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ISO 2808

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Paints and varnishes — Determination of film thickness

Peintures et vernis — Détermination de l'épaisseur du feuil

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 2808 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Sub-Committee SC 9, *General test methods for paints and varnishes*.

This second edition cancels and replaces the first edition (ISO 2808:1974), of which it constitutes a technical revision.

Annex A forms an integral part of this International Standard.

Paints and varnishes — Determination of film thickness

1 Scope

This International Standard is one of a series of standards dealing with the sampling and testing of paints, varnishes and related products. It describes a number of methods that are applicable to the measurement of the thickness of coatings applied to a substrate. Some of the techniques described can be adopted for the measurement of the thickness of detached coatings. Details of the methods, their particular field of application and the expected precision are given in table 1.

NOTE 1 Many of the methods referred to in table 1 may be adapted for use with detached films.

Table 1 — Methods of film thickness measurement

Number and description	Applications	Remarks
Method No. 1 Determination of dry film thickness by relating dry film mass to dry film thickness	For use on films too soft to be measured by instrumental methods.	Measurements are not precise but provide a check that the mean thickness lies between specified limits. The test film remains undamaged.
Method No. 2 Measurement of dry film thickness by the micrometer method	Test panels or painted surfaces that are substantially flat.	The film has to be hard enough to resist indentation on closing the micrometer jaws. Uncertainty is ± 5 µm: the method is therefore not normally suitable for films less than 25 µm thick. The film is damaged in the test.
Method No. 3 Measurement of dry film thickness by a dial gauge method	Test panels or painted surfaces that are substantially flat.	The film has to be hard enough to resist indentation on lowering the gauge presser foot. Uncertainty is ± 2 µm: the method is therefore not normally suitable for films less than 15 µm thick. The film is damaged in the test. May be used on site.

Number and description	Applications	Remarks
Method No. 4 Measurement of dry film thickness by the profilometric method	Recommended as a referee method for test panels or painted surfaces that are substantially flat. By taking suitable precautions determinations may be made on curved surfaces.	The film has to be hard enough to resist indentation by the profile-tracing stylus. Uncertainty is ± 2 µm: the method is therefore not normally suitable for films less than 15 µm thick. The film is damaged in the test.
Method No. 5 Measurement of dry film thickness: microscope methods	A Recommended as a referee method and for films on substrates of varying profile, for example, grit-blasted steel.	A portion of the panel or painted article is cut out and mounted in resin. Uncertainty is normally less than 2 µm, but is dependent on the degree of substrate preparation and the type of microscope used.
	B Not applicable to brittle or friable films.	A special cutting tool is required to cut through the film and into the substrate. May be used on site. Uncertainty is normally less than 2 µm, but is dependent on the degree of substrate preparation and the type of microscope used.
	C Applies to a film cleanly removed from the substrate.	A special microscope is used to examine the profile of the film from which a small portion has been removed down to the substrate. Uncertainty is normally less than 2 µm, but is dependent on the degree of substrate preparation and the type of microscope used.

Number and description	Applications	Remarks
Method No. 6 Measurement of dry film thickness: non-destructive instrumental	A For magnetic metallic substrates.	Instruments operate on the a) electromagnetic induction principle, or b) permanent magnet pull-off principle. mounted in resin. May be used on site. Uncertainty is a) ± 1,5 µm or ± 10 % whichever is the greater; b) ± 2 µm or ± 12 % whichever is the greater. May be used on site.
	B For non-magnetic metallic substrates.	a) Instruments operate on the eddy current principle. Uncertainty is ± 1,5 µm or ± 10 % whichever is the greater. May be used on site. b) Instruments operate on the dielectric principle. Uncertainty is ± 1 µm or ± 10 % whichever is the greater. May be used on site.
	C Applied where contact by the measuring instrument with the coating is avoided.	Instruments operate on the a) beta-particle back-scatter principle, or b) X-ray fluorescence principle. Paint films have to be homogeneous for measurements to be accurate. Uncertainty is ± 2 µm or ± 10 % whichever is the greater.
Method No. 7 Assessment of wet film thickness	A Wheel gauge For measurement of wet film thickness on laboratory test panels or freshly painted surfaces.	Measurements are not precise but enable an estimate to be made of the approximate thickness the film will have when dry.
	B Comb gauge For measurement of wet film thickness during painting operations on site.	Measurements give an approximate indication of thickness of the wet film. May be used on site.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1514:1984, *Paints and varnishes — Standard panels for testing.*

ISO 2178:1982, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method.*

ISO 2360:1982, *Non-conductive coatings on non-magnetic basis metals — Measurement of coating thickness — Eddy current method.*

ISO 3543:1981, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method.*

ISO 4518:1980, *Metallic coatings — Measurement of coating thickness — Profilometric method.*

ISO 8503-4:1988, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure.*

3 Required supplementary information

For any particular application, the test methods specified in this International Standard need to be completed by supplementary information. The items of supplementary information are given in annex A.

4 Number and location of test areas

In this International Standard, information is given concerning the number and location of test areas to be adopted when determining paint film thickness on typical test panels (see ISO 1514). On other test panels and on painted articles, the number and location of test areas shall be such as to provide a representative picture of the thickness of the paint film and shall be the subject of agreement between the interested parties.

5 Method No.1 — Determination of dry film thickness by calculation from the ratio of dry film mass to dry film thickness

5.1 Field of application

This method describes a means for checking that the thickness of a dried film of paint on a test panel lies within the limits specified for the relevant test. It is not intended to give a precise measurement of the actual thickness of the film.

The measurement is obtained by reference to a graph showing the relationship between film thickness and film mass of the product under test.

