new coatings, which first appeared in AS 2423—2002, *Coated steel wire fencing products for terrestrial, aquatic and general use*, is to provide superior protection to steel wire subjected to the more aggressive forms of corrosive environment, such as immersion in seawater.

This edition contains improved guidelines, set out in an Appendix, for the selection of appropriate coatings for the corrosion protection of steel wire.

During the preparation of this Standard cognisance was taken of ISO 7989:1988, *Zinc coatings for steel wire*. However, this international Standard could not be endorsed as an Australian Standard, as it is deficient in technical detail and is considered unsuitable by Australian industry.

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, where an ‘informative’ appendix is only for information and guidance.

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## STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

**Australian/New Zealand Standard****Zinc and zinc/aluminium-alloy coatings on steel wire****1 SCOPE**

This Standard specifies requirements for the mass, quality and testing of zinc coatings and zinc/aluminium-alloy coatings on steel wire of circular or non-circular (shaped) cross-section. The coatings are applied in a continuous process and may be formed either by the application of molten metal or by electrodeposition.

Six standard coating mass classes and a range of special coating mass classes are covered. The standard classes are intended, in general, for applications subjected to normal atmospheric corrosion conditions, whereas the special classes are specifically designed to provide acceptable durability under severe to extreme service conditions, such as for prolonged immersion in freshwater or seawater.

This Standard applies to coatings on wire at its final size, whether or not the coating has been applied after final cold working, prior to cold working, or at an intermediate stage of cold working.

Matters not relating to the coating itself are outside the scope of this Standard.

This Standard does not apply to coatings on articles that have been fabricated from uncoated steel wire and which have subsequently been coated with zinc or zinc/aluminium alloy, except where the coating has been applied in a specialized continuous process (e.g. for wire netting) as opposed to batch treatment (e.g. for nails).

**NOTES:**

- 1 Advice and recommendations on information to be supplied by the purchaser at the time of enquiry or order are contained in Appendix A.
- 2 Coatings in accordance with this Standard may not be available in every combination of wire size, coating mass class and coating type. Reference should be made to appropriate Australian Standards for the types of wire involved.
- 3 Means for determining compliance with this Standard are given in Appendix B.
- 4 Except as stated in this Clause, requirements for zinc coatings on manufactured wire articles, which have been electroplated following fabrication, are given in AS 1789.
- 5 This Standard does not specify the Preece test for coating uniformity. If this test is required, arrangements should be made between the purchaser and the supplier.

**2 REFERENCED DOCUMENTS**

The following documents are referred to in this Standard:

**AS**

|        |                                                                                              |
|--------|----------------------------------------------------------------------------------------------|
| 1199   | Sampling procedures for inspection by attributes                                             |
| 1199.0 | Part 0: Introduction to the ISO 2859 attribute sampling system                               |
| 1199.1 | Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection |
| 1242   | Zinc ingots                                                                                  |
| 1329   | Methods for the analysis of zinc and zinc alloys                                             |
| 1329.1 | Method 1: Determination of aluminium content—Titrimetric method                              |

|                   |                                                                                                                       |
|-------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>AS</b>         |                                                                                                                       |
| 1789              | Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)                                   |
| 2331              | Methods of test for metallic and related coatings                                                                     |
| 2331.1.4          | Method 1.4: Local thickness tests—Magnetic induction and eddy current methods                                         |
| 2331.2.3          | Method 2.3: Tests for average coating mass per unit area or for thickness—Hydrogen evolution method for zinc coatings |
| 2331.3.1          | Method 3.1: Corrosion and related property tests—Neutral salt spray (NSS) test                                        |
| 2505              | Metallic materials                                                                                                    |
| 2505.6            | Method 6: Wire—Wrapping test                                                                                          |
| 2706              | Numerical values—Rounding and interpretation of limiting values                                                       |
| <b>AS/NZS</b>     |                                                                                                                       |
| 2243              | Safety in laboratories                                                                                                |
| 2243.1            | Part 1: Planning and operational aspects                                                                              |
| 2243.2            | Part 2: Chemical aspects                                                                                              |
| 2312              | Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings           |
| <b>AS/NZS ISO</b> |                                                                                                                       |
| 9001              | Quality management systems—Requirements                                                                               |
| 9004              | Quality management systems—Guidelines for performance improvements                                                    |
| HB18.28           | Conformity assessment—Guidance on a third party certification system for products                                     |
| <b>ISO</b>        |                                                                                                                       |
| 9223              | Corrosion of metals and alloys—Corrosivity of atmospheres—Classification                                              |
| <b>SANZ</b>       |                                                                                                                       |
| HB18.28           | Guide 28—General rules for a model third-party certification system for products                                      |

### 3 DEFINITIONS

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

#### 3.1 Coating class

An alphanumeric notation describing the coating mass in relation to the wire size for standard coatings, but independent of wire size for special coatings (see Clauses 4.2 and 8).

