INTERNATIONAL STANDARD 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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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2808 was drawn up by Technical Committee ISO/TC 35, *Paints and varnishes,* and circulated to the Member Bodies in May 1972.

It has been approved by the Member Bodies of the following countries :

Austria	Ireland	South Africa, Rep. of
Chile	Israel	Sweden
Czechoslovakia	Netherlands	Switzerland
Egypt, Arab Rep. of	New Zealand	Thailand
France	Poland	Turkey
India	Portugal	United Kingdom
Iran	Romania	U.S.S.R.

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

Canada
Germany

Printed in Switzerland

Paints and varnishes — Determination of film thickness

0 INTRODUCTION

This International Standard is one of a series dealing with the sampling and testing of paints, varnishes and related products. It should be read in conjunction with ISO/R 1512, *Paints and varnishes — Sampling*, ISO/R 1513, *Paints and varnishes — Examination and preparation of samples for testing*, and ISO/R 1514, *Paints and varnishes — Standard panels for paint testing.*

This International Standard specifies methods for measuring the film thickness of paints and related materials. It is not intended to cover all methods available and seeks only to specify methods for determining film thickness under certain conditions.

Suggestions are made concerning the number and location of test areas to be adopted for typical test panels. 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.

The methods of test specified require to be completed, for any particular application, by the following supplementary information. This information should be derived from the national standard or other document for the product under test or, where appropriate, should be the subject of agreement between the interested parties.

1) Method of application of test coating to substrate and whether it is a single coating or multicoat system (if applicable).

2) The method of measurement of film thickness, when a particular method is necessary.

3) Duration and conditions of drying of the coated panel or article before testing (or conditions of stoving and ageing, if applicable).

Details on the methods, their field of application and the precision, are given in the table overleaf.

TABLE OF METHODS

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, e.g. test panels of air drying paints in early stages of hardening	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 which are substantially flat	The film must be hard enough to resist indentation on closing the micrometer jaws. Accuracy is ± 5 µm : the method is therefore not suitable for films less than 25 µm thick. The film is damaged in the test.
METHOD No. 3 Measurement of dry film thickness by the dial gauge method	Test panels or painted surfaces which are substantially flat	The film must be hard enough to resist indentation on lowering the gauge presser foot. Accuracy is ± 2 µm. The film is damaged in the test.
METHOD No. 4 Measurement of dry film thickness : Microscope methods A and B	A Measurement of film thickness to an accuracy of ± 2,5 µm or better	A portion of the panel or painted article is cut out and mounted in resin. Recommended as a referee method and for films on substrates of varying profile, e.g. grit-blasted metal.
	B Measurement of film thickness to an accuracy of ± 1 µm	A special microscope is used to examine the profile of the film from which a small portion is removed down to the substrate.
METHOD No. 5 Non-destructive instrumental methods	For magnetic metallic substrates	Instruments operate on 1) magnetic flux principle or 2) eddy current principle or 3) magnetic pull-off principle.
	For non-magnetic metallic substrates	Instruments operate on an eddy current principle.
β-ray backscatter method	Mainly used in continuous measurement of moving films, e.g. coil coatings	Highly specialised instrument employing radio-active sources. Paint films must be homogeneous for measurements to be accurate.
METHOD No. 6 Determination 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 of the film when dry.
	B Comb gauge For measurement of wet film thickness during painting operations on site	Measurements give a rough indication of thickness of the wet film. NOTE — Dry film thickness should in both cases be checked by method No. 5.

1 METHOD No. 1

Determination of dry film thickness by relating dry film mass to dry film thickness

1.1 Scope and field of application

1.1.1 This section specifies a method 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 material under test.

1.1.2 This method is intended for use with air-drying paints which produce films that require several days before they are sufficiently hard to permit thickness measurements by instrumental methods.

1.1.3 The method 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.

1.2 Apparatus

1.2.1 Plastics foil, resistant to a temperature of 105 ± 2 °C and unaffected by paint solvents.

NOTE – A material found to be suitable for this method is a polyester film approximately 25 μm thick.

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

1.2.3 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.