It is intended for use with air-drying paints that produce films requiring several days before they are sufficiently hard to permit thickness measurements by instrumental methods; it gives an overall mean value for the thickness of the paint film based on its dry mass and does not involve any mechanical damage to the paint film.

5.2 Apparatus and materials

5.2.1 Thin plastics sheet, resistant to a temperature of (105 ± 2) °C and unaffected by paint solvents.

NOTE 2 Polyester sheet, approximately 25 µm thick, has been found to be suitable for this method.

5.2.2 Film spreading devices, capable of producing uniform films approximately 50 µm and 100 µm thick.

5.2.3 Glass plates, not less than 250 mm in length, not less than 100 mm in width and approximately 6 mm thick, of a size suitable for use with the film spreading devices (5.2.2).

5.2.4 Balance, accurate to 1 mg or better.

5.2.5 Dial gauge, capable of measurement to 2 µm, mounted on a rigid support.

5.2.6 Oven, capable of being maintained at (105 ± 2) °C.

5.2.7 Metal template, 80 mm square.

5.2.8 Mineral hydrocarbon solvent.

5.3 Calibration of dry film mass against dry film thickness

NOTE 3 Calibration is required only the first time any particular coating is tested.

5.3.1 Cut the thin plastics sheet (5.2.1) to the size of the glass plates (5.2.3), and weigh each to the nearest 1 mg.

Select six of the cut sheets with masses not differing by more than 3 mg.

5.3.2 Wet the surface of one of the glass plates with the solvent (5.2.8) and squeegee one of the selected plastics sheets into intimate contact with the surface of the glass plate, taking care to avoid trapping air bubbles or solid particles.

Repeat the procedure with three further glass plates and plastics sheets.

5.3.3 Place a suitable quantity of the paint on one end of one of the four plastics sheets and distribute it evenly over the surface of the sheet on the plate using the film spreading device (5.2.2) to give a film 50 µm thick.

Repeat the procedure with a second plastics sheet on a plate.

5.3.4 Repeat procedure 5.3.3 on a third and fourth plastics sheet using the film spreading device to give a film 100 µm thick.

5.3.5 Remove the coated plastics sheets from the glass plates and after 15 min dry for 2 h at (105 ± 2) °C in the oven (5.2.6) together with the two unpainted sheets, maintaining the sheets in a horizontal position throughout the operation.

NOTE 4 If appreciable decomposition or wrinkling of the product under test occurs under these drying conditions, other, more suitable, conditions may be used by agreement between the interested parties.

5.3.6 Remove all six sheets from the oven and allow them to cool for 1 h at room temperature.

5.3.7 Using the template (5.2.7), cut two squares from the central area of each sheet.

Weigh each square to the nearest 1 mg and initially calculate the mean mass of the four unpainted squares.

Determine the mass of paint on each of the eight painted squares by subtracting the mean mass of the unpainted squares from the mass of the painted square. Calculate the mass per area of the paint film, in grams per square metre.

5.3.8 Measure the thickness of each painted square with the dial gauge (5.2.5) in six places and calculate the mean thickness for each square.

Measure the thickness of each unpainted square in six places with the dial gauge and so calculate the mean thickness of the plastics sheet.

Calculate the mean thickness of the paint film on each painted square by subtracting the mean thickness of the unpainted squares from the thickness of the painted square.

5.3.9 Construct a graph showing the relation between the film thickness and mass per area for the eight painted squares, drawing the best straight line passing through the origin and between the plotted points.

5.4 Determination of dry film thickness for the test panels

5.4.1 Use a weighed test panel prepared in accordance with the requirements of ISO 1514.

5.4.2 Coat the panel with the product under test by the appropriate method.

Allow the panel to dry for 24 h at (23 ± 2) °C and a relative humidity of (50 ± 5) %.

5.4.3 Weigh the panel and calculate the mass per area of the dry film, in grams per square metre.

5.4.4 Determine the mean equivalent film thickness by reference to the graph.

6 Method No. 2 — Measurement of dry film thickness by the micrometer method

6.1 Field of application

This method describes a means for measuring, to within 5 µm, the thickness of a dried paint film on a painted article or test panel.

The measurement is made after the film has dried to a condition such that after closure of the jaws of the micrometer, the jaws do not produce any visible indentation of the film.

It is only suitable for painted specimens that are substantially flat and for coatings that can be removed by solvent or paint remover.

6.2 Apparatus

Suitable micrometer, capable of measurement to 5 µm, fitted with a ratchet.

6.3 Procedure

6.3.1 Select positions where readings are to be taken that are free from surface irregularities and are not less than 20 mm from any paint film edge and approximately 50 mm apart.

For large areas, select the number and distribution of the test areas to be a representative indication of the film thickness.

Mark an area around each test position by lightly drawing a circle approximately 10 mm in diameter and add a distinctive number alongside.

6.3.2 Support the painted specimen rigidly in a manner such that all the test positions are accessible to the micrometer (6.2).

6.3.3 Position the micrometer with the fixed jaw in plane contact with the underside of the test specimen and immediately opposite the first test area. Gently screw home the movable jaw until a resistance is felt and no further movement of the jaw occurs on turning the ratchet.

Note the reading on the micrometer, using a mirror if necessary to read the vernier scale. Record the reading and the position reference number on a test record sheet.

Release the micrometer and repeat the whole procedure at each of the other test positions.

Record the readings for each test position.

6.3.4 Carefully remove the paint film from within the circle at each test area with a suitable solvent or paint remover, taking care not to obliterate the distinctive number.

NOTE 5 For example, this may be done by covering the test area with a small circle of thick filter paper and applying to it a few drops of a suitable solvent or paint remover.

Measure the thickness of the substrate by repeating the procedures 6.3.2 and 6.3.3 at each test area.

