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COMPARISON OF UNITED STATES AND BRITISH
METHODS FOR TESTING PLASTIC MATERIALS

PLASTICS TECHNICAL EVALUATION CENTER
DOVER, NEW JERSEY

SEPTEMBER 1976

PLASTEC NOTE N32

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COMPARISON OF
UNITED STATES AND BRITISH METHODS
FOR
TESTING PLASTIC MATERIALS



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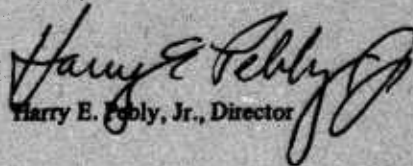
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UNITED STATES AND BRITISH METHODS
FOR
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by

ARTHUR H. LANDROCK

SEPTEMBER 1976

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PREFACE

This report was prepared as a result of the participation of the United States, through the Army Materials and Mechanics Research Center (AMMRC) in the program of standardization of plastics test methods carried out by the Quadripartite Nations (United States, Great Britain (UK), Australia and Canada). The Plastics Technical Evaluation Center (PLASTEC), which has had extensive experience in standardization, was asked by AMMRC in March of 1975 to carry out a comparison of British Standards and U.S. test methods (mostly ASTM) in three major areas: Mechanical Properties, Effects of Temperature, and Miscellaneous. Later, these areas were extended to cover the following additional subject areas: Electrical Tests, Optical Properties, and Chemical Tests.

The initial assignment was to determine the ASTM equivalents of British Standards, and vice versa. It soon became apparent that it was not possible to determine comparability on an absolute basis, because in practically all cases such comparability has to be qualified.

The final product, the compilation of discussions on the comparison of test methods for plastics, was a 108-page document. In this document, under each of the 42 test method areas covered, the ASTM methods are generally listed first, with mention of the ASTM Annual Book of Standards part (volume) number in which the method is found, along with a discussion of the essentials of the method, followed by a similar listing of the closest British Standard (BS) method. BS methods, in turn, are listed next where no ASTM equivalent is apparent. Full titles of the methods are given in all cases. In general, comments on the equivalency or comparability of methods are made at the end of each entry.

The reader will note that the text starting on page 51 is treated slightly differently than the preceding pages. This is because the material in the second half of the report was prepared at a much later date. Attention is also given in this more recent material to Federal (U.S.) Test Method Standards (FTMS) and Underwriters Laboratories (UL) Standards, where it is felt that such standards are widely cited and used in the U.S. This newer material was prepared for submission to AMMRC in August of 1976 and, aside from the differences in type style, there are minor differences in the manner of discussion, when compared with the initial material. The entire report has occasional cross references to BS methods which were not actually studied, and to Federal Republic of Germany (FRG) DIN specifications, International Electrotechnical Commission (IEC) Recommendations, International Standards Organization (ISO) Recommendations, and British Defence Specifications. All standardization documents mentioned in this report are listed in an index at the end of the report. A total of 96 ASTM Standards are cited. Other totals are: British Standards - 16 (but

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including a total of 135 different test methods, most of which are listed under BS 2782); DIN specifications - 5; IEC Recommendations - 2; ISO Recommendations - 16; UL specifications - 1; Federal Test Method Standard No. 406 - 9 methods. A total of 265 test methods are discussed.

During the course of preparing the material for the first part of this study the author came across the very useful reference by Ives et. al. (see list of references). This source comments on comparisons between many ASTM and BS methods, and many of these comments are cited in the text.

In several entries under 1. Tensile Properties, tables are given showing a comparison between ASTM and BS dumbbell-type specimen dimensions. These tables were put together by the author to support his reasoning in listing an ASTM method as similar to a BS method. Note that in some cases it was necessary to guess at a dimension. The letters W, L, etc. in the left-hand columns are the abbreviations for width of narrow section, length of narrow section, etc. as used in ASTM D 638 and other ASTM procedures. T represents thickness.

Throughout the report, when known, corresponding ISO Recommendations and DIN methods are listed, although no special effort was made to cover this area. In general, ASTM methods are broader and more comprehensive than Methods under BS 2782 and other British Standards. This is not meant to be a criticism of British Standards, which were found to be very carefully prepared documents.