1.2.4 Balance, capable of weighing accurately to 1 mg.

1.2.5 Suitable dial gauge, capable of measuring accurately to 2 μm, mounted on a rigid support.

1.2.6 Suitable oven, capable of being controlled at a temperature of 105 ± 2 °C.

1.2.7 Metal template, 80 mm square.

1.3 Procedure for calibrating dry film mass against dry film thickness

1.3.1 Cut a number of sheets of the plastics foil to the size of the glass plates.

Select six sheets and weigh each to the nearest milligram.

Select four sheets whose masses do not differ by more than 3 mg.

1.3.2 Wet the surface of a glass plate with a solvent conforming to Type A of ISO 1250[1] and squeegee one of the selected sheets of foil into intimate contact with the surface of the glass plate, taking care to avoid air bubbles or any other surface irregularities.

1.3.3 Place a suitable quantity of the paint on one end of the sheet of foil and distribute it evenly over the foil using the 50 μm film spreading device.

1.3.4 Repeat procedures 1.3.2 and 1.3.3 on a second sheet of foil using the 100 μm film spreading device.

1.3.5 Remove the painted sheets of foil from the glass plates and after 15 min dry them in an oven, together with the two unpainted sheets, for 2 h at 105 ± 2 °C, maintaining the sheets in a horizontal position throughout the operation.

NOTE – In cases where appreciable decomposition may occur under these drying conditions, other more suitable conditions may be used by agreement between the interested parties.

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

1.3.7 Using the template, cut two squares from the central area of each sheet.

Weigh each square to the nearest milligram.

Calculate the mean mass of the four unpainted squares.

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

1.3.8 Measure the thickness of each painted square with the dial-gauge 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 foil.

Calculate the 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.

1.3.9 Construct a graph showing the relation between the film thickness and film mass on the four painted squares, drawing the best straight line passing through the origin and between the plotted points.

1) ISO 1250, *Mineral solvents for paints (white spirits and related products).*

1.4 Procedure for determining the dry film thickness on test panels

1.4.1 Use a weighed test panel prepared in accordance with the requirements of ISO/R 1514.

1.4.2 Coat the panel with the material under test by the appropriate method.

Allow the panel to dry for 24 h at a temperature of 23 ± 2 °C and a relative humidity of 50 ± 5 %. Other ambient temperatures and relative humidities may be used by agreement between the interested parties.

1.4.3 Weigh the panel and calculate the mass of the dry film in grams per square metre.

1.4.4 Determine the equivalent film thickness by reference to the graph.

2 METHOD No. 2

Measurement of dry film thickness by the micrometer method

2.1 Scope and field of application

2.1.1 This section specifies a method for measuring the thickness of a dried paint film on a painted article or test panel to an accuracy of ± 5 μm.

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

2.1.3 The method is only suitable for flat surfaces such as sheet metal or similar material.

2.2 Apparatus

A suitable micrometer capable of measuring accurately to 5 μm, fitted with a ratchet.

2.3 Procedure

2.3.1 Select the positions at which readings are to be taken. They shall be free from surface irregularities and shall be not less than 20 mm from any paint film edge and approximately 50 mm apart.

As a guide, suitable positions on a 150 mm × 100 mm test panel are shown in Figure 1, but for larger areas the number and distribution of the test areas shall be such as to give a representative indication of the film thickness.