#### 3.2 Coating mass

Mass of zinc coating or zinc/aluminium-alloy coating per unit surface area of steel base, expressed in grams per square metre.

#### 3.3 Electrogalvanized coating

A zinc coating (see Clause 3.7) applied to the wire by electrodeposition.

NOTE: In order to avoid confusion, it is essential that the term ‘electrogalvanized’ and any of its derivatives not be shortened to ‘galvanized’ or any of its abbreviations, such as ‘galv’, since ‘galvanized’ is conventionally employed for the hot-dip process.

### 3.4 Galvanized coating

A zinc coating (see Clause 3.7) alloyed to the steel substrate and applied to the wire by hot-dip immersion in molten zinc of at least 98% purity by mass.

### 3.5 Hot-dip coating

A coating applied by immersion of separated single strands of wire, or of a continuous length of fabricated wire product, in a bath of molten zinc or zinc/aluminium alloy.

### 3.6 Wire

A steel filament of dimensionally uniform cross-section along its length, which is either the feedstock for coating or is finish-coated with zinc or zinc/aluminium alloy.

### 3.7 Zinc coating

A coating composed essentially of zinc, with or without zinc/iron alloy formation at the zinc/iron interface, and produced in a continuous manufacturing operation by dipping (immersing) prepared and separated single strands of steel wire, or a continuous length of fabricated wire product, in a bath of at least 98% purity by mass of molten zinc, or in an electroplating bath containing a solution of an appropriate zinc salt.

### 3.8 Zinc/aluminium-alloy coating

A coating applied in a continuous manufacturing operation by dipping (immersing) either uncoated or zinc-coated separated single strands of steel wire, or a continuous length of fabricated wire product, in a bath of molten zinc/aluminium alloy containing between 4.5% and 50% aluminium. The designated nominal aluminium content is based on the resultant aluminium content of the coating, usually taken to be the nominal aluminium content of the bath.

## 4 DESIGNATION

### 4.1 General

The coating class, type and material shall be designated in sequence as follows:

- (a) The number of this Standard, i.e. AS/NZS 4534.
- (b) The coating class (see Clause 4.2).
- (c) The coating type and material (see Clause 4.3).

### 4.2 Designation of coating class

For standard coatings, the coating class shall be designated by the letter W followed by a two-digit number, as follows: W02, W05, W10, W15, W20 or W25 (see Table 1).

For special coatings, the coating class shall be identified by the letters SW followed by a number representing the specified minimum coating mass in  $\text{g/m}^2$  (see Clause 8.2).

### 4.3 Designation of coating type and material

The coating type and material shall be designated in accordance with the following:

- (a) Hot-dip zinc or zinc/aluminium-alloy coating applied at final size:
  - (i) Zinc .....Z.
  - (ii) Zinc/aluminium alloy .....ZA.
- (b) Electroplated zinc coating applied at final size .....E.
- (c) Drawn (or rolled) after hot-dip coating ..... DZ or DZA, as appropriate.
- (d) Drawn (or rolled) after electroplating ..... DE.

For zinc/aluminium-alloy coatings, the designation ZA shall include a number inserted between the letters to indicate the nominal percentage of aluminium by mass in the coating (see Clause 3.8), e.g. Z5A for 5% of aluminium.

Examples of designation:

- (i) Example 1: AS/NZS 4534/W02Z—hot-dip zinc, Class W02.
- (ii) Example 2: AS/NZS 4534/W05Z10A—hot-dip zinc/10% aluminium, Class W05.
- (iii) Example 3: AS/NZS 4534/W25E—electroplated zinc (at final size), Class W25.
- (iv) Example 4: AS/NZS 4534/W10DZ—drawn (or rolled) hot-dip zinc, Class W10.
- (v) Example 5: AS/NZS 4534/SW600Z—special coating, hot-dip zinc, 600 g/m<sup>2</sup> minimum.