It should be noted that there is a definite movement in the United States to replace Federal Test Method Standards with ASTM Standards, with the U.S. Government giving official recognition to the latter. A number of ASTM standards have already achieved this status. ASTM standards listed in this report are those actually studied in the preparation of the author's analysis. They are not necessarily the latest revisions of the standards, which can be obtained in more recent editions of the Annual Book of ASTM Standards, or directly from ASTM Headquarters in separate issues.

ABSTRACT

This report is a comparison of United States test methods, primarily American Society for Testing and Materials (ASTM) methods with British Standards, for testing plastics materials. A total of 265 test methods are discussed covering the following major subject areas: Mechanical Properties, Effects of Temperature, Miscellaneous, Electrical Tests, Optical Properties and Chemical Tests. The objective of the study, which was carried out in cooperation with a Quadripartite Nations project, was to identify comparable U.S. and British Specifications. The report covers standardization methods issued through 1975.

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DISCLAIMER AND COMMENT

The technical opinions expressed in this report as to comparability of test methods are those of the Plastics Technical Evaluation Center (PLASTEC), and, in particular, those of the author, except where otherwise indicated. The report is an initial evaluation of British and American test methods and subject to ratification by cognizant international parties. However, the Department of the Army feels that the report is of sufficient importance to warrant widespread distribution, albeit on an information basis only. It is not to be regarded as an official standardization document.

It should be noted that this report is based on a unilateral effort by the United States to help in achieving international standardization of plastics test methods. To further this aim PLASTEC has arranged for distribution of this report to all possible interested parties. PLASTEC welcomes opinions and comments on the conclusions made in the report. The author would also appreciate statements as to omissions of test methods which should have been considered. Any comments received will be carefully evaluated and possibly used to improve the commentary of the report. Comments should be addressed to:

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COMPARISON OF TEST METHODS

MECHANICAL PROPERTIES

1. Tensile Properties

ASTM D 412-68 Standard Method of
TENSION TESTING OF VULCANIZED RUBBER (in Part 37, 1974 Annual Book of
ASTM Standards)

Used for testing sheeting made from nonrigid plastics (elastoplastics) of 1.0 mm or greater, according to ASTM D 882-75b TENSILE PROPERTIES OF THIN PLASTIC SHEETING. It is intended primarily for use with vulcanized rubber and similar rubber-like materials at room temperature and elevated temperature.

The piece of rubber to be tested shall, whenever possible, be between 1.5 - 3.0 mm in thickness. Standard wetting dies (dumbbells) of 6 different dimensions are specified. Ring specimens are also used.

Results are obtained for tensile stress in kg/sq cm or psi and elongation. Test temp is 23°C. Reference lines vary from 33 - 59 mm apart for dumbbells.

Approximately equivalent to BS 2782 Method 301E.

BS 2782: Part 3: 1970
Method 301E
TENSILE STRENGTH AND ELONGATION AT BREAK OF FLEXIBLE UNSUPPORTED
POLYVINYL CHLORIDE SHEET

Title is descriptive of purpose. Standard dies (dumbbells) of 3 different dimensions are specified. No ring specimens are used! In all 3 cases the reference lines are 51 mm apart. Test temperature is 23°C. Results are reported on MN/m², but tentatively results may be reported as kg/sq cm or psi. Elongation is also calculated, as a percentage of the original distance between the reference lines.

Approximately equivalent to ASTM D 412-68.

NOTE: Of these two methods the ASTM method is more general, but will cover PVC flexible sheet. The BS applies only to PVC flexible sheet.

ASTM D 638-72 Standard Method of Test for
TENSILE PROPERTIES OF PLASTICS (in Part 35, 1974 Annual Book of ASTM
Standards)

Used for determining the tensile properties of plastics in the form of standard test specimens (A. Sheet, plate and molded plastics - dumbbells, B. Rigid tubes, and C. Rods). For sheet, plate and molded plastics five different specimen types are specified. Types I, II, III and V specimens are used for rigid plastics and Type IV for non-rigid, primarily. The dimensions for Type IV specimens are essentially the same as those of Die C in ASTM D 412. Type I specimen dimensions have approximate equivalents in BS 2782, Methods 301 B, H and J. Types II and III have equivalents in BS 2782, Method 301C, and Type IV has equivalents in BS 2782, Methods 301 D, F, G and K. ASTM D 638-72 is a broad, all-encompassing specification, however, and has no precise counterpart in the BS series.

