STANDARDS AUSTRALIA

RECONFIRMATION

OF
AS 3894.3—2002
Site testing of protective coatings
Method 3: Determination of dry film thickness

RECONFIRMATION NOTICE

Technical Committee CH-003 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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The following are represented on Technical Committee CH-003:

Australasian Corrosion Association
Australian Paint Approval Scheme
Australian Paint Manufacturers' Federation
Australian Pipeline Industry Association
Water Corporation Western Australia

NOTES

AS 3894.3—2002
Reconfirmed 2013

Australian Standard™

Site testing of protective coatings

Method 3: Determination of dry film thickness

PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee CH-003, Paints and Related Materials, to supersede AS/NZS 3894.3:1993. 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 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.

Standards Australia

CONTENTS

FOREWORD

When determining a method of measuring the dry film thickness of a protective coating in the field, the following factors need to be taken into account:

(a) The need for an uncoated reference substrate that has a surface preparation identical to that of the work piece.

(b) Provision of standard test blocks bearing a calibrated non-magnetic coating that is traceable to a national Standard, i.e. NBS or DIN.

(c) The utilization of non-magnetic or non-metallic shims.

(d) Calibration of instruments and adjustment of instruments.

(e) Examination of coating on various faces as a sampling process.

(f) Expression of results.

The protective coating system examined here is not a separately manufactured article but one that is part of a manufactured product. There are several ways in which the concept of thickness, or its quantitative expression, differs from those criteria that usually characterize the thickness of sheets, foils, films, plates and tubes.

The durability of the protective coating system can be governed by the thickness of film, above the asperities of the substrate that is lying outside the peaks of the surface profile. Measurement of this film thickness at a large number of arbitrarily chosen spots on the test piece will commonly yield a number of readings, some of which are 50% greater than others. At the same time, on any face of the test piece, a mean value for a large number of readings will differ from the mean value of the reading observed on another face. It is the objective of this Standard to achieve uniformity of practice in dealing with such a distribution of film thickness values.

The coating surface in view may be sensibly smooth even though it has a waviness on the large scale. As well as being hidden and inaccessible to the instrument, the underside of the protective film replicates the irregularity of the surface profile, on both the small and the large scale.

Many of the methods available for examining the dry film thickness of a paint coating on a test panel are not for the use of site testing of protective coatings because of the inability to weigh the work piece, measure volume of coatings, or to mar the coating by destructive testing. It is for this reason that only non-destructive instruments, operating on magnetic or electromagnetic principles, have any practical use. The range of thicknesses of protective coatings is usually beneath the level of discrimination of acoustic instruments.

ISO 2808, and Steel Structures Painting Council Specification SSPC-PA-2 provide additional information on the determination of film thickness.

METHOD

1 SCOPE

This Standard provides practical test methods for the on-site determination of the range of thicknesses and the mean dry film thickness of a protective coating system, or its component coats, upon a metallic structure or fabrication.

The coated fabrications to which the methods may be applied include tanks or reservoirs, bridge girders, equipment used in processing chemicals or petroleum, pipelines, and fabricated articles such as vehicles, white goods and other items of industrial production, where there is lack of uniformity of substrate thickness, metallographic character, surface condition and the film of the protective coating.

NOTES:

1 Appendix A provides a laboratory test method for the microscopic determination of the thickness of the film adhering to a substrate. This method would only be used where no other method is acceptable.

2 Appendix B provides a method for determining the thickness of a flake of the coating using an optical microscope.

3 ISO 2808 provides information on additional methods of determining film thickness.

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
2483	Testing of coatings
AS/NZS	
1580	Paints and related materials—Methods of test
1580.108.2	Method 108.2: Dry film thickness—Paint inspection gauge
2310	Glossary of paint and painting terms
2312	Guide to the protection of iron and steel against exterior atmospheric corrosion
ISO	
2808	Paints and varnishes—Determination of film thickness

3 DEFINITIONS

For the purpose of this Standard, the definitions of AS/NZS 2310 and those below apply:

3.1 Dry film thickness

The thickness of the coating measured, at any location on the test surface, above the peaks of the profile (anchor pattern or surface profile) of the substrate.

3.2 Primary standards

Reference standards that are maintained and housed under controlled conditions at the principal office of the test organization.

3.3 Reference substrate

A surface used to set the instrument zero, and for comparing results obtained from the test piece.

3.4 Secondary standards

Standards that are referenced to the primary standards and are used in the field.

4 TEST METHODS

The coating film thickness may be measured using magnetic pull-off gauges (see clause 9), or by eddy current or magnetic induction type instruments (see clause 10) of the type generally described in Table 1:

NOTES:

1 Owing to the inherent inaccuracies of some magnetic pull-off gauges, they are recommended only for process control operations, where accurate and reproducible measurements are not required.

2 Appendix C provides a method for determining the wet film thickness during application of a coating, which will assist applicators in achieving the required dry film thickness.

5 PRECAUTIONS

The accuracy of measurement of a coating thickness may be affected by a number of factors. The following precautions should be observed:

(a) *Calibration* The instrument should be calibrated in accordance with Appendix D prior to use, re-calibrated after each hour and rechecked at the end of the work period.

(b) *Substrate thickness* For each instrument, there is a critical thickness of metal substrate below which the accuracy of the instrument cannot be assured. Since this thickness depends on both the measuring frequency of the probe system and the electrical conductivity or the magnetic permeability of the substrate, its value should be determined experimentally, unless it is specified by the manufacturer of the test instrument.

(c) *Edge effects* Measurements should not be taken close to an edge, hole or inside corner of a test specimen unless the instrument is calibrated for such measurements.

(d) *Curvature* Measurements are affected by the curvature of the specimen. The influence of curvature varies considerably, depending on the make and type of instrument, but always becomes more pronounced as the radius of curvature decreases. Measurements made on curved test specimens will therefore not be valid unless the instrument is specifically calibrated for such measurements.

(e) *Surface profile and roughness* Measurements are influenced by the surface topography of the substrate and of the coating. Rough surfaces and the anchor pattern of a surface profile can cause both systematic and random errors.

(f) *Foreign particles* The probes of the coating thickness gauge need to make contact with the test surface. The instruments are therefore sensitive to any foreign material that prevents intimate contact between the probe and surface of the coating. The probe tip should be checked periodically for cleanliness and foreign particles removed using plasticine or similar material.

(g) *Soft coatings* Soft coatings may be deformed by the probe. Valid measurements on such test specimens may only be possible with the use of special probes or fixtures.