## 5 WIRE MANUFACTURING PROCESS

### 5.1 Continuous coating process

#### 5.1.1 Raw materials

Zinc for replenishing the molten bath, or for electrodes for electrolysis, shall comply with the requirements of AS 1242 and shall be of 98.5% purity, or better, depending on the quality demands of the coating process.

Zinc/aluminium-alloy bath replenishment shall be accomplished in such a way that the aluminium content of the zinc/aluminium alloy coating on the wire (see Clause 3.8) is within +0.5% and –0.5% of the designated nominal value. Raw material additions to the bath may contain minor levels of control elements.

#### 5.1.2 Precautions

The wire manufacturer shall take care in the coating process to avoid undue changes to the mechanical properties of the steel base, particularly in respect of embrittlement, and to avoid damage, such as scoring, of the coating itself.

NOTE: Appendix C gives advice on unavoidable changes, which may occur to the mechanical properties of softened wires, and on the effects of hydrogen embrittlement resulting from electrodeposition.

The wire manufacturer shall take every precaution to ensure that the coating is free of irregularities and defects (see Clause 6).

### 5.2 Drawing or rolling process

For wires that are cold worked after the application of the coating, due care shall be taken by the manufacturer to avoid damage to the coating, such as abrasion, scoring or chatter marks, either prior to, or at any stage of, the cold working operation.

### 5.3 Supplementary non-metallic coatings

Zinc or zinc/aluminium-alloy coatings may be covered with a supplementary adherent coating, such as chromate, paint, plastic, wax, or residual drawing lubricant.

NOTES:

- 1 Hot-dip zinc or zinc/aluminium-alloy coatings may carry a thin covering of wax, applied to reduce friction during subsequent mechanical forming treatments.
- 2 Zinc or zinc/aluminium-alloy coated wires that have subsequently been drawn normally carry a thin covering of wire-drawing lubricant.

## 6 APPEARANCE

The zinc coating or zinc/aluminium-alloy coating shall be continuous, as smooth and evenly distributed as modern industrial technology permits, and be free of defects that are detrimental to the stated use of the wire.

### NOTES:

- 1 Defects cannot be completely quantified. Where the presence, size or frequency of defects in the coating is considered to be of concern, appropriate arrangements should be made between the purchaser and the wire manufacturer or supplier. This may be achieved by the provision of acceptable type samples or methods of test.
- 2 The coating on hot-dip galvanized or zinc/aluminium-alloy-coated wire is not perfectly smooth or devoid of irregularities. It should be noted that diameter or dimensional tolerances, required by appropriate wire or wire product specifications, apply to representative uniformly coated areas of the wire.
- 3 With increasing coating mass, hot-dip coatings usually become less smooth.
- 4 Hot-dip coatings applied in a specialized continuous process to fabricated wire articles are usually not as smooth as coatings applied to single wire strands.
- 5 The finish of untreated zinc-coated wire, i.e. without a supplementary non-metallic coating (see Clause 5.3), is usually a lustrous silver colour when produced, but ages to a dull grey. Zinc/aluminium-alloy coatings age from silver, when initially produced, to a deep grey. Provided that the coating complies with the requirements of this Standard, the colour and lustre of the finish should not be considered detrimental to the performance of the coating in service.
- 6 Advice on the transport and storage of coated wire is given in Appendix D.

## 7 SELECTION OF TEST SPECIMENS FOR COATING MASS AND COATING ADHERENCE TESTS

### 7.1 General

A suitable length of wire for performing the required tests shall be cut from one or both ends of each coil selected for sampling. If the ends of the coil are damaged or otherwise abnormal, an appropriate length of wire shall be discarded before taking the test lengths. Any supplementary non-metallic coating (see Clause 5.3), which may interfere with testing, shall be removed, taking care not to damage the surface of the zinc or zinc/aluminium-alloy coating.

Lengths taken from products or articles fabricated from zinc-coated or zinc/aluminium alloy-coated wire shall be as representative as possible of the original coated wire.

Lengths taken from products or articles that have been zinc or zinc/aluminium alloy-coated after fabrication, by means of a specialized continuous operation, shall be as representative as possible of the batch involved.

Unless specified otherwise, test specimens taken from fabricated products or articles shall not be required to undergo adherence testing. However, the adhesion of the coating shall be fit for purpose.

### 7.2 Coating mass

The lengths of test specimens required for gravimetric, volumetric or non-destructive determination of coating mass are specified in Paragraphs E2.3, E3.4 or E4 respectively of Appendix E.