6.4 Calculation

6.4.1 Calculate the film thickness at each test position by subtracting the reading obtained after removal of the film from that obtained before removal.

6.4.2 Calculate the mean value for the thickness of the film on the test panel to the nearest multiple of 5 µm.

7 Method No. 3 — Measurement of dry film thickness by the dial gauge method

7.1 Field of application

This method describes a means for measuring, to within 2 µm, the thickness of a dried paint film on a painted article or test panel.

The measurement is made after the film has dried to a condition such that the lowering of the presser foot of the instrument does not produce any detectable indentation of the film.

It is only suitable for painted specimens that are substantially flat and for coatings that can be removed by solvent or paint remover.

7.2 Apparatus

7.2.1 Dial gauge, capable of measurement to an accuracy of 2 µm, mounted on a rigid support.

7.3 Procedure

7.3.1 Select positions where readings are to be taken that are free from surface irregularities, are not less than 20 mm from any paint film edge and are approximately 50 mm apart.

For large areas, select the number and distribution of test areas to give a representative indication of the film thickness.

Mark an area around each test position by lightly drawing a circle approximately 10 mm in diameter and add a distinctive number alongside.

7.3.2 Set the reading on the dial to zero. Raise the presser foot and place the test panel, paint film uppermost, so that the presser foot is immediately above the centre of the first test area. Support the panel in such a way that no movement can occur during the taking of a reading.

Carefully lower the presser foot until it is in good contact with the paint film. If, after making contact with the paint film, the dial pointer does not remain steady, select a new test position and repeat the procedure. If the pointer again shows movement after making contact with the surface, the paint film is not sufficiently dry and readings shall be discontinued until such time as a steady reading is obtained on lowering the presser foot.

Record the reading and the position reference number on a test record sheet. Repeat the procedure at each test position.

Record the readings for each test position.

7.3.3 Raise the presser foot and carefully remove the paint film from within the circle at each test area with a suitable solvent or paint remover, taking care not to obliterate the distinctive number.

NOTE 6 For example, this may be done by covering the test area with a small circle of thick filter paper and applying to it a few drops of a suitable solvent or paint remover.

Carefully lower the presser foot until it is in good contact with the cleaned surface.

Record the readings and the position reference number on the test record sheet. Repeat the procedure at each test position.

7.4 Calculation

7.4.1 Calculate the film thickness at each test position by subtracting the reading obtained after removal of the film from that obtained before removal.

7.4.2 Calculate the mean value for the thickness of the film on the test panel to the nearest multiple of 2 µm.

8 Method No. 4 — Measurement of dry film thickness by the profilometric method

8.1 Field of application

This method describes a procedure for measuring the thickness of a dried paint film on a painted article or test panel to within 2 µm.

NOTE 7 For reliable results, the minimum coating thickness should be not less than 10 times the roughness amplitude of the substrate.

The measurement is made after the film has dried to a condition such that the contact of the profile-tracing stylus does not cause any detectable indentation of the film.

This method is only suitable for specimens that are small enough to be accommodated on the test apparatus and is most suitable for substantially flat specimens and for coatings that can be removed by solvent, paint remover, or use of a tube drill. The method is recommended as a referee method to be used in cases of dispute provided that the substrate is substantially flat.

More detailed information on this method is given in ISO 4518.

8.2 Apparatus

Assembly comprising a traversing stylus with suitable amplifying and recording equipment. The apparatus is generally used to measure surface roughness but for the purpose of this International Standard it is used to record the profile of a step.

8.3 Procedure

8.3.1 Remove a portion of the coating with a suitable solvent or paint remover (see note 8). Alternatively, cut through the paint film to the substrate with a tube drill of diameter 10 mm and remove the isolated section of paint film.

NOTE 8 For example, this may be done by covering the test area with a small circle of thick filter paper and applying to it a few drops of a suitable solvent or paint remover. If the solvent or paint remover causes the paint film adjacent to the test area to swell, the alternative method for removal, as given above, can be used. Ensure that the surface of the coating forming the top of the step is not damaged and that the exposed substrate is free of all traces of the coating.

8.3.2 For larger areas, select the number and distribution of the test areas to be a representative indication of the film thickness.

Record the profile of the step in accordance with the instrument manufacturer's instructions, selecting a suitable sensitivity to ensure the maximum use of the recording chart.

8.3.3 Draw a mean line through each recording of the upper and lower levels of the step and extend them so that the two mean lines overlap. Assess the step height from the two mean lines at the midpoint of the step.

9 Method No. 5 — Measurement of dry film thickness: microscope methods

9.1 Field of application

These methods specify three procedures by which microscopes are used for measuring the dry film thickness of paint films on a variety of substrates.

Method 5A is a general method for measuring, to within 2 µm, the thickness of a dried film of paint on a section cut from a test panel or painted article.

It is recommended as a referee method in any dispute concerning the thickness of the paint film on a painted specimen. It is particularly useful in measuring variations in thickness that occur due to unevenness of the substrate, for example on grit-blasted steel.

Method 5B is a general method for measuring the thickness of a dried paint film. The coating is cut at a prescribed angle through to the substrate. The method is not applicable to brittle or friable coatings or to those with a film thickness of less than 2 µm.

Method 5C employs an apparatus by means of which an image of the surface profile of the test specimen is viewed in a special microscope. It does not involve cutting out a section of the substrate as described in method 5A but it is destructive to the coating.

The number of specimens prepared by any of the methods shall be such as to be representative of the painted article or test panel.

9.2 Method 5A

9.2.1 Apparatus and materials

9.2.1.1 Microscope, with a suitable objective, and with an eyepiece bearing a scale capable of measuring to an accuracy of 2 µm or better.