The results are reported as tensile strength at yield or at break, whichever is applicable. Elongation is also calculated. According to ASTM Subcommittee 20.10, who prepared this method, it is applicable to laminates, although it may require special grips (Bell Laboratories use a template grip). The term "plastics" in the title applies to all types of plastics. Testing is carried out at 23°C and 50% RH.

BS 2782: Part 3: 1970

Method 301A

TENSILE STRENGTH OF THERMOSETTING MOULDING MATERIAL

This test is carried out at $20 \pm 5^{\circ}\text{C}$ on a dogbone-type specimen moulded to shape. This specimen is unique and there is nothing resembling it in ASTM D 638-72.

This method has no ASTM equivalent.

BS 2782: Part 3: 1970

Method 301B

TENSILE STRENGTH OF CELLULOSE ACETATE MOULDING MATERIAL

This test is carried out at $23 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen cut from sheet. Elongation is not calculated.

Specimen Dimensions

	<u>BS 2782 Method 301B</u>	<u>ASTM D 638, Type I</u>
W	0.50"	0.50"
L	--	--
WO	1.0"	0.75"
LO	6.0"	6.5"
G	1.5"	2.0"
D	5"	4.5"
R	3.5"	3.0"
RO	--	--
T	.05"	0.28" or under

Approximately equivalent to ASTM D 638-72, Type I.

BS 2782: Part 3: 1970
Method 301C

TENSILE STRENGTH OF LAMINATED SHEET (THERMOSETTING)

This test is carried out at $20 \pm 5^{\circ}\text{C}$ on a dumbbell-type specimen machined to shape. No mention is made of the location of the reference or gauge lines, although it is probably a 3" span.

Specimen Dimensions

	<u>BS 2782 Method 301C</u>	<u>ASTM D 638, Type</u>	
		<u>II</u>	<u>III</u>
W	0.25"	0.25"	0.75"
L	3.0"	2.25"	2.25"
WO	1.5"	0.75"	1.13"
LO	9.0"	7.2"	9.7"
G	3.0"	2.0"	2.0"
D	ca 6.0"	5.3"	4.5"
R	2.0"	3.0"	3.0"
RO	--	--	--
T	To 0.50"	To 0.28"	0.28-0.55"

Approximately equivalent to ASTM D 638-72, Types II and III.

BS 2782: Part 3: 1970
Method 301D

TENSILE STRENGTH AND ELONGATION AT BREAK OF FLEXIBLE POLYVINYL CHLORIDE EXTRUSION COMPOUND

This test is carried out at $23 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen cut from sheet with a punch. The sheet must be .050" thick. Results in tensile strength are reported in MN/m^2 , but tentatively results may be reported in kg/sq cm or psi. Elongation is also calculated, as a percentage of the original distance between the reference lines.

Specimen Dimensions

BS 2782 Method 301D (also F & G) ASTM D 638, Type IV (non-rigid plastics)

W	0.25"	0.25"
L	1 15/16" + ?	1.30"
WO	1.00"	0.75"
G	1.00"	1.00"
D	?	2.5"
R	9/16" .56	0.56"
RO	1.00"	1.00"
T	.050"	0.16" or under

This method is approximately equivalent to ASTM D 638-72, Type IV. Note that Method 301D calls for only a single specified thickness, however.

BS 2782: Part 3: 1970

Method 301F

TENSILE STRESS AT YIELD AND AT BREAK AND ELONGATION AT BREAK OF POLYTHENE COMPOUND OF ELONGATION AT BREAK NOT LESS THAN 100%

This test is carried out at $23 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen cut from sheet of .060" thickness with a punch. Results in tensile strength are reported in MN/m^2 , but tentatively results may be reported in kg/sq cm or psi . Elongation is also calculated, as a percentage of the original distance between the reference lines. The method is essentially identical to Method 301D, except that a slightly thicker specimen (.060") is used. Again, the method is approximately equivalent to ASTM D 638-72, Type IV. Note that Method 301F calls for only a single specified thickness, however.