NOTE: When softness of the film is caused by the degree of cure, it may be necessary to defer testing.

(h) *Surface contamination* Sticky, greasy, tacky material, or other types of contaminants, may cause a build-up on the probe, so care should be taken that such material does not affect measurements.

NOTE: If contamination is severe, it may become necessary to defer the testing.

(i) *Probe pressures* Excessive pressure on the probe may damage a coating. Care should be taken to ensure that magnetic instrument probes are held vertically and that the coating is not damaged by the probe when determining measurements.

(j) *Electromagnetic fields* Instruments may not operate correctly in the presence of strong electromagnetic fields. Inaccurate results may be obtained where strong fields are present, e.g. near aluminium smelter pot lines or in the vicinity of electric welding activities.

(k) *Magnetic properties of pigments* The magnetic effect of certain pigments and extenders, such as micaceous iron oxide (MIO) and red iron oxide, can affect the accuracy of measurements obtained from some instruments.

NOTE: Such errors are usually within the normal accuracy of the instrument and may not be significant.

(l) *Temperature effects* Extremes of temperature may influence both the readings obtained from the instrument and the deformation properties of the coating being measured.

6 INSPECTION PERIOD

All thickness testing on the coating shall be performed at an appropriate time—

(a) after the coating manufacturer's specified handling time has elapsed, or when the coating has hardened sufficiently so that it is not deformed by the application of the probe;

(b) before the maximum permissible recoating period has elapsed; and

(c) not more than seven days after the manufacturer's specified handling time has elapsed.

7 INSPECTION PLANS

7.1 General

When devising an inspection plan for the number of measurements required to determine the thickness of a coated finish, it is necessary to consider such aspects as—

(a) the extent and duration of the project;

(b) when the inspection work is to be carried out;

(c) the configuration of the coated work, including the presence of braces, supports and other appurtenances; and

(d) the pattern of inspection points that has proved acceptable for previous projects that have used the same coatings, the same methods of application, and operatives of equivalent skill.

Clauses 7.3 to 7.5 provide a guide to inspection plans that have been found appropriate for different programs of work. As each of Clauses 7.3 to 7.5 offers a different inspection plan, a procedure appropriate to the specific program of work needs to be selected.

7.2 Point reading

When determining a reading at a point on the coating, a single reading is sufficient. However, for suspect or disputed readings the mean of three separate gauge readings, taken within the area of a 12 mm diameter, should be recorded.

7.3 Large surface areas

For large areas of flat or uniformly curved coated surfaces, five separate point readings (see Clause 1.7.2), evenly spaced throughout, should be made in each 10 m^2 area examined. The 10 m^2 inspection areas should be selected as follows:

(a) *Structures not exceeding 30 m^2* Each 10 m^2 area should be measured.

(b) *Structures not exceeding 100 m^2* Three 10 m^2 areas should be chosen at random and measured.

(c) *Structures exceeding 100 m^2* The first 100 m^2 area should be measured in accordance with Option (b), and for each additional 100 m^2 area, a 10 m^2 area should be chosen at random and measured.

(d) Where the thickness for any 10 m^2 area chosen in accordance with Option (b) or (c) does not meet the required specification, then each 10 m^2 area of surface should be measured.

NOTE: This inspection plan is recommended by the National Association of Corrosion Engineers (NACE) and Steel Structures Painting Council Specification SSPC-PA-2.

TABLE 1

TYPICAL PROPERTIES OF FILM THICKNESS INSTRUMENTS

No.	Instrument Type	Test range	Typical instrument accuracy	Application	Scale	Calibration	Remarks
1	Pencil gauge Magnetic pull-off	0–600 µm	±15%	Magnetic substrates	Fixed	Nil	Inherently variable in its accuracy Suitable for mid-range readings only on horizontal surfaces
2	Banana gauge Magnetic torsion pull-off models	0–10 000 µm using separate models	±10%	Magnetic substrates	Fixed	Single point	Suitable for use in any orientation locations Hand-held, portable, of moderate cost and suitable for process control
3	Multi-reel readout Magnetic induction Electro-mechanical operation	0–2000 µm	±5 µm* or ±5%	Magnetic or non-ferrous substrates, according to model	Fixed	Single point	Solid state electronic instrument suitable for all applications and orientations Small, compact, battery-operated, hand-held
4	Magnetic induction Electronic operation Analogue read out	0–2500 µm	±5 µm* or ±5%	Magnetic or non-ferrous substrates, according to model	Adjustable	Two points	Solid state electronic instrument suitable for all applications and orientations Small, compact, battery-operated, hand-held
5	Magnetic induction Electronic-digital liquid crystal display (LCD)	0–20 000 µm	±2 µm* or ±1% up to 12 500 µm ±5% greater than 12 500µm	Magnetic substrates only	Adjustable	Two points	Suitable for all applications and rough surfaces Microprocessor control

TABLE 1 (*continued*)

No.	Instrument Type	Test range	Typical instrument accuracy	Application	Scale	Calibration	Remarks
							(*continued*)
6	Magnetic induction and eddy current Micro-processor computer controlled LCD	0–10 000 µm	±2 µm* or ±1% up to 12 500 µm ±5% greater than 12 500 µm	Magnetic or non-ferrous substrates	Adjustable	Two points	Microprocess or control for all applications Statistical/ memory capacity/ batch analysis Hard copy facility
7	Paint inspection gauge (PIG) Cutter and optical microscope	0–1.3 mm	±10%	All substrates	—	Certificate for cutter	Hand-operated optical microscope. A destructive test (refer to AS 1580.108.2)
8	Optical microscope with magnification up to 500×	—	±2 µm	Measurement of film flake	—		Referee method Not suitable for site use

* Whichever is the greater.

NOTE: Ultrasonic gauges are available to measure coating thickness on concrete, masonry, timber, glass and ceramics.

TABLE 2

SAMPLE INSPECTION PLAN FOR COATING

Number of 10 m^2 areas in a batch (Batch size)	Number of 10 m^2 areas to be randomly selected for test (Sample size)	Maximum number of defective 10 m^2 areas for batch to be accepted (Acceptance number)
2 to 8	2	0
9 to 15	3	0
16 to 25	5	0
26 to 50	8	0
51 to 90	13	0
91 to 150	20	1
151 to 280	32	1
281 to 500	50	2
501 to 1 200	80	3
1 201 to 3 200	125	5
3 201 to 10 000	200	7
10 001 and over	315	10

7.4 Small surface areas

For small items and coating areas, point thickness measurements may be taken as follows:

(a) *Flat areas less than 10 m^2* A minimum of 3 point readings per square metre.