9.2.1.2 Waterproof silicon-carbide abrasive paper, grades 280, 400 and 600.

9.2.1.3 Diamond paste, or similar paste, with grade 1 200 grit.

9.2.1.4 Cold-setting potting or casting resin[1], that has no deleterious effect on the paint film.

The colour of the mounting resin shall be such that it can be distinguished clearly from the paint film under test. This may be achieved by the incorporation of suitable dyestuffs or pigments into the resin.

9.2.2 Procedure

A suitable procedure is as follows.

9.2.2.1 Cut test sections, approximately 25 mm square, from the painted specimens with a sharp hacksaw. Remove any burrs with abrasive paper.

9.2.2.2 Cover a flat metal plate with a sheet of polyethylene film and place it in a horizontal position.

9.2.2.3 Construct a small cylindrical cell from thin waxed carboard of a size sufficient to contain the cut section.

Fix the cell to the polyethylene film with molten paraffin wax and allow the wax to cool.

9.2.2.4 Support the cut section within the cell with a straight cut edge resting on the polyethylene film and the painted surface in a vertical plane.

NOTE 9 A suitable means of supporting the specimen is shown in figure 1.

9.2.2.5 Mix sufficient resin (9.2.1.4) to cover the section, allow it to stand a few minutes for air bubbles to escape and carefully pour it into the cell, taking care that the painted surface remains in a vertical plane.

Allow the test section in the resin to stand for 24 h at room temperature.

9.2.2.6 Remove the resin block from the polyethylene film and rub down the face that was in contact with the film on the coarsest grade of abrasive paper (9.2.1.2), using plenty of water as a lubricant. Support the paper on a flat glass plate.

Continue abrading until the edge of the cut section is free from resin and the thickness of the paint film is fully exposed.

Continue abrading on the next finest grade of paper.

Throughout abrading take great care to maintain the painted surface of the section at right angles to the plane of the abrasive paper, so as to avoid bevelling the cut edge. Examine the abraded surface periodically under the microscope (9.2.1.1) to see if it is sufficiently smooth for a reading to be taken.

Finally polish the specimen using the diamond paste (9.2.1.3), rinse the polished surface under the tap and dry it with a clean soft rag.

9.2.2.7 Mount the test section in the resin block on a microscope slide with the polished face uppermost and parallel to the plane of the slide.

NOTE 10 This is readily done by placing a piece of soft putty between section and slide and levelling the polished surface with a spirit level.

9.2.2.8 Place the slide under the microscope and measure the thickness of the paint film by the scale on the eyepiece.

9.2.2.9 Record at least five measurements along the edge of the paint film and calculate the mean thickness.

If the film thickness is markedly variable along the specimen, supplement the readings by pictorial illustrations such as photomicrographs or drawings.

1) Suitable mixtures are obtainable commercially.

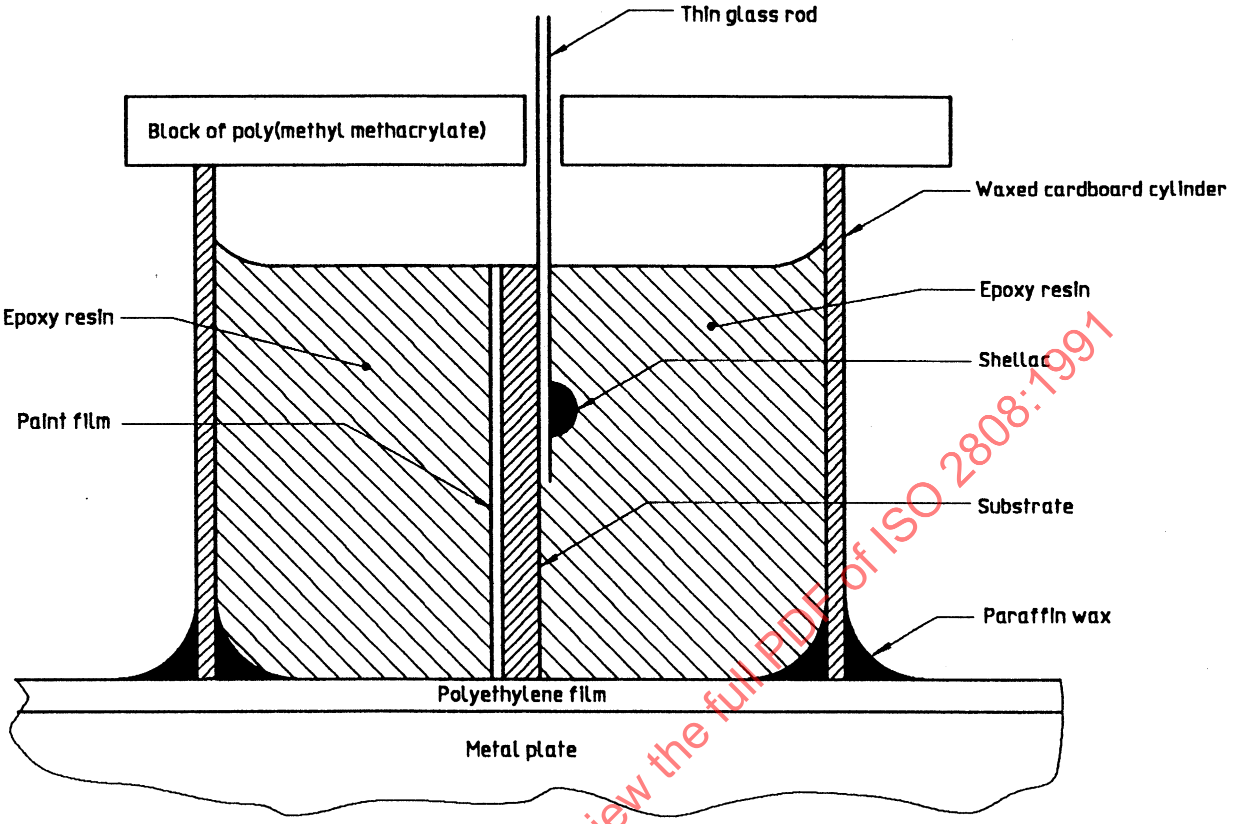


Figure 1 — Method of preparing specimens for measurement of dry film thickness according to microscope method 5A

9.3 Method 5B

9.3.1 Apparatus

9.3.1.1 Microscope, with a suitable objective, and with an eyepiece bearing a scale capable of measuring to an accuracy of 2 µm or better.