Dimensions in millimetres

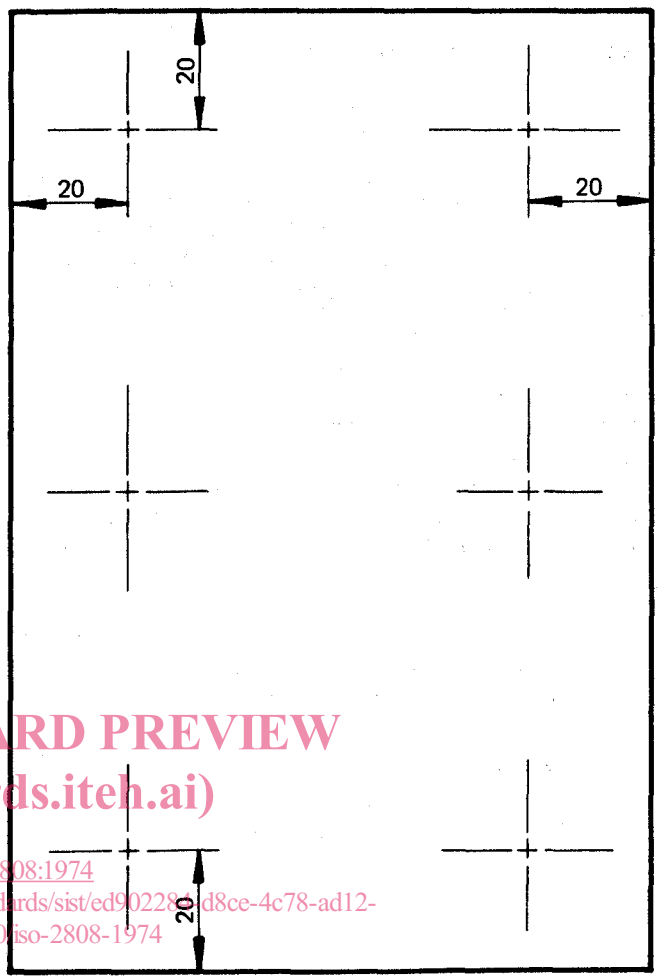


FIGURE 1 – **Measurement of dry film thickness : selection of positions for measurement of film thickness on panel 150 mm × 100 mm**

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

2.3.2 Support the painted specimen rigidly in a manner such that all the test positions are accessible to the micrometer.

2.3.3 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 position reference number on a test record sheet.

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

Record the results as before.

2.3.4 Remove the test specimen 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. For example this may be done by covering the test area with a small circle of thick filter paper and applying a few drops of a suitable solvent.

2.3.5 Repeat procedures 2.3.2 and 2.3.3 at each test area and thus measure the thickness of the substrate.

2.4 Calculation

2.4.1 Calculate the film thickness at each test area by subtracting the second reading from the first.

2.4.2 Calculate the mean value for the test panel, rounding the result to the nearest multiple of 5 μm.

3 METHOD No. 3
Measurement of dry film thickness by the dial gauge method

3.1 Scope and field of application

3.1.1 This section specifies a general method for measuring the thickness of a dried paint film on a painted article or test panel to an accuracy of ± 2 μm.

3.1.2 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.

3.1.3 The method is only suitable for painted specimens that are substantially flat.

3.2 Apparatus

A suitable dial gauge, capable of measuring accurately to 2 μm, mounted on a rigid support.

NOTE – Some instruments have facilities for applying a load on the presser foot during operation. The load applied shall be such that no indentation of the paint film occurs during test (see 3.3.2).

3.3 Procedure

3.3.1 Select the positions at which readings are to be taken. They shall be free from surface irregularities and shall be not less than 20 mm from any paint film edge and approximately 50 mm apart.

As a guide, suitable positions on a 150 mm × 100 mm test panel are shown in Figure 1, but for larger areas the number and distribution of test areas shall be such as to give a representative indication of the film thickness.

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

3.3.2 Set the reading on the dial to zero. Raise the presser foot and place the test specimen, paint film uppermost, so that the presser foot is immediately above the centre of the first test area. Support the specimen in such a way that no movement occurs 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 pressure foot.

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

3.3.3 Raise the presser foot and carefully remove the paint film from within the circle of the test area with a suitable solvent or paint remover, taking care not to obliterate the distinctive number. For example, this may be done by covering the test area with a small circle of thick filter paper and applying a few drops of a suitable solvent.

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.

3.4 Calculation

3.4.1 Calculate the film thickness at each position by subtracting the second reading from the first.

3.4.2 Calculate the mean value for the test panel, rounding the result to the nearest multiple of 2 μm.

4 METHOD No. 4
Measurement of dry film thickness : Microscope methods

4.1 Scope and field of application

4.1.1 This section specifies two methods in which microscopes are used for measuring the dry film thickness of paint films on a variety of substrates.

4.1.2 Method A is a general method for measuring the thickness of a dried film of paint on a section cut from a test panel or painted article.

It is recommended for use 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 such as occur due to unevenness of the substrate, for example grit-blasted steel.

4.1.3 Method B employs 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 specimen as described in Method A.

4.1.4 The number of specimens prepared by either method shall be such as to be representative of the painted article or test panel.

4.2 Method A

4.2.1 *Apparatus*

4.2.1.1 Microscope, with a suitable objective, and an eyepiece bearing a scale such that thicknesses may be read to an accuracy of 2,5 μm or better.