(b) *Pipe work* At each metre of pipe run, point readings shall be taken evenly around the circumference as follows:

Nominal pipe size, mm	Number of circumferential readings
≤150	2
>150 ≤300	4
>300 ≤600	6

(c) *Beams/angles* One reading on each flat face less than 300 mm in width, for each linear metre.

7.5 Statistical sampling

Depending on the nature of the work, it may be appropriate to devise a specific inspection plan based on statistical sampling. Such a procedure will only be effective if the following requirements are met:

(a) The sample is drawn randomly from work of known history. The sample should enable verification of coatings produced at essentially the same time using essentially the same process and system of control.

(b) For each situation, a suitable inspection plan needs to be defined. An inspection plan devised for one contractor of given capability, when applying a particular coating, may not be relevant to another contractor applying the same coating.

For statistical sampling to be of value, the contractor needs to have a demonstrated level of expertise. Sampling and the establishment of an inspection plan should be carried out in accordance with AS 1199, guidance to which is given in AS 1399.

NOTE: Table 2 provides an example of an inspection plan based on an AQL of 1.5%.

8 INSPECTION OBJECTIVES

8.1 General

The procedures of Clause 9 or Clause 10 shall be followed, according to the type of instrument employed, to record an appropriate number of determinations with a properly calibrated instrument.

The objective is to ascertain whether the structure or steel fabrication has the desired thickness of protective coating; however, this is commonly a contractual matter between at least two parties. For any point at which a measurement reveals a reading that is outside the specification limits, it is not only necessary to inspect closely the immediate area to establish the extent of the out-of-specification film, but also to identify and mark it for further consideration or action.

The criteria for further action will depend upon the service to which the substrate is likely to be exposed, and are given in Clauses 1.8.2 to 1.8.4. In some instances, it may be essential that the specified maximum coating thickness be not exceeded, to ensure adequate performance of the coating.

8.2 Severe environment

For surfaces that are to be immersed, buried or subjected to a very severe chemical or marine environment, a minimum film thickness should be specified and achieved.

Although, for cost-effective reasons, a specification may in such cases accept an absolute minimum area of somewhat lower thickness, irrespective of the inspection plan adopted, any point thickness determination found to be outside the specified thickness range should be identified to enable restorative action to be taken.

8.3 Atmospheric exposure

For structures exposed to the atmosphere, especially when protected by coating systems nominated in AS/NZS 2312, the following requirements should be met:

(a) The average of five point readings for each 10 m^2 area of coating surface should not be outside the specified coating thickness range.

(b) No single point reading in any 10 m^2 area should be less than 80% of the specified minimum coating thickness. However, where three readings are averaged to produce a point reading, an individual reading may be less than 80% of the minimum coating thickness.

8.4 Large numbers of small components

Where a statistical inspection plan is adopted, such as shown in Table 2, the number of defective areas should not exceed that permitted by the plan.

9 MAGNETIC INSTRUMENT METHOD—METHOD A

9.1 Scope

These Clauses set out a method for measuring the thickness of non-magnetic dried coatings (Method A) on structural steel or other ferromagnetic substrates. It is intended for use with paints that produce films that are firm and are not indented by the instruments used.

9.2 Principle

Instruments using the magnetic pull-off principle measure the force required to overcome the attraction between a magnet and the magnetic substrate. The magnitude of the force is dependent on the distance between the magnet and the substrate, which, in the case of painted specimens, is the coating thickness.

9.3 Apparatus

9.3.1 *Calibration standards*

Standard test blocks bearing calibrated non-magnetic coatings that are traceable to a suitable national standard, covering the appropriate range of film thickness to be measured.

9.3.2 *Magnetic pull-off instrument*

Measuring the attractive force between the substrate and the magnet, which is separated by the coating thickness to be measured.

The instrument may be one of a type incorporating either of the following:

(a) A spring that is extended by the action of lifting the instrument (by hand) with the magnet in place on the coating. The graduated extension at the point where the magnet leaves the coating provides a measure of film thickness.

(b) A counterbalance lever attached to the magnet and connected to a spiral torsion spring. The spring is wound up by smooth rotary action applied by the thumb, to increase the force of retraction on the magnet lever. At the point of pull-off, the calibrated dial provides a reading of film thickness.

NOTE: Instruments used in Option (a) are not recommended for routine inspection work.

9.4 Preparation of test surface

The test surface shall be clean, free of foreign matter and, if necessary, degreased using a suitable degreasing agent that does not attack the coating.

9.5 Precautions

9.5.1 *General*

In addition to factors referred to in Clause 1.5, magnetic pull-off instruments should be subject to the considerations given in Clauses 9.5.2 to 9.5.5.

9.5.2 *Reproducibility*

To ensure reproducibility of results, hand operation of the instrument should be carried out slowly with a smooth action.

9.5.3 *Vibration*

Care should be taken that vibration of the test surface does not influence the reading obtained.

9.5.4 *Measuring*

For instruments in Clause 9.3.2(b), the measuring uncertainty inherent in the method is typically ±10% of the coating thickness. The inaccuracy is greater at each end of the scale.

9.5.5 *Probe position*

Care should be taken to ensure that the probes are held vertical to the test coating.

9.6 Procedure

The coating thickness shall be measured as follows:

(a) Select an instrument with a mid-range appropriate to the thickness to be measured.

(b) Ensure that the coating is firm and resists deformation prior to use of the instrument.

(c) Inspect the probe tip and the surface to be measured to ensure that they are clean.

(d) Calibrate the instrument in accordance with Appendix D.

(e) Take readings in areas that are free of vibration and electrical or magnetic fields.

(f) For a film thickness less than three times the profile height, measure the uncoated substrate (A) at a number of points to obtain a representative average value, then follow Steps (g) and (h).

(g) Measure the dry coating film (B) at the specified number of points to obtain a representative average value.

(h) Subtract reading (A) from (B) to obtain the thickness of the coating film.

NOTES:

1 When a fixed scale gauge is used, it is necessary to correct the A and B measurements using the corrections determined in Steps (b) and (d) of Paragraph D5.2 Appendix A.

2 Where the thickness of the measured coating exceeds three times the surface profile height of the uncoated substrate, it is not necessary to determine a reading on uncoated substrate for subtraction from the reading obtained over the coating.

3 For practical purposes, when the profile height is not accessible, as a guide a value of one third of the expected profile height may be used as a correction for profile effects as a deduction from measurement B.