9.3.1.2 Cutting tool, with knife edge ground to an angle appropriate to the film thickness (see table 2). The cutting tool shall be mounted in a suitable guide.

Table 2 — Cutting tool edge angle

Appropriate range of film thickness µm	Cutting angle, α degrees	tan α
20 to 2 000	45	1,0
10 to 1 000	26,6	0,5
8 to 800	21,8	0,4
2 to 200	5,7	0,1
1,5 to 150	4,3	0,075

9.3.2 Procedure

9.3.2.1 In order to facilitate the determinations, mark the test piece with a felt tip pen in a contrasting colour at the areas where the determinations are to be made. Whilst holding the guide firmly against the coated specimen, press the cutting tool so as to produce a clean wedge-shaped cut through the film and into the substrate (see figure 2).

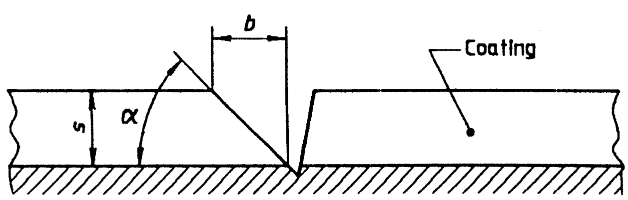


Figure 2 — Diagrammatic representation of the wedge cut

NOTE 11 Coatings with pronounced elasticity may give invalid results due to deformation during cutting. This effect may be reduced by cooling the specimen before carrying out the determination.

9.3.2.2 Using the marking to locate the cut with the microscope, measure, in micrometres, the projected width b of the wedge cut.

9.3.3 Calculation

Calculate the film thickness s, in micrometres, from the equation:

$$s = b \tan \alpha$$

where

b is the projected width, in micrometres, of the cut measured by the microscope;

α is the ground angle, in degrees, of the cutting tool.

NOTE 12 If the determination has been carried out on a curved surface, correction of the equation for the effect of the curvature may be necessary.

9.4 Method 5C

9.4.1 Apparatus

9.4.1.1 Profile measuring microscope, consisting of an illuminator projecting a flat parallel beam of light on the surface at an angle of 45° and an objective viewing the reflected light beam so that an image of the surface profile is seen in the microscope.

One such instrument employs a special objective combining the illuminator and a reflected beam receptor. The eyepiece carries cross-wires for focussing on the images of the portion of the beam reflected from the upper surface of the paint film and of the portion reflected from the exposed substrate. A vernier attachment measures the distance between the two portions of the reflected beam and thus enables the thickness of the film to be calculated.

9.4.2 Procedure

Using a sharp cutting tool, carefully remove a small portion of the paint film in such a manner as to expose completely a small area of the substrate, but taking care not to cut into the substrate (see figure 3).

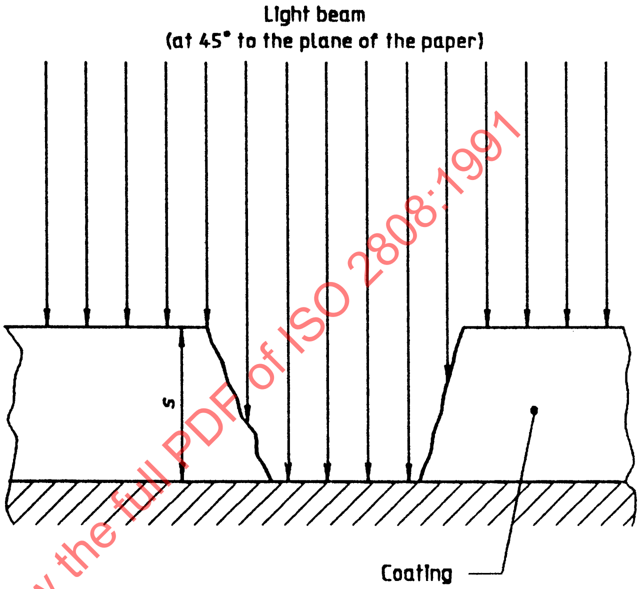


Figure 3 — Sectioned view of incised painted specimen

Direct the beam from the illuminator on to the area at an angle of 45° and along the length of the incision. View the reflected image in the profile measuring microscope (9.4.1). Determine the thickness of the paint film by measuring the distance between the image of the paint film upper surface and the image of the exposed surface of the substrate using the scale of the measuring eyepiece or the vernier attachment fitted in the microscope. Using the calibration factor, convert the reading in scale divisions into the corresponding thickness, in micrometres.

Figure 4 shows the appearance of a typical specimen as seen in the viewing microscope. Reading d in eyepiece scale divisions is converted into the corresponding film thickness s in micrometres (see figure 3).