BS 2782: Part 3: 1970

Method 301G

TENSILE STRENGTH OF RIGID POLYVINYL CHLORIDE COMPOUND

This test is carried out at $23 \pm 2^{\circ}\text{C}$ on a dumbbell-type specimen cut from sheet of .060" thickness with a punch. Results in tensile strength are reported in MN/m^2 , but tentatively results may be reported in kg/sq cm or psi . Elongation is not calculated. This method is approximately equivalent to ASTM D 638-72, Type IV, which, although usually used for non rigid plastics, can be used for rigid plastics too. Note that Method 301G calls for only a single specified thickness, however.

BS 2782: Part 3: 1970

Method 301H

TENSILE STRENGTH AND ELONGATION AT BREAK OF TOUGHENED POLYSTYRENE FOR SHEET EXTRUSION

This test is carried out at $23 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen. Results in tensile strength are reported as MN/m^2 , but tentatively results may be reported as kg/sq cm or psi . Elongation is also calculated as a percentage of the original distance between the reference lines.

Specimen Dimensions

	<u>BS 2782 Method 301H</u>	<u>ASTM D 638, Type I</u>
W	0.50"	0.50"
L	--	--
WO	1.0"	0.75"
LO	6.0"	6.5"
G	1.5"	2.0"
D	5.0"	4.5"
R	3.5"	3.0"
RO	--	--
T	.05"	0.28" or under

Approximately equivalent to ASTM D 638-72, Type I.

BS 2782: Part 3: 1970

Method 301J

TENSILE STRENGTH AND ELONGATION AT BREAK OF TOUGHENED POLYSTYRENE MOULDING MATERIAL

This test is carried out at $23 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen. Results in tensile strength are reported as MN/m^2 , but tentatively results may be reported as kg/sq cm or psi . Elongation is also calculated as a percentage of the original distance between reference lines.

Specimen Dimensions

	<u>BS 2782 Method 301J</u>	<u>ASTM D 638, Type I</u>
W	.50"	.50"
L	2.25"	2.25"
WO	0.75"	0.75"
LO	7.5"	6.5"
G	2.00"	2.00"
D	4.00"	4.5"
R	3.00"	3.00"
RO	--	--
T	.125"	0.28" or under

Approximately equivalent to ASTM D 638-72, Type I.

BS 2782: Part 3: 1970

Method 301K

TENSILE STRENGTH AND ELONGATION AT BREAK OF PTFE (EXCLUDING ROD)

The test is carried out at $35 \pm 1^{\circ}\text{C}$ on a dumbbell-type specimen cut from sheet at 40°C . The sheet thickness shall be that of the sheet under test, but with a maximum of .1" (2.5 mm). Results in tensile strength

are reported as MN/m², but tentatively results may be reported as kg/sq cm or psi. Elongation is also calculated as a percentage of the original distance between reference lines.

The specimen dimensions are the same as for BS 903, "Methods of Testing Vulcanized Rubber, Part A2, Determination of Tensile Stress-Strain Properties," except that some tolerances in Method 301K are wider and are in accordance with ISO/R37, "Determination of Tensile Stress-Strain Properties of Vulcanized Rubbers, 2nd Ed."

The specimen dimensions for Method 301K are much smaller than those for all dies of ASTM D 412, "Tension Testing for Vulcanized Rubber." They are much closer to the dimensions of ASTM D 638, Type IV, as shown below.

Specimen Dimensions

	<u>BS 2782, Method 301K</u>	<u>ASTM D 638, Type IV</u>
W	.16"	.25"
L	1.00"	1.30"
WO	0.50"	0.75"
G	.79"	1.0"
D	ca 1.00"	2.5"
R	3.125"	--
RO	--	1.0"
T	max .10"	max .16"

Approximately equivalent to ASTM D 638, Type IV.