(i) If thickness readings are found outside the range of accuracy determined in Step (d), repeat the calibration procedure in that range. Check the calibration frequently during use to ensure that the instrument continues to read correctly.

(j) Recalibrate the instrument at appropriate periods (see Clause 1.5.1).

(k) Take a sufficient number of readings in accordance with Clause 1.7.

(l) Take measurements no closer than 25 mm to an edge, and no closer than 75 mm to another mass of metal.

NOTE: If measurements are required within these specified limits, recheck the calibration in the specific area to determine the effect that the edge or mass of metal has on the instrument reading.

(m) Record the results.

9.7 Report

The report shall include the following information:

(a) Name of testing organization/inspector.

(b) Date of the test and report number.

(c) Identification and description of the item tested and its coating, including shape, substrate material, coating type and specified film thickness.

(d) A description of the location where the test was conducted, the project identification and the test conditions.

(e) Description of the test equipment used and calibration details.

(f) Film thickness measurements, in micrometres.

(g) Reference to this Australian/New Zealand Standard, i.e. AS/NZS 3894.3, Method A.

(h) Any deviations from this test method.

NOTE: Appendix E provides a sample test report form.

10 MAGNETIC INDUCTION AND EDDY CURRENT METHODS—METHOD B

10.1 Scope

This Clause sets out methods for non-destructive measurement of the thickness of cured coatings, as follows:

(a) *Magnetic induction (low frequency) method* For non-magnetic metallic coating and organic coatings on magnetic substrates.

(b) *Eddy current (high frequency) method* For non-conductive coatings on non-magnetic metallic substrates.

(c) *Eddy current (high frequency) method* For metallic and non-metallic coatings on metallic substrates which differ appreciably in conductivity.

10.2 Application

The methods may be applied to coatings and substrates referred to in Clause 3.1, where the coating thickness is not less than 2 µm, and the surface contour permits calibration of the appropriate instruments (see also Appendix D).

The magnetic induction (low frequency) method is suitable for the measurement of non-magnetic metallic coatings, such as silver, tin and zinc, and organic coatings such as paints and plastics on magnetic substrates.

The eddy current (high frequency) method is frequently applied to the measurement of organic coatings on non-magnetic metallic substrates and to the measurement of anodized coatings.

With suitable instruments using appropriate frequencies, it is possible to measure the thickness of various metallic coatings on either magnetic or non-magnetic substrates; e.g. tin-lead on copper, silver on nickel-silver, copper on steel, zinc on steel, cadmium on steel, tin on steel, copper on a non-metallic base, and silver on a non-metallic base.

These methods, under the best conditions of use, are accurate to 2 µm, or ±5%, whichever is the greater.

NOTE: The methods are not suitable for the measurement of chemical conversion coatings.

10.3 Principle

An electromagnetic field is generated in the probe system of both the magnetic induction instrument and the eddy current instrument.

Magnetic induction instruments generate a low-frequency alternating current (typically 50 Hz to 60 Hz) in a probe, which produces measurable magnetic induction when it is placed on a test specimen with a magnetic metal substrate. A controlled oscillator produces a low-level alternating voltage, which energizes one coil in a multi-coil probe. This in turn induces a voltage in the coil in close proximity to the first. As the magnitude of this voltage depends on the distance between the probe and the ferromagnetic substrate, this voltage represents the coating thickness.

Eddy current instruments generate higher frequencies in the probe (typically about 6000 kHz), which produces eddy currents in the test specimen when the probe is placed on the test surface. A single coil probe is driven by a low-level alternating voltage produced by a crystal controlled oscillator. This voltage induces small currents (eddy currents) which flow in conductive materials in opposition to the original field and effectively reduce the voltage across the coil. The change in voltage is dependent upon the distance of the probe from a conductive substrate; this distance is the coating thickness.

10.4 Apparatus

An instrument that complies with the appropriate principle that is outlined in Clause 3.3 and which can be calibrated for the known thicknesses of coating (see Appendix D) is required.

10.5 Preparation of test surface

The test surface shall be clean, free of foreign matter and, if necessary, shall be degreased using a suitable degreasing agent that does not attack the coating.

10.6 Precautions

In addition to the factors in Clause 1.5, eddy current and magnetic induction type instruments should be subject to the following considerations:

(a) *Conductivity of the substrate* Measurements using eddy current instruments can be affected by the electrical conductivity of the substrate. This is a function of the composition and heat treatment of the material. The influence of electrical conductivity on the measurement varies considerably with the make and type of instrument.

If the substrate alloy or its heat treatment changes, the zero reading should be rechecked and the instrument recalibrated if necessary.

For eddy current instruments, the assumption is made that the full properties are known. In the event that a change in substrate conductivity is suspected, a small area of coating shall be removed to allow calibration of the instrument on the bare metal.

A rapid change in a series of readings may indicate that there is a change in substrate composition.

(b) *Measuring accuracy* The measuring uncertainty inherent in this method is typically ±2 μm or ±5% of the coating thickness, whichever is the greater.

(c) *Probe temperature* The characteristics of the probe may vary as the temperature changes. Wherever possible, measurement should only be taken under the conditions that apply during calibration of the instrument probe combination. Where extreme surface temperatures are encountered, the probe manufacturer's advice should be sought.

10.7 Procedure

The coating thickness shall be measured as follows, using the method appropriate to the coating (see Clause 3.2):

(a) Check that the substrate thickness is greater than the critical minimum thickness specified by the instrument manufacturer.

(b) Ensure that the coating is firm and resists deformation prior to use of the instrument.

(c) Inspect the probe tip and the surface to be measured to ensure that they are clean.

(d) Check the calibration of the instrument on a smooth substrate similar to that being tested (see Appendix D).

(e) Press the probe on the point to be measured, at right angles to the test surface.

(f) For a film thickness less than three times the profile height, measure the uncoated substrate (A) at a number of points to obtain a representative average value, then follow Steps (g) and (h).

(g) Measure the dry coating film (B) at the specified number of points to obtain a representative average value.

(h) Subtract reading (A) from (B) to obtain the thickness of the coating film.

NOTES:

1 When a fixed scale gauge is used, it is necessary to correct the A and B measurements using the corrections determined in Steps (b) and (d) of Paragraph D5.2, Appendix D.

2 Where the thickness of the measured coating exceeds three times the surface profile height of the uncoated substrate, it is not necessary to determine a reading on the uncoated substrate for subtraction from the reading obtained over the coating.

3 For practical purposes, when the profile height is not accessible, as a guide a value of one third of the expected profile height may be used as a correction for profile effects as a deduction from measurement B.