### 7.3 Adherence of coating

The test specimen shall be cut from the sample and shall be of sufficient length to ensure complete control of the wrapping or bending operation employed for adherence testing.

## 8 TEST METHOD AND REQUIREMENTS FOR COATING MASS

### 8.1 General

The coating mass of zinc or zinc/aluminium-alloy coatings on steel wire of circular or non-circular cross-section, as produced, shall be determined in accordance with one of the methods specified in Paragraphs E2, E3 or E4 of Appendix E. In cases of dispute, the gravimetric method (see Paragraph E2, Appendix E) shall be used as the referee test method.

The coating mass of zinc or zinc/aluminium-alloy coatings on round wire shall conform to the limits specified in Table 1 for standard coatings and as given in Clause 8.2 for special coatings. For shaped wires, an equivalent nominal diameter appropriate to Table 1 is determined using the following equation:

$$d = \frac{c}{\pi} = 0.318c$$

where

$d$  = the equivalent nominal diameter corresponding to the nominal size of the coated shaped wire, in millimetres

$c$  = the circumference of the nominal size of the coated shaped wire, in millimetres

NOTE: The 'nominal diameter' shown in Table 1 relates to the zinc or zinc/aluminium alloy-coated wire, excluding any supplementary non-metallic coating.

If coating mass determinations are carried out on products that have been fabricated from zinc-coated or zinc/aluminium alloy-coated wires, the specified minimum coating masses shown in Table 1 and in Clause 8.2 shall be reduced by 3%, and then rounded to the nearest 5 g/m<sup>2</sup>, unless specifically stated otherwise in the relevant product Standards.

### 8.2 Specific requirements for special coatings

For special zinc or zinc/aluminium-alloy coatings, the specified coating mass shall be at least 300 g/m<sup>2</sup> minimum with incremental increases of 50 g/m<sup>2</sup>; that is, 300, 350, 400, 450 g/m<sup>2</sup> minimum and so on.

NOTES:

- 1 Special SW coating masses are independent of wire size; that is, the specified coating mass does not vary with wire size.
- 2 Not every specified minimum coating mass nor wire size may be commercially available.

## 9 TEST METHOD AND REQUIREMENTS FOR COATING ADHERENCE

The adherence of the zinc coating or zinc/aluminium-alloy coating shall be tested by means of a cylindrical mandrel. For wires of circular cross-section the relationship between mandrel diameter and wire diameter shall be in accordance with Table 2. For shaped wire, unless specified to the contrary, the nominal diameter given in Table 2 shall be taken to be its overall minor dimension.

NOTES:

- 1 This test applies only to wire where the coating is clearly visible through any thin, supplementary non-metallic coating (such as wax or wire-drawing lubricant), or where no supplementary non-metallic coating exists, or where it has been carefully stripped from the wire.
- 2 The 'nominal diameter' shown in Table 2 relates to the diameter of the zinc or zinc/aluminium-alloy coated wire, excluding any supplementary non-metallic coating.

For wires of nominal diameter 7.50 mm and smaller, the adherence of the coating shall be tested by wrapping the wire at least six close turns snugly around the mandrel as specified in Table 2 (see Note 3), and in accordance with the procedure given in AS 2505.6. For wires over 7.50 mm nominal diameter, the adherence of the coating shall be tested by bending the wire through an angle of at least 90° around the appropriate mandrel specified in Table 2.

The coating shall remain firmly adherent to the steel base and shall not crack or flake to a degree that any flakes of coating can be removed by rubbing with the bare fingers.

NOTES:

- 1 Loosening or detachment of small particles of coating during the adherence test, arising from mechanical polishing of the surface of the coated wire, should not be deemed cause for rejection. Small particles of coating, formed as small globules or fragments on the surface during the coating process, may loosen or detach during the test, and this too should not be deemed to be cause for rejection.
- 2 Due care should be exercised in selecting the appropriate mandrel for the wrap or bend test since such mandrels are usually marked with radius rather than diameter.
- 3 With shaped wires carrying less than Class W10 coatings, it may be found impracticable to satisfactorily perform the wrap test as specified, when the ratio of the major dimension to the minor overall dimension is greater than 1.5. In such instances, the adherence of the coating may be tested by bending the wire through an angle of at least 90° around the mandrel appropriate to the minor dimension, which is taken as the nominal diameter.

## 10 CORROSION RESISTANCE

The corrosion resistance of zinc-coated or zinc/aluminium-alloy coated wire is dependent on a number of factors including coating thickness and the atmospheric environment to which it is subjected.

NOTE: Guidance on the selection of coatings for various corrosive environments is given in Appendix F.

## 11 ROUNDING OF TEST RESULT VALUES

The determined value of coating mass shall be rounded to the nearest 5 g/m<sup>2</sup>. For advice on the method of rounding see AS 2706.

## 12 MARKING

Except where a wire or a wire product is covered by an Australian or Australian/New Zealand Standard, which refers the coating requirements to a specific class in this Standard, each coil of wire shall be legibly and durably tagged to enable the coating to be identified with this Standard. The information on the tag pertaining to the coating shall include the following:

- (a) The number of this Standard, i.e. AS/NZS 4534.

NOTE: Where the space is limited on the tag, manufacturers may designate the number of this Standard as AS 4534 or NZS 4534, as appropriate.

- (b) Designation of coating class (see Clause 4.2).  
(c) Designation of coating type and material (see Clause 4.3).  
(d) Manufacturer's trade identification.

NOTE: Manufacturers making a statement of compliance with this Australian/New Zealand Standard on a product, packaging, or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

**TABLE 1**  
**STANDARD COATING MASSES FOR ROUND WIRE**

| Nominal diameter of coated wire, mm | Minimum coating mass, g/m <sup>2</sup> |           |           |           |           |           |
|-------------------------------------|----------------------------------------|-----------|-----------|-----------|-----------|-----------|
|                                     | Class W02                              | Class W05 | Class W10 | Class W15 | Class W20 | Class W25 |
| >0.19 ≤0.23                         | —                                      | 15        | 25        | 40        | 50        | 65        |
| >0.23 ≤0.33                         | —                                      | 25        | 45        | 70        | 90        | 115       |
| >0.33 ≤0.40                         | —                                      | 35        | 60        | 90        | 120       | 150       |
| >0.40 ≤0.46                         | —                                      | 40        | 75        | 115       | 150       | 190       |
| >0.46 ≤0.53                         | —                                      | 50        | 90        | 135       | 180       | 225       |
| >0.53 ≤0.63                         | 20                                     | 60        | 105       | 160       | 210       | 265       |
| >0.63 ≤0.75                         | 20                                     | 65        | 120       | 180       | 240       | 300       |
| >0.75 ≤0.85                         | 25                                     | 70        | 130       | 195       | 260       | 325       |
| >0.85 ≤0.95                         | 25                                     | 80        | 140       | 210       | 280       | 350       |
| >0.95 ≤1.06                         | 25                                     | 85        | 150       | 225       | 300       | 375       |
| >1.06 ≤1.18                         | 25                                     | 90        | 160       | 240       | 320       | 400       |
| >1.18 ≤1.32                         | 30                                     | 95        | 170       | 255       | 340       | 425       |
| >1.32 ≤1.55                         | 30                                     | 100       | 185       | 280       | 370       | 465       |
| >1.55 ≤1.80                         | 35                                     | 110       | 200       | 300       | 400       | 500       |
| >1.80 ≤2.24                         | 35                                     | 120       | 215       | 325       | 430       | 540       |
| >2.24 ≤2.72                         | 40                                     | 125       | 230       | 345       | 460       | 575       |
| >2.72 ≤3.15                         | 45                                     | 130       | 240       | 360       | 480       | 600       |
| >3.15 ≤3.55                         | 50                                     | 135       | 250       | 375       | 500       | 625       |
| >3.55 ≤4.25                         | 60                                     | 140       | 260       | 390       | 520       | 650       |
| >4.25 ≤5.00                         | 70                                     | 150       | 275       | 415       | 550       | 690       |
| >5.00 ≤8.00                         | 80                                     | 160       | 290       | 435       | 580       | 725       |
| >8.00 —                             | 80                                     | 170       | 305       | 460       | 610       | 765       |

## NOTES:

- 1 The class identification numbers reflect the minimum coating masses relative to Class W10. For example, the minimum coating masses for Class W05 are approximately half those for Class W10; those for Class W25 are 2.5 times those for Class W10.
- 2 Guidance for the selection of coating mass and material to suit particular external exposure conditions is given in Appendix F.
- 3 For coating mass requirements for shaped wires, see Clause 8.1