BS 2782: Part 3: 1970
Method 301L

TENSILE STRENGTH OF REINFORCED PLASTICS WITH RECTANGULAR TEST

This method is for determining the tensile strength of reinforced moldings or laminates using a rectangular test specimen, i.e., a test specimen without the usual waisted middle portion. The use of this specimen simplifies and reduces the amount of machinery required to fabricate the test specimen from sheet. It is known to be suitable for testing glass-reinforced materials, particularly those with coarse reinforcements, e.g. woven rovings, and bonded with polyester, epoxy or silicone resins. It is not intended to supersede Method 301C in any instance where that method is satisfactory. The test is carried out at 20 ± 5°C.

This method is approximately equivalent to ASTM D 3039-74. The end pieces are not bevelled as they are in the ASTM method, which calls them tabs. This method is written much simpler than the ASTM method. Only tensile strength is determined, while in the ASTM method strain at failure, elastic modulus and Poisson's ratio are also determined.

ASTM D 3039-74 Standard Method of Test for
TENSILE PROPERTIES OF ORIENTED FIBER COMPOSITES (in Part 33, 1974 Annual
Book of ASTM Standards)

This method covers the determination of the tensile properties of resin-matrix composites reinforced by oriented continuous or discontinuous high-modulus $> 20 \text{ GN/m}^2$ ($> 3 \times 10^6$ psi) fibers. This includes only symmetric laminates in 0 and 90-deg properties. This specification was developed by ASTM Committee D30 on High Modulus Fibers and Their Composites, rather than by D20 on Plastics and D11 on Rubber and Rubber-Like Products.

The method requires reporting tensile strength, strain at failure, elastic modulus, and Poisson's ratio. The test specimen is rectangular and is very similar to that of BS 2782, Method 301L.

ASTM D 1623-72 Standard Method of Test for
TENSILE PROPERTIES OF RIGID CELLULAR PLASTICS (in Part 36, 1974 Annual
Book of ASTM Standards)

This specification covers rigid cellular plastics. Two types of specimens are used. Type A specimens are cut on a lathe and are used where enough sample material exists to form the necessary specimen. Type B specimens may be used where only smaller specimens are available, as in sandwich panels. The test is carried out at $23 \pm 2^\circ\text{C}$ and 50% RH. Tensile strength and elongation are calculated.

This test is approximately equivalent to BS 4370: Part 2, Method 9.

BS 4370: Part 2: 1973 (Methods of Test for Rigid Cellular Materials)
Method 9
DETERMINATION OF TENSILE STRENGTH

This method is for determining the tensile strength of rigid cellular materials by stretching a specimen to breaking point, the stress being applied substantially uniformly over the cross section. Two types of dumbbell specimens are used, one for thickness up to 1/2", and the other for thicknesses over 1/2". The specimens are cut with a bandsaw. The test is carried out at $23 \pm 1^\circ\text{C}$ after conditioning at 50% RH. The tensile strength is determined as k Pa (k N/m^2).

This method is approximately equivalent to ASTM D 1623-72.

ASTM D 1708-66 (1970) Standard Method of Test for
TENSILE PROPERTIES OF PLASTICS BY USE OF MICROTENSILE SPECIMENS (in Part
35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the comparative tensile strength and elongation properties of plastics in the form of standard microtensile test specimens when tested under defined conditions of pretreatment,

humidity and testing machine speed. It can be used for specimens of any thickness up to 1/8", including thin films, and is designed specifically for use where only limited amounts of material are available. The method cannot be used for the determination of modulus of elasticity.

Results obtained by this method are essentially comparable to results obtained in sheet materials by methods ASTM D 638 and ASTM D 882.

Testing is carried out at $23 \pm 2^{\circ}\text{C}$ and 50% RH.

Calculations include yield strength, tensile strength at break and percent elongation at yield point and at break.

There appears to be no BS equivalent of this method.

ASTM D 882-75b Standard Method of Test for
TENSILE PROPERTIES OF THIN PLASTIC SHEETING (in Part 35, 1974 Annual
Book of ASTM Standards)

This method covers the determination of tensile properties of plastics in the form of thin sheeting (less than 1.0 mm (0.04") in thickness). It does not cover films (up to 0.25 mm (0.010")). Therefore, the range it covers is between .010"- 0.04". There are two methods prescribed. Method A (preferred) is a Static Weighing - Constant-Rate-of-Grip Separation Test and Method B is a Pendulum Weighing - Constant-Rate-of-Powered-Grip Motion Test. Since the actual loading rates in these two methods vary, the results using the two methods cannot be directly compared. The test is carried out at $23 \pm 2^{\circ}\text{C}$ and 50% RH.