(i) Recalibrate the instrument at appropriate periods (see Clause 1.5.1).

(j) Take a sufficient number of readings in accordance with Clause 1.7.

(k) Record the results.

NOTE: Appendix E shows a typical form that may be used to record results.

10.8 Report

The report shall include the following information:

(a) Name of testing organization/inspector.

(b) Date of the test and report number.

(c) Identification and description of the item tested and its coating, including shape, substrate material, coating type and specified film thickness.

(d) A description of the location where the test was conducted, the project identification and the test conditions.

(e) Description of the test equipment used and calibration details.

(f) Film thickness measurements, in micrometres.

(g) Reference to this Australian/New Zealand Standard, i.e. AS/NZS 3894.3, Method B.

(h) Any deviations from this test method.

NOTE: Appendix E provides a sample test report form.

APPENDIX A

MICROGRAPHIC EXAMINATION OF CROSS-SECTIONS

(Informative)

A1 SCOPE

This Appendix sets out the method for measuring the local thickness of protective coatings by micrographic examination of cross-sections.

The method is suitable for measuring the thickness of protective coatings on various substrates. It provides a general method for measuring, to within 2 µm or better, the thickness of a protective coating on a section cut from a test panel or coated article.

It is recommended as a referee method where a dispute cannot be resolved concerning the thickness of a protective coating. It is particularly useful for measuring variations in thickness, which occur due to unevenness of the substrate, for example on grit-blasted steel.

A2 PRINCIPLE

Test specimens are cut from coated products, prepared for testing and then examined micrographically.

A3 APPARATUS

A microscope fitted with distance measuring equipment such that the uncertainty is not greater than ±2 µm.

A4 PREPARATION OF TEST SPECIMENS

A4.1 General

Test specimens should be free of foreign matter and, if necessary, should be degreased in a solvent that does not attack the coating.

For soft coatings, with thickness less than 50 µm, the degreased surface of the coating should be painted with a contrasting plastics coating. The paint should not be reactive with the coating to be measured.

A4.2 Mounting of test specimen (see Note 1)

The test specimen may be mounted in a plastics material that is neither reactive to nor affects the coating, e.g. a suitable clear-coating cold-setting resin or material such as Plaster of Paris. Care should be taken to ensure that voids do not form between the test specimen and the mounting material, and that the coated surface is at right angles to the surface being ground and polished (see Note 2).

NOTES:

1 When testing coated sheet and strip metals, test specimens may be appropriately clamped prior to mounting and polishing.

2 A deviation of only 10 ° from the vertical introduces an error of approximately 2% in the coating thickness determination.

A4.3 Grinding and polishing

The surface of the test specimen, prepared as described in Paragraph A4.1, is generally in a condition suitable for the grinding operation. Should burrs be present on either the test piece or its mountings, they may be removed by means of a smooth file.

The test specimen is to be ground and polished in accordance with good micrographic practice. The following procedure has been found to be satisfactory:

(a) Abrade the test specimen with successively finer silicon carbide wet and dry abrasive papers placed on a flat glass plate and copiously lubricated with water during the grinding process.

NOTE: A satisfactory finish is generally obtained by first using P180 grade paper and then successively using P360, P600 and P1200 grades.

(b) In each case, immediately before passing to the next finer grade of paper, the test specimen should be abraded with a back and forth movement in a straight line to ensure that, before washing, scratches due to that particular paper are in one direction.

(c) On transferring the test specimen to the next finer paper, rotate the test piece through 90% and then repeat the back and forth movement across previous scratches until they disappear. This provides a convenient way of determining when to transfer the test specimen to the next finer grade of paper.

(d) When operations have been finished on the finest grade paper, rinse and polish the test specimen by using either a water suspension of a suitable polishing medium, such as finely divided magnesium oxide, aluminium oxide, or diamond dust (0 to 1 μm) suspended in a suitable wax or paste. The polishing operation should be carried out using a soft cloth without the use of undue pressure.

NOTES:

1 ‘Selvyt’ cloth or chamois, or materials of similar softness, are suitable polishing cloths.

2 The following precautions will facilitate the preparation of satisfactory test specimens:

(a) Polished surfaces should not be fingered.

(b) Polishing pads should be covered when not in use to avoid contamination by airborne dust.

(c) At the completion of the polishing process, the surface should be washed with a suitable solvent, rinsed in alcohol and dried in an air stream.

A5 PROCEDURE

The coating thickness is measured as follows:

(a) Project the image of the test specimen section onto the screen of a metallographic microscope at a known and properly calibrated magnification.

(b) Measure accurately the thickness of the deposit on the projected image using a graduated linear scale.

The actual thickness of the coating may be determined by dividing this measurement by the magnification, or by measuring the thickness using a metallurgical microscope fitted with a micrometer eyepiece that has been calibrated against an accurately graduated reference scale.

In either case the magnification used should be sufficient to allow the thickness of the coating to be determined to the required accuracy.

(c) A minimum of 10 readings should be made. The thickness of the coating should be read from the highest peak of the metal substrate in the field of view.

(d) Record the result in micrometres.

A6 REPORT

The report should include the following information:

(a) Test specimen identification.

(b) Relevant product specification.

(c) Each thickness measurement of the coating, in micrometres.

(d) Report number and date.

(e) Reference to this test method, i.e. AS/NZS 3894.3, Appendix A.

(f) Any deviations from this test method.

APPENDIX B

MICROSCOPIC MEASUREMENT OF PAINT FLAKES

(Informative)

B1 SCOPE

This Appendix sets out a method of speedily determining the film thickness of small specimens of paint flakes removed from the substrate, using a micrographic examination of the cross-sections. The method also allows the determination of the number and thickness of visibly different overlapping coatings.

B2 PRINCIPLE

A cross-section of a paint flake is mounted in wax or plasticine on a glass slide and is examined and its thickness is measured under a microscope.

B3 APPARATUS

B3.1 Optical microscope

Binocular type of variable magnification up to 100×, fitted with appropriate measuring graticules.

B3.2 Camera

Where required, capable of being used in conjunction with the microscope (B3.1).

B4 PREPARATION OF THE TEST SPECIMEN

The specimen is prepared as follows:

(a) Snap the flake to be examined or, in the case of a very flexible specimen, tear the flake to present as straight an edge as possible. Do not cut or polish the specimen as this will blur the detail and burr the edges.

(b) Mount the specimen in wax or plasticine, on a glass slide.

(c) Ensure that the specimen is held vertically and edge-onto the lens.