4.2.1.2 Waterproof silicon-carbide abrasive paper, of suitable grades.

NOTE – Grades 280, 400 and 600 are suitable grades. According to the information at present available, these are grades of silicon-carbide grit, standardized through the Federation of European Producers of Abrasive Products (FEPA).

4.2.2 *Reagent*

Cold-setting potting or casting resin having no deleterious effect on the paint film.

NOTE – Typical mixtures found suitable for this purpose are :

a) Epoxy resin MY753 (C.I.B.A. Ltd.) 10 volumes,
Hardener HY951 (C.I.B.A. Ltd) 1 volume

b) Epoxy resin EPIKOTE 815 (Shell Chemical) 100 parts by mass,
Hardener EPIKURE TET (Shell Chemical) 13 parts by mass.

The colour of the mounting resin shall be such as to distinguish it clearly from the paint film under test. This may be achieved by the incorporation of suitable dyes or pigments into the resin.

4.2.3 *Procedure*

4.2.3.1 Cut test sections from the painted specimen with a sharp hacksaw. The painted area shall be approximately 25 mm square. Remove any burrs with abrasive paper.

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

4.2.3.3 Construct a small cylindrical cell from thin waxed cardboard 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.

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

NOTE – A suitable means of supporting the specimen is shown in Figure 2.