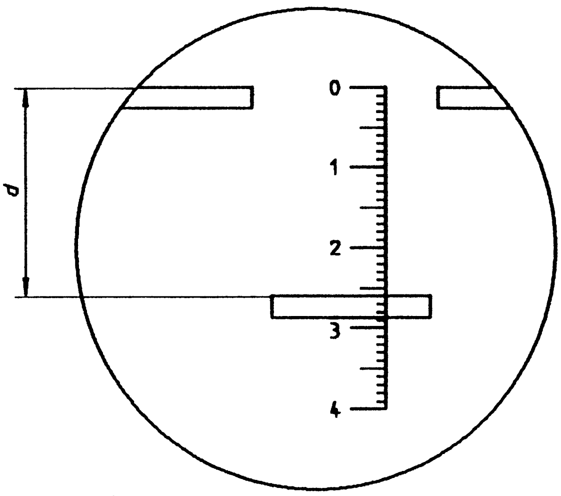


Figure 4 — Typical image as seen in the microscope

10 Method No. 6 — Measurement of dry film thickness by non-destructive instrumental methods

10.1 Field of application

These methods describe non-destructive procedures for determining the thickness of dry paint films on metallic substrates.

A variety of instruments is available for this purpose and they are classified under the following headings:

a) the nature of the substrate to which they are applicable, i.e. non-magnetic metals, magnetic metals;

b) the principle by which the instrument operates.

The thickness and contours of some substrates may render some instruments unsuitable for measuring the thickness of the surface coating and the instrument manufacturer's instructions in such cases are to be strictly observed. Because of the difficulties when measuring paint films on grit-blasted metal, the use of microscope method 5A (see 9.2) is recommended in such instances.

10.2 Procedure

For all methods (see 10.3 to 10.5) take several readings to obtain representative results over the painted area. Strictly observe the manufacturer's instructions when making measurements with all instruments.

10.3 Method 6A — Measurement on magnetic metallic substrates

10.3.1 Principle

NOTE 13 The instruments may be calibrated in such a manner that the thickness of the paint film is indicated directly. Attention is drawn to the precautions to be observed (see 10.6).

10.3.1.1 Magnetic flux principle — Method 6Aa)

Instruments of this type operate on the principle that the magnetic flux between a magnet and a magnetic substrate varies according to the size of the non-magnetic gap between the two or, in the case of painted substrates, the thickness of the paint film between the magnet and the substrate, which in the case of painted specimens is the coating thickness.

The magnet may be either an electromagnet or a permanent magnet. Attention is also drawn to ISO 2718.

10.3.1.2 Magnetic pull-off principle — Method 6Ab)

Instruments of this type 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.

10.3.1.3 Eddy current principle — Method 6Ba)

Instruments are available which operate on a similar principle to that described in 10.4.1.1, using a probe specially designed for use on magnetic substrates. Attention is also drawn to ISO 2360.

10.3.1.4 Dielectric principle — Method 6Bb)

This type of instrument utilizes the relationship between capacitance and the thickness of the dielectric layer between electrodes. One electrode is the substrate and the other is the probe of the instrument, with the paint film, which has to be electrically non-conducting, forming the dielectric.

10.3.2 Apparatus

10.3.2.1 Magnetic flux principle

10.3.2.1.1 Electromagnet

Instruments using this principle may be equipped either with a single- or a twin-pole probe. In general, because of its very concentrated electromagnetic field radiation, only the twin-pole probe can be used on narrow surfaces.

However, single-pole probes are often more convenient to use and modern development has reduced the area of influence of such probes to make measurement on small areas possible.

Instruments of this type are usually calibrated using non-magnetic shims. The probe is first placed on an unpainted metal surface similar to that bearing the paint film under test and the scale reading adjusted to zero. The sensitivity is regulated by placing a shim of known thickness, preferably near to the upper end of the range of the instrument, between the probe and the substrate, and adjusting the scale reading to agree with the thickness of the shim.

NOTE 14 An alternative method of calibration uses shims to set both the upper and lower limits of the range being measured.

After calibration, the head is placed on the painted surface and the indicated thickness of the coating noted.

Modifications include the use of microprocessors to assist in calibration and presentation of results.

10.3.2.1.2 Permanent magnet

Instruments of this type incorporate a permanent magnet with one or more pole pieces in the form of spherical contacts which are placed on the painted surface.

Calibration is normally carried out as described in 10.3.2.1.1.

After calibration the instrument is placed on the painted surface and the dial reading noted. Several readings are made, each time rotating the probe between readings so that it moves through a total of 360°, in order to minimize the effects of residual magnetism in the substrate and environmental magnetism.

Record the mean value of film thickness.

10.3.2.2 Magnetic pull-off instruments

This type of instrument most commonly incorporates a permanent magnet to which is attached a spring. Various forms of the instrument are available including a simple pencil-type spring balance and another type in which tension is applied by turning a calibrated circular dial until the magnet and attached spring detach from the painted surface.

Such instruments normally have a fixed scale graduation and cannot be operator-adjusted at zero or against calibration foils. The scale shall be suitably calibrated.

More complex instruments incorporating an electromagnet are also available.

10.3.2.3 Dielectric principle

Instruments of this type have a flat probe, which forms one electrode, and which may be as small as 6 mm diameter. To ensure intimate contact with the paint the probe is pressed against the constant pressure of a spring. The capacitance of the condenser so formed is measured with an alternating current bridge.

Calibration is performed using foils of known thickness and dielectric properties.

The method may be applied to any type and thickness of metal substrate provided that it is substantially flat.

10.4 Method 6B — Measurement on non-magnetic metallic substrates

10.4.1 Principle

10.4.1.1 Eddy current principle — Method 6Ba)

Instruments of this type operate on the principle that changes occur in the apparent impedance of a probe coil due to eddy currents induced in the substrate by a high frequency energizing current in the coil. The interaction of the eddy currents, whose magnitude depends on the conductivity of the substrate, with the coil current alters the amplitude and phase of the latter to an extent that is dependent on the distance between the probe and the substrate.

10.4.1.2 Dielectric principle — Method 6Bb)

See 10.3.1.4.

10.4.2 Apparatus

10.4.2.1 Eddy current principle

Most eddy current instruments use an alternating current impedance bridge with the coil of the probe forming one arm of the bridge. Calibration is carried out via standards that must reliably reproduce the electrical characteristics of both coating and substrate. Usually results are indicated directly in units of thickness.

Instruments of this type are particularly sensitive to surface curvature and it is therefore essential that they be calibrated using unpainted metal surfaces of the same curvature as the test piece.

10.4.2.2 Dielectric principle

See 10.3.2.3.

10.5 Method 6C — Measurement of thickness without contact with the surface

Methods of this type are principally used for on-line process control, such as in the evaluation of coil coatings.

10.5.1 Principle

10.5.1.1 Beta-particle backscatter — Method 6Ca)

Beta-particles from a suitable isotope are scattered by the coating and substrate, and the scattered radiation is detected by means of a Geiger-Müller counter. The major restriction is that the backscatter from the coated substrate should be substantially different from that obtained from the substrate alone. Attention is also drawn to ISO 3543.

10.5.1.2 X-ray fluorescence — Method 6Cb)

X-rays are absorbed by metals and re-emitted at a different (longer) wavelength. Paint films fluoresce much less than metals, but still absorb radiation according to their thickness. Again it is essential that the fluorescence from the coated substrate is substantially different from that emanating from the substrate alone.

The technique can be used for coatings on metallic substrates with atomic numbers greater than 20, by relying on the absorbance of substrate fluorescence by the coating, or on non-metallic substrates (e.g. plastics) by detecting fluorescence from metals, such as titanium, in the film.

10.5.2 Apparatus

10.5.2.1 Beta-particle backscatter

The measuring head is located at a fixed distance from the surface being assessed, and the detected radiation is converted by means of a microprocessor into a direct reading of thickness. Calibration is carried out via coated standards of the same composition as the test films. In addition an infinitely thick (from an instrument viewpoint) film of the coating is necessary.

10.5.2.2 X-ray fluorescence

Fluorescent radiation is detected by a scintillation crystal proportional counter to give a value that can be converted into film thickness. As with the beta-particle method, standards with identical composition to the test coatings are necessary. An advantage is that the distance between probe and coating is largely irrelevant.

10.6 Precautions to be observed when using apparatus described in 10.3.2, 10.4.2 and 10.5.2

10.6.1 General

Follow the manufacturer's instructions for operation of the instrument.

Always make several measurements in the same local area and take the mean.

Always check the instruments for repeatability, and check standardization and the condition of the probe tip at regular intervals.

10.6.2 Edge effect

Some instruments are affected more than others by the presence of a material edge, and of these some can be calibrated to take account of this effect. Measurements should only be made either more than 25 mm from the edge of a panel or at the distance from the edge for which the instrument has been calibrated.

10.6.3 Magnetism in the substrate (for magnetic or eddy current instruments)

Some instruments are affected by substrate magnetism, particularly those relying on permanent magnets for generation of a magnetic field. Most modern electronic gauges generate their own small high-intensity magnetic fields and are less sensitive to the presence of inherent or residual magnetism in the substrate. Calibrating with materials similar in shape, composition and treatment to the test pieces may alleviate the problem but the only real solution is to be able to zero the instrument at the same point as the coating is to be measured.

10.6.4 Rough surfaces

Measurement on rough surfaces can be made provided that a sufficient number of measurements (at least 10) is made in the same area. Preferably the roughness value of the surface R_{y5} should not exceed 5 % of the film thickness (for measurement see ISO 8503-4).

11 Method No. 7 — Measurement of wet film thickness

11.1 Field of application

This method describes two means of measuring the thickness of wet paint films.

The chief use of these methods is to determine wet film thickness and spreading rate achieved. In addition, by using a suitable correlation procedure, it is possible to estimate the approximate thickness of a dry film by measuring its wet film thickness immediately after application. This is useful when dry film thickness methods are destructive or not very accurate, e.g. on wood or masonry substrates.

The methods described are suitable for use on rigid substrates of suitable profile.

The wheel gauge (11.2) may be used both in the laboratory and in control of paint application.

The comb gauge (11.3) gives only a rough indication of the wet film thickness and consequently is used mainly during painting operations to check that major deviations from specified thicknesses are not occurring.