NOTE: A deviation of only 10° from the vertical introduces an error of approximately 2% in the coating thickness determination.

(d) Adjust the flake to expose as large a portion of the edge as possible, positioned at right angles to the lens mounting.

B5 PROCEDURE

The test procedure is as follows:

(a) Illuminate and focus on the cross-sectional edge, using the lowest magnification first, e.g., 50×.

NOTE: For measurement of film thickness, 50× and 100× are the most frequently used magnifications.

(b) Align the linear graticule across the flake and record the measurement.

(c) Determine the thickness of the specimen by viewing through the microscope. The readings on the graticule are interpreted as follows:

(i) 50× 1 mm on the graticule represents 2000 μm.

(ii) 100× 1 mm on the graticule represents 1000 µm.

(d) Determine the thickness of the specimen by producing a micrograph. The specimen thickness may be measured from the print using the following conversion:

(i) 50× 1 mm represents 20 µm.

(ii) 100× 1 mm represents 10 µm.

(e) Record the measured thickness of the specimen.

B6 REPORT

The report should include the following information:

(a) Test specimen identification.

(b) Relevant product specification.

(c) Each thickness measurement of the coating, in micrometres.

(d) Report number and date.

(e) Reference to this test method, i.e. AS/NZS 3894.3, Appendix B.

(f) Any deviations from this test method.

APPENDIX C

WET FILM THICKNESS BY COMB GAUGE

(Informative)

C1 SCOPE

This Appendix describes a method of determining a field measurement of the wet film thickness of a coating using a comb gauge.

The comb gauge gives only a rough indication of wet film thickness and consequently is used mainly for field checks during painting operations and to show that major deviations in film thickness are not occurring. Use of a suitable correction factor with the wet film thickness obtained by the comb gauge will provide an estimate of the dry film thickness of the finished coating.

C2 PRINCIPLE

The comb gauge is inserted in the wet film, normal to the coated surface, and is then examined to determine the shortest tooth touching the coating.

C3 APPARATUS—COMB GAUGE

Of metal or plastics material, the outer teeth of which form a baseline (see Figure C1). The inner teeth are progressively shorter, thus presenting a range of gaps between the tips of the teeth and the baseline which correspond to a scale marking on the gauge.

C4 PROCEDURE

The procedure is as follows:

(a) Immediately after the application of the paint, place the comb gauge firmly onto the substrate in such a way that the teeth are normal to the plane of the surface.

(b) Remove the gauge and examine the teeth to determine which is the shortest one to have touched the wet paint film.

(c) Record the film thickness as lying between the last ‘touching’ tooth and first ‘non-touching’ tooth, as shown on the tooth calibrations marked on the gauge.

(d) Take at least two further readings in different places to obtain representative results over the painted area.

(e) Clean the gauge teeth after each film thickness determination.

(f) If required, estimate the dry film thickness using a conversion method given in Paragraph C5.

C5 ESTIMATION OF DRY FILM THICKNESS

The dry film thickness may be estimated from a wet film measurement using the following equation:

$$DFT = \frac{WFT \times v}{100 + t} \qquad \ldots \text{C5(1)}$$

where

DFT = dry film thickness, in micrometres

WFT = wet film thickness, in micrometres

v = volume solids in paint before thinning, as a percentage

t = thinner added to paint, as a percentage

The required wet film thickness to achieve a desired dry film thickness may be estimated from the following equation:

$$WFT = \frac{DFT \times (100 + t)}{v} \quad \ldots \text{C5(2)}$$

Alternatively, Table C1 may be used to determine the percentage volume solids present, after thinning the paint. Table C2 or Figure C2 may be used to determine the wet film thickness required to achieve a specified dry film thickness for thinned paint containing of varying percentages volume solids.

C6 REPORT

Where a test report is required, it should contain the following information:

(a) The name of the project.

(b) The identification of the product tested.

(c) The date of the test.

(d) The average wet film thickness measured.

(e) If required, the estimated dry film thickness obtained after applying a stated correction factor.

(f) Reference to this test method, i.e. AS/NZS 3894.3, Appendix C.

(g) Any deviations from this test method.

TABLE C1

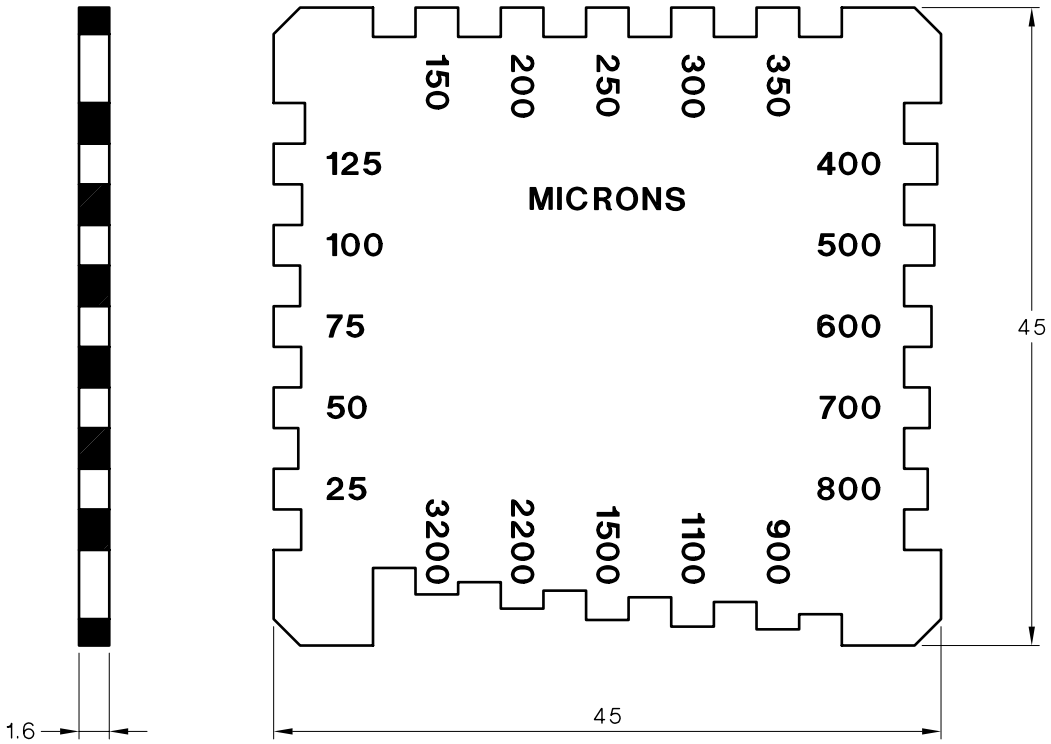
REDUCED PERCENTAGE VOLUME SOLIDS IN PAINT AFTER THINNING

Percentage volume solids before thinning	Percentage of thinner added									
	2½	3½	5	6¼	7½	10	12½	18¾	25	37½
100	98	97	96-95	94	93	91	89	84	80	73
95	93	93	91-90	90	89-88	87	85	81	77	70
90	88	87	86	84	84	82	80	76	72	66
85	83	82	81	80	79	78	76	72	68	62
80	78	78	77-76	75	74	73	71	68	64	58
75	73	73	72	71	70	69-68	67	63	60	55
70	68	68	67	66	65	64	62	59	56	51
65	64	63	62	61	60	60-59	58	55	52	47
60	59	58	57	57	55-56	55	53	51	48	44
55	54	53	53-52	52	51	50	49	46	44	40
50	49	48	48	47	46	46	45	42	40	36
45	44	44	43	42	42	41	40	38	36	33
40	39	39	38	38	37	37-36	36	34	32	29
35	34	34	34	33	33	32	31	30	28	28
30	29	29	29	28	28	27	27	25	24	22
25	24	24	24	24	23	23	22	21	20	18

TABLE C2

WET FILM THICKNESS, IN MICROMETRES, TO ACHIEVE SPECIFIED DRY FILM THICKNESS FOR PAINT OF VARIOUS VOLUME SOLIDS

Required dry film thickness µm	Percentage volume solids in applied film												
	35	40	45	50	55	60	65	70	75	80	85	90	95
25	71	63	56	50	46	42	39	36	33	31	29	28	26
50	143	125	111	100	91	83	77	71	67	63	59	56	53
75	214	188	167	150	136	125	115	107	100	94	88	83	79
100	286	250	222	200	182	167	154	143	133	125	118	111	105
125	357	313	278	250	227	208	192	179	167	156	147	139	132
150	429	375	333	300	273	250	231	214	200	188	176	167	158
175	500	438	389	350	318	292	269	250	233	219	206	194	184
200	571	500	444	400	364	333	308	286	267	250	235	222	211
250	714	625	556	500	455	417	385	357	333	313	294	278	263
300	857	750	667	600	546	500	462	429	400	375	353	333	316



NOTE: The comb gauge illustrated is for the range 25-3200 μm; combs are available in a range of scales, shapes and sizes.

DIMENSIONS IN MILLIMETRES

FIGURE C1 TYPICAL COMB GAUGE

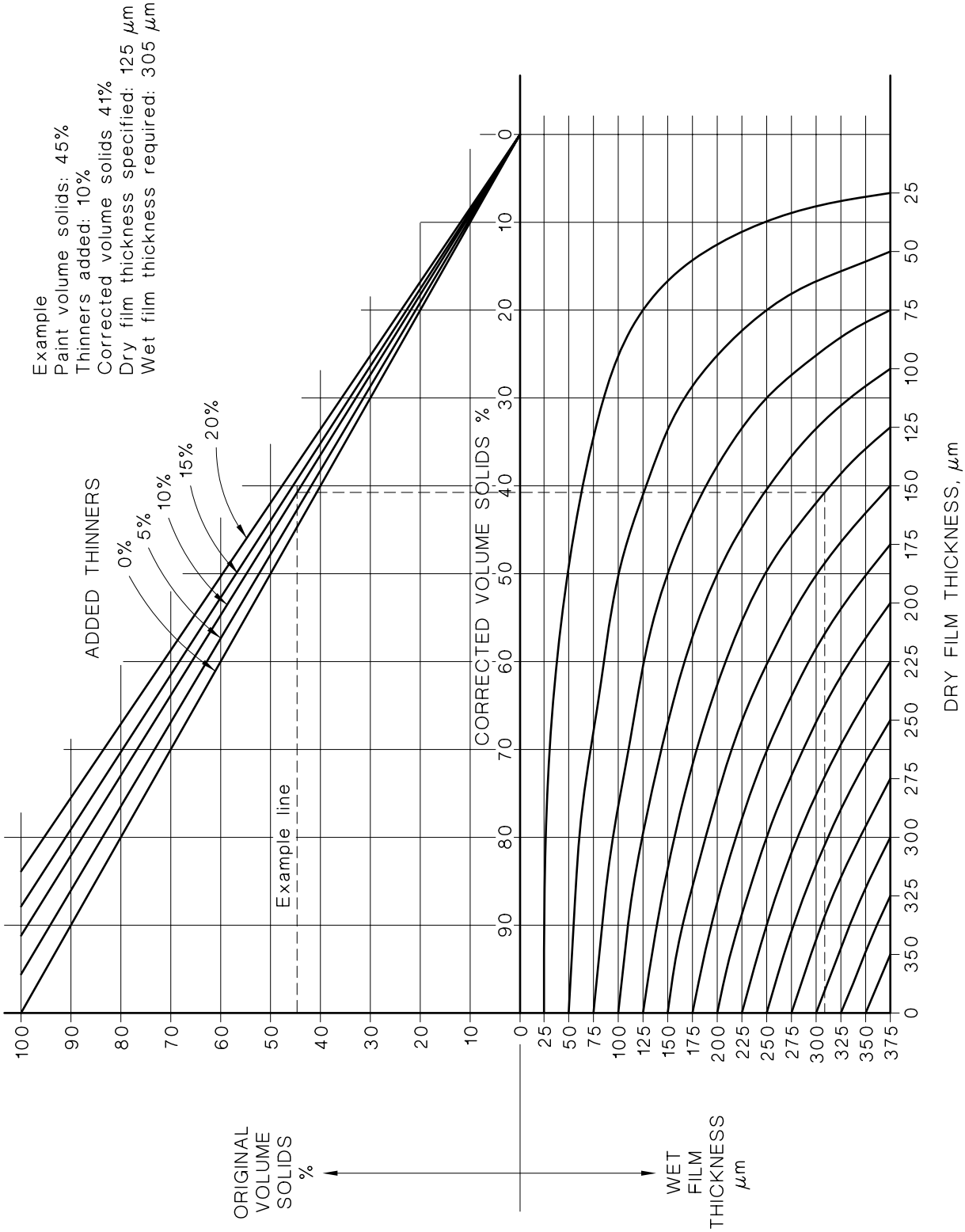


FIGURE C2 CHART FOR THE CORRECTION OF VOLUME SOLIDS FOLLOWING THE ADDITION OF THINNERS AND DETERMINATION OF REQUIRED WET FILM THICKNESS TO ACHIEVE A SPECIFIED DRY FILM THICKNESS

APPENDIX D

CALIBRATION OF MEASURING INSTRUMENTS

(Normative)

D1 SCOPE

This Appendix provides requirements for and information on the calibration of magnetic pull-off gauges and magnetic induction and eddy current measuring instruments.