The method calls for calculating tensile strength, breaking factor, elongation, yield strength, and modulus of elasticity.

The specimens are rectangular strips of uniform width and thickness at least 50 mm (2") longer than the grip separators used. The nominal width must be not less than 5.0 mm (0.20") nor greater than 25.4 mm (1.0"). A width-thickness ratio of at least 8 shall be used.

This standard does not appear to have any BS equivalent, except possibly for BS 2782, Method 301E, which uses dumbbell-shaped specimens, rather than rectangular, and is written particularly for PVC sheet.

ASTM D 2289-69 Standard Method of Test for
TENSILE PROPERTIES OF PLASTICS AT HIGH SPEED (in Part 35, 1974 Annual
Book of ASTM Standards)

This method covers the determination of the tensile properties of plastics over a broad range of testing speeds extending from conventional speeds (ASTM D 638 and D 882) to those at which stress wave propagation

effects may become important. This method normally uses grip displacement as a means for measuring strain. Direct strain measurement requires use of optical, photographic or strain gage systems. Tensile strength, elongation and work values are reported. The procedure may be used for molded plastics or films.

This standard does not appear to have any BS equivalent.

2. Flexural Properties

ASTM D 747-70 Standard Method of Test for
STIFFNESS OF PLASTICS BY MEANS OF A CANTILEVER BEAM (in Part 35, 1974
Annual Book of ASTM Standards)

This method is well suited for determining relative flexibility of plastics over a wide range. Test specimens may be molded or cut from molded, calendered or cast sheets of the material to be tested.

This method has no BS equivalent.

BS 2782: Part 3: 1970
Method 302D
ELASTIC MODULUS IN BEND OF RIGID MATERIALS

In this test a rectangular bar is placed symmetrically across two parallel supports and a force is applied uniformly across the width of the specimen by means of a loading nose midway between the two supports. The corresponding deflection is measured. With varying loads, a load-deflection curve is drawn. The elastic modulus in bend is calculated from the initial (straight) portion of the curve.

This method has no ASTM equivalent.

ASTM D 790-71 Standard Methods of Test for
FLEXURAL PROPERTIES OF PLASTICS (in Part 35, 1974 Annual Book of ASTM
Standards)

These methods cover the determination of flexural properties of plastics and electrical insulating materials in the form of rectangular bars molded directly or cut from sheets, plates or molded shapes. These methods are generally applicable to rigid and semirigid materials. However, flexural strength cannot be determined for those materials that do not fail in the outer fibers.

Method I-A 3-pt. loading system utilizing center loading on a simply supported beam.

Method II-The bar rests on two supports and is loaded at 2 pts. (by means of loading noses), each an equal distance from the adjacent support point. The distance between the loading noses is one-third of the support span.

Calculations include: Max. strength in the outer fibers of the specimen, flexural strength (if applicable), tangent or secant modulus of elasticity in bending, flexural yield strength (if desired), flexural offset yield strength (if desired), and stress at any given strain up to 5% if desired.

Method I is approximately equivalent to BS 2782, Method 302D.

BS 2782: Part 3: 1970
Method 304A
CROSS-BREAKING STRENGTH OF THERMOSETTING MOLDING MATERIALS

Approximately equivalent to ASTM D 790-71, Method I, Test Specimens, Paragr. 5.4, except that the British method uses V-blocks for loading.

BS 2782: Part 3: 1970
Method 304B
CROSS-BREAKING STRENGTH OF LAMINATED SHEET (THERMOSETTING)

Approximately equivalent to ASTM D 790-71, Method I, Test Specimens, Paragr. 5.2, except that the British method uses V-blocks for loading.

BS 2782: Part 3: 1970
Method 304C
CROSS-BREAKING STRENGTH OF CASTING AND LAMINATING RESIN SYSTEMS

Approximately equivalent to ASTM D 790-71, Method I, Test Specimens, Paragr. 5.5, except that the British method uses V-blocks for loading.