11.2 Method 7A — Wheel gauge

11.2.1 Apparatus

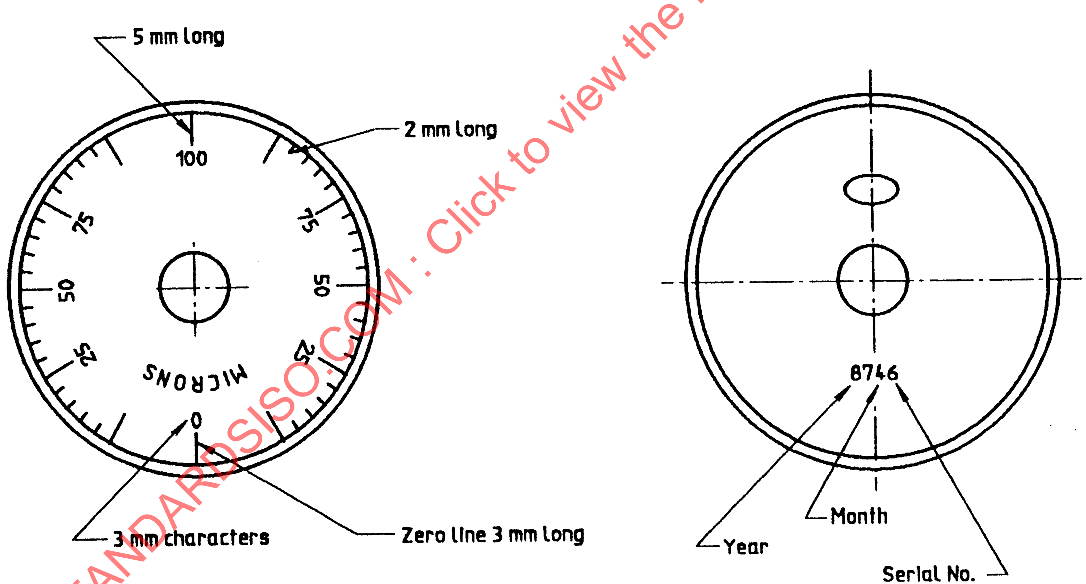
The gauge consists of a wheel of which the perimeter has three equally spaced rims, the central one of which is smaller than and eccentric to the outer ones. When the gauge is rolled over a wet film, the eccentric central rim shows a position at which it just touches the wet paint surface, and a calibrated scale engraved on the outer wheel enables the wet paint thickness at this point to be noted. A range of gauges is available. A typical gauge showing a calibration serial is shown in figure 5.

Several readings are taken in a similar manner to obtain representative results over the painted area.

11.2.2 Procedure

Immediately after the application of the paint, place the wheel gauge into the paint film so that the two outer rims are in contact with the substrate at the point of maximum gap (i.e. the largest reading on the calibrated scale). Roll the wheel through at least 180° in one direction along the surface and then in the other direction, and take the mean of the two readings, at the nearest lower scale division, as one reading.

Repeat the procedure at least twice in different places in a similar manner to obtain representative results over the painted area.



Other gauge scales				
0	50	100	150	200
0	125	250	375	500
0	250	500	750	1 000

Figure 5 — Typical wheel gauge

11.3 Method 7B — Comb gauge

11.3.1 Apparatus

The gauge consists of a stainless steel comb, the outer teeth of which form a baseline. The inner teeth are progressively shorter so as to present a range of gaps between the teeth and the baseline, and the size of each gap can be read from a scale on the gauge. A typical comb gauge is illustrated in figure 6.

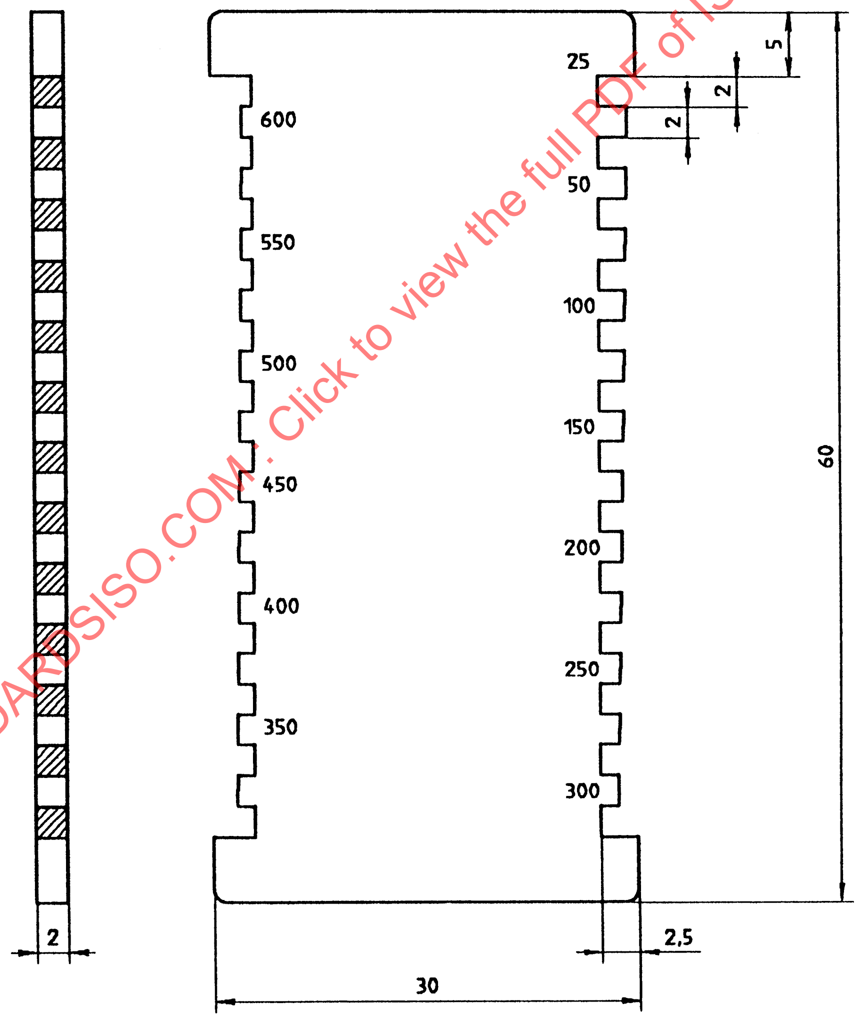
11.3.2 Procedure

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 and the gauge does not slip. Remove the gauge, and examine the teeth to determine which is the shortest one to touch the wet paint film.

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.

Take at least two further readings in different places in a similar manner to obtain representative results over the painted area.

Dimensions in millimetres, except for the gauge graduations



NOTE — The comb illustrated is for 25 μm to 600 μm; combs are available in a range of scales

Figure 6 — Typical comb gauge