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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 $\pm$ 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