BS 2782: Part 3: 1970
Method 304D
CROSS-BREAKING STRENGTH OF LAMINATED SHEET (THERMOSETTING) WITH COARSE FILLER

Approximately equivalent to ASTM D 790, Test Specimens, Paragr. 5.2, except that the British method uses V-blocks for loading.

BS 2782: Part 3: 1970
Method 304E
CROSS-BREAKING STRENGTH (FLEXURAL STRENGTH, ISO METHOD)

Approximately equivalent to ASTM D 790, except for slight differences in the loading surfaces. Also equivalent to ISO/R1674, except for a relaxation on one tolerance of dimension in the BS method.

BS 4370: Part 1: 1968 (Methods of Test for Rigid Cellular Materials)
Method 4
CROSS-BREAKING STRENGTH

This method is for measuring the cross breaking strength in bend at fracture of rigid cellular material when subjected to three-point loading.

There is no ASTM equivalent of this method.

3. Impact Strength

ASTM D 256-73 Standard Methods of Test for
IMPACT RESISTANCE OF PLASTICS AND ELECTRICAL INSULATING MATERIALS (in
Part 35, 1974 Annual Book of ASTM Standards)

These methods cover the determination of the resistance to breakage by flexural shock of plastics and electrical insulating materials as indicated by the energy extracted from "standardized" machines, in breaking standard specimens with the pendulum swing. Except for ceramic specimens, the standard tests for these methods required specimens made with a milled notch.

Basic types {

Method A Cantilever Beam (Izod-type) Test
Approximately equivalent to BS 2782, Method 306A.

Method B Simple Beam (Charpy-type) Test
Approximately equivalent to BS 2782, Method 306E

Method C Cantilever Beam (Izod-type) Test for Materials of Less than
27 J/M (0.5 ft-lb/in) of Notch

This method is Method A modified by the addition of the determination of toss correction. There is no BS equivalent.

Method D Notch radius sensitivity test (for Method A)

This method provides a measure of notch sensitivity of plastics. There is no BS equivalent.

Method E Cantilever Beam Reversed Notch Test

This method gives an indication of the unnotched strength of plastics. It is similar to Method A, except that the specimen is reversed in the vise of the machine 180 deg. to the usual striking position, such that the striker of the apparatus impacts the specimen in the face opposite the notch.

Approximately equivalent to BS 2782, Method 306D.

BS 2782: Part 3: 1970

Method 306A IMPACT STRENGTH (PENDULUM METHOD)

In this method a notched cantilever (Izod) specimen of standard dimensions is broken by a blow from a weighted pendulum and the loss of energy of the pendulum is measured.

This method is approximately equivalent to ASTM D 256-73, Method A.

BS 2782: Part 3: 1970

Method 306D CHARPY IMPACT RESISTANCE WITH UNNOTCHED SPECIMEN

This method is for determining the impact strength, using a Charpy-type pendulum apparatus, of unnotched specimens.

No close ASTM equivalent, since the closest ASTM method (D 256-73, Method B) uses notched specimens.

BS 2782: Part 3: 1970
Method 306E CHARPY IMPACT RESISTANCE WITH NOTCHED SPECIMEN

This method is for determining the impact strength, using a Charpy-type pendulum apparatus, of notched specimens.

This method is approximately equivalent to ASTM D 256-73, Method B.

ASTM D 1709-67 (1972) Standard Methods of Test for
IMPACT RESISTANCE OF POLYETHYLENE FILM BY THE FREE FALLING DART METHOD
(in Part 36, 1974 Annual Book of ASTM Standards)

These methods cover the determination of the energy that causes polyethylene film to fracture under specified conditions of impact of a free-falling dart.

Method A - for impact strengths of 300 g or less (66 cm ht)

Method B - " " " over 300 g to 1300 g (152.4 cm ht)

Method A is approximately equivalent to BS 2782, Method 306B.

Method B has no BS equivalent, since its height of fall is too high and the dart is larger.

BS 2782: Part 3: 1970
Method 306B
IMPACT STRENGTH (FALLING WEIGHT METHOD WITH SHEET SPECIMEN)

In this method a weight, guided or unguided, is allowed to fall on to the center of a disc or a square piece of standard dimensions on an annular support. The impact strength is the energy of a blow that would be expected to fracture half of a large number of specimens. The height of fall is 600 mm (2 ft).