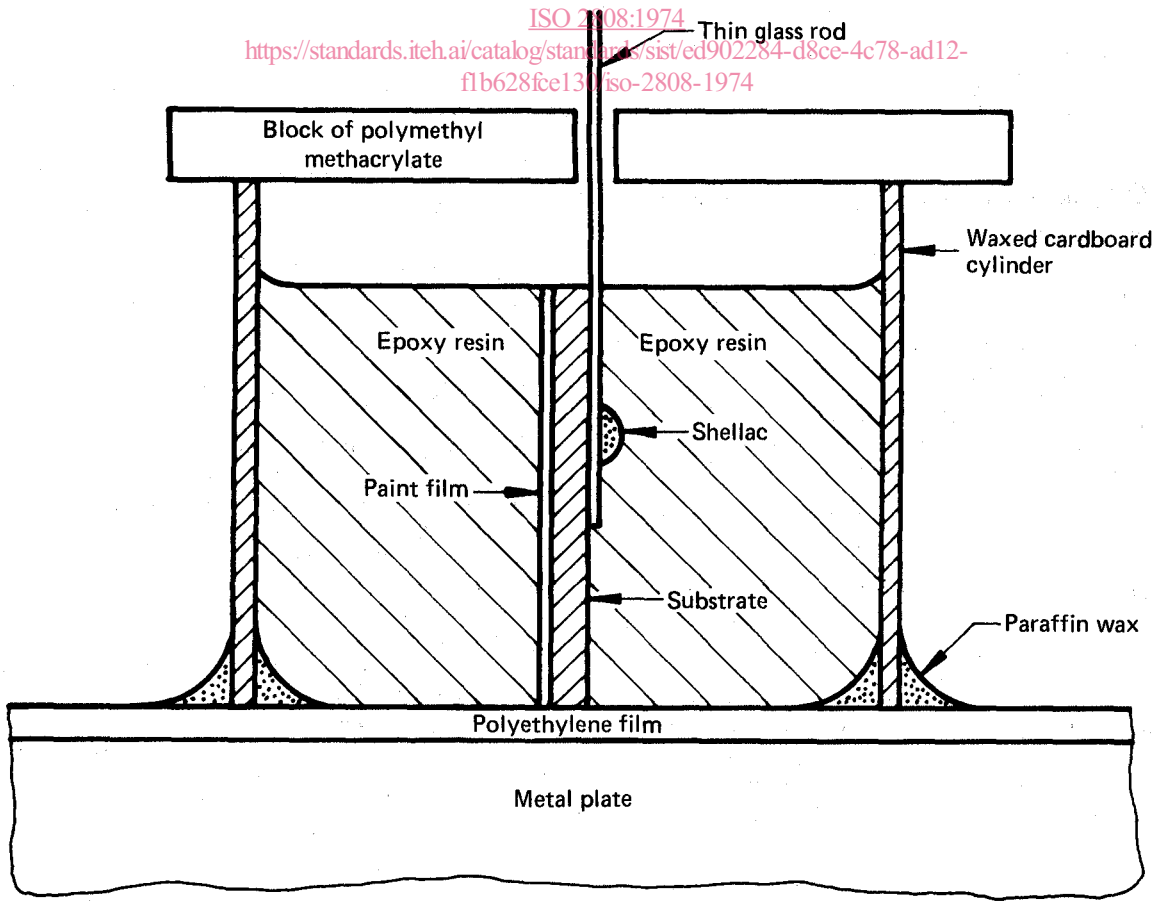


FIGURE 2 – **Method for preparing specimen for measurement of dry film thickness**

4.2.3.5 Mix sufficient of the potting resin to cover the section, allow it to stand a few minutes to release air bubbles and carefully pour it into the cell, taking precautions to see that the painted surface remains in a vertical position.

Allow the potted section to stand for 24 h at room temperature.

4.2.3.6 Remove the resin block from the polyethylene foil and rub down the face which was in contact with the foil on the coarsest grade of abrasive paper 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 to see if it is sufficiently smooth for a reading to be taken.

Finally polish the specimen on the finest grade of abrasive paper, rinse it under the tap and dry it with a clean soft rag.

4.2.3.7 Mount the potted section on a microscope slide with the polished face uppermost and parallel to the plane of the slide. (This is readily done by placing a piece of soft putty between section and slide and levelling the polished surface with a spirit level.)

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

4.2.3.9 Take measurements at seven places along the edge of the paint film and calculate the mean thickness.

Where the film thickness is markedly variable along the specimen it is often useful to supplement the readings by pictorial illustrations such as photomicrographs or drawings.

4.3 Method B

4.3.1 *Apparatus*

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

One 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.

NOTE — In favourable circumstances it is possible to make readings to an accuracy of 1 μm.

4.3.2 *Procedure*

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

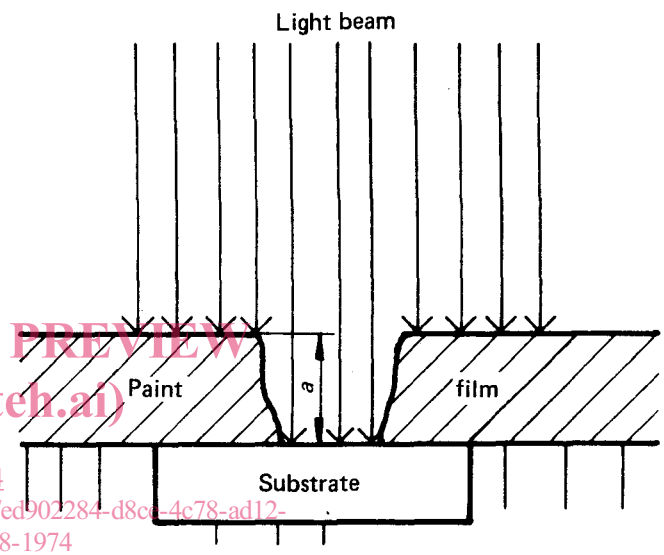
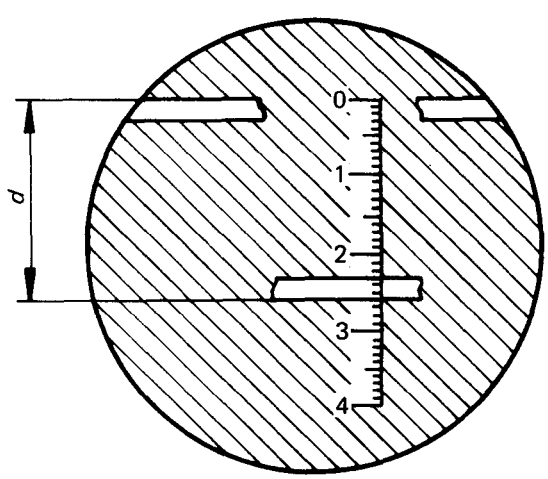


FIGURE 3 — **Sectioned view of incised painted specimen**



Reading *d* in eyepiece scale divisions is converted into the corresponding film thickness *a* (see Figure 3) in micrometres.

FIGURE 4 — **Typical image as seen in the microscope**