D2 GENERAL

Instruments shall be operated in accordance with the manufacturer's instructions. Using suitable thickness standards, calibration shall be carried out in the range of thicknesses to be measured during the tests.

To ensure consistency of measurements, recalibration checks using secondary standards or suitable reference substrates shall be carried out at frequent intervals during testing.

The type of calibration standards used will depend on the type of instrument and the nature of the coating under test.

D3 CALIBRATION STANDARDS

D3.1 General

Primary standards for magnetic pull-off gauges and magnetic induction and eddy current measuring instruments shall be in accordance with Paragraph D3.2. Secondary standards may be in accordance with Paragraph D3.3.

D3.2 Primary standards

Primary standards shall be test blocks bearing calibrated non-magnetic coatings that are traceable to a national standard. They may consist of small panels, each uniform in thickness, covering the appropriate range of film thicknesses to be measured.

NOTE: Eddy current measuring instruments may only be calibrated using a non-metallic coating on a metal substrate, or a substrate with a coating having the same magnetic properties as the material under test.

D3.3 Secondary standards

Secondary standards may take the form of plastic films, shims or precoated reference panels, made either of plastics materials or a non-magnetic metal, which give a similar equipment response to the coating to be tested, e.g. shims of non-magnetic metal such as brass for the magnetic pull-off gauge, and plastics for the other types of instruments.

The use of plastic films is advantageous for the calibration of instruments used for measuring curved surfaces.

To avoid errors in measurement, ensure intimate contact between a film and the substrate.

Calibration foils are subject to indentation and require replacement when worn or damaged. Resilient foils should not be used.

D4 REFERENCE SUBSTRATES

Substrate references are used for setting the zero and comparing results obtained from the test piece. Reference substrates may be made from the material under test or may be an uncoated smooth metal plate. The reference substrate should be of similar geometry for small or curved sections. For use with magnetic induction instruments, they may also be

made from material having similar permeability as the material under test. For eddy current instruments, material having similar electrical response properties may be used.

The reference substrate should be smooth, without roughness or profile.

When the substrate thickness is below the minimum critical thickness, the thickness may be built up by adding packing pieces of the same metal. However, packing pieces should only be used as a last resort.

Packing pieces are not suitable when the substrate is coated on both sides or when there is a gap between the substrate and the back-up metal.

D5 PROCEDURE

D5.1 General

The calibration of test equipment entails simulating the coating under test by use of incremental thicknesses of calibration foils, films or coating standards.

Instruments shall be adjusted during calibration, in accordance with the manufacturer's instructions (see Paragraphs D5.2 and D5.3). Appropriate calibration standards shall be used.

Magnetic pull-off gauges shall be calibrated in accordance with Paragraph D5.2. Magnetic induction instruments and eddy current instruments shall be calibrated in accordance with Paragraph D5.3.

D5.2 Magnetic pull-off gauges

Instruments that are capable of calibration shall be calibrated using the following procedure:

(a) Measure the thickness on a primary standard (see Paragraph D3.2), at or slightly above the expected range of coating thickness.

(b) Depending upon the type of instrument, either adjust the reading or record the calibration variation at standard thickness. To guard against gauge drift during use, recheck the gauge with one or more of the standards at least once each hour and on completion of each work shift.

(c) Record the thickness of the calibration standards.

(d) Crosscheck in the field using a precoated reference panel as a secondary standard, at or slightly above the expected range of coating thickness.

NOTE: Although not ideal, for practical purposes in the field, shims may be used as a secondary standard as an alternative to precoated reference panels.

(e) When the gauge adjustment has drifted so far that large corrections are needed, readjust closer to the standard values and recalibrate. When the gauge can no longer be adjusted to the calibration standards, have it rebuilt or replaced.

(f) Do *not* zero the gauge on the profile of the uncoated substrate.

D5.3 Magnetic induction and eddy current instruments

The procedure for calibration is as follows:

(a) Adjust the zero of the instrument on the smooth clean reference substrate (see Paragraph D4).

(b) Hold the instrument probe firmly against a primary or secondary standard, but avoid excessive pressure, which could indent the coating.

(c) Set the instrument while holding the probe firmly against the calibration film.

(d) Confirm the instrument setting by measuring the calibration film at several areas of the smooth clean reference substrate.

(e) Recheck the instrument using Steps (a) through to (d) as needed to obtain an average setting representative of the calibration range.

(f) Record the thickness of the calibration standard.

(g) Recheck the instrument setting at hourly intervals to guard against gauge drift during use.

APPENDIX E

A SAMPLE REPORT FORM FOR DRY FILM THICKNESS TESTING*

(Informative)

TEST REPORT AS 3894.3 METHOD A/B

Site testing of protective coatings—Dry film thickness

Project: .....

Contract No.: .....

Name of testing laboratory/authority: .....

Date of conduct of test: .....Report number: .....

Identification/description of test item

Substrate material: .....

Surface profile: .....

Description of workpiece: .....

Coating system: .....

Method of coating application and date: .....

Curing conditions (time/temperature): .....

Method of cure: .....

Specified dry film thickness—Maximum: ..... Minimum: .....

Test procedure

Make and model of instrument used: .....

Calibration standard thickness: .....

Test results (attach results sheets)

Dry film thickness: (micrometres)

Maximum ..... Minimum .....

Readings taken ..... Total No: .....

No. above specification ..... No. below specification .....

Inspector's name (print) ..... Signature .....

Name of contractor's representative (print): .....

Signature of contractor's representative: .....

Average dry film thickness—conforms to specified thickness

Yes No

* Modification of this form may be necessary depending on the size and scope of the project.

NOTES

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NOTES

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The following are represented on Committee CH-003:

Australian Paint Approval Scheme
Australian Paint Manufacturers Federation
AUSTROADS
Building Research Association of New Zealand
Institution of Professional Engineers New Zealand
Master Painters Australia
National Association of Testing Authorities Australia
New Zealand Abrasive Blasting Association
New Zealand Manufacturers Federation
New Zealand Painting Contractors Association
Surface Coatings Associatoin Australia
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Australian Institute of Protective Coatings
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