This method is approximately equivalent to ASTM D 1709-67 (1972), Method A, except that it applies to all types of film, not only polyethylene. It is also approximately equivalent to ASTM D 3029-72, Procedure A.

BS 2782: Part 3: 1970
Method 306C
IMPACT STRENGTH (MODIFIED METHOD 306B)

Similar to 306B, but the height of fall is 300 mm (1 ft), which is one half that of 306B.

There is no ASTM equivalent with this low a height of fall.

BS 2782: Part 3: 1970
Method 306F

IMPACT RESISTANCE OF FLEXIBLE FILM WITH FALLING DART

This method is for measuring the toughness of thin flexible sheet (film) up to 0.3 mm (.012") thick. A dart with a hemispherical head is dropped from a specified height on to a disc of film 127 mm (5") in diameter formed by clamping the film across an annular specimen holder. The impact resistance is the mass in grams of the dart that would be expected to break half of a large number of test specimens. The weight falls through 660 mm (26").

Approximately equivalent to ASTM D 1709-67, Method A.

ASTM D 1822-68 (1973) Standard Method of Test for
TENSILE IMPACT ENERGY TO BREAK PLASTICS AND ELECTRICAL INSULATING
MATERIALS (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the energy required to rupture standard tension-impact specimens of plastic or electrical insulating materials. Materials that can be tested by this method are those too flexible or too thin to be tested by ASTM D 256. The energy utilized in this method is delivered by a single swing of a calibrated pendulum of a standardized tension-impact machine.

There is no known BS equivalent to this method.

ASTM D 3029-72 Standard Method of Test for
IMPACT RESISTANCE OF RIGID PLASTIC SHEETING OR PARTS BY MEANS OF A TUP
(FALLING WEIGHT) (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the energy required to crack or break rigid plastic sheeting or parts under specified conditions of impact of a free-falling tup or weight.

There are two procedures, A & B, A requiring a relatively large tup and test specimen. Each procedure establishes the weight of a specified tup which will cause 50% of the specimens to fail at a given drop height. The technique used is commonly called the Bruceton Staircase Method or the Up-and-Down Method.

Procedure A test conditions - same as ASTM D 1709, Method A.

Procedure B - the tup head is the same as that of Tup C of ASTM Method D 2444, "Standard Method of Test for IMPACT RESISTANCE OF THERMO-PLASTIC PIPE AND FITTINGS BY MEANS OF A TUP (FALLING WEIGHT)". The greater stress concentration offered by the smaller tup of Procedure B results in failures of tough or thick specimens which cannot be cracked by Procedure A.

Procedure A is approximately equivalent to BS 2782, Method 306B.

Procedure B has no BS equivalent.

4. Shear Strength

ASTM D 732-46 (1969) Standard Method of Test for
SHEAR STRENGTH OF PLASTICS (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the punch-type of shear test and is intended for use in determining the shear strength of test specimens of organic plastics in the form of sheets and molded disks in thicknesses from 0.125 to 12.5 mm (0.005" to 0.500"). The specimen is 2" square or 2" diameter disk. A hole approximately 11 mm (7/16") in diameter is drilled through the specimen at its center.

The load in newtons (pounds) required to shear the specimen is determined and the shear strength calculated in meganewtons/cm² (psi).

Approximately equivalent to BS 2782, Method 305A, and, to a lesser extent, Method 305B.

BS 2782: Part 3: 1970
Method 305A
SHEAR STRENGTH OF MOULDING MATERIAL

This method is for determining the shear strength of a molded test specimen by shearing a 12.7 mm (1/2") diameter hole through it. The specimen is a molded disc .25-.27 mm (ca 1") in diameter and 1/16" thick.

Approximately equivalent to ASTM D 732-46 (1969) except that the Method 305A is more restrictive.

BS 2782: Part 3: 1970
Method 305B
SHEAR STRENGTH OF SHEET MATERIAL

This method is for determining the shear strength of sheet material by shearing a 1/4" hole through it. The specimen is a rectangular bar of 1/4" width and not less than 1 1/4" length. The thickness of the specimen is the thickness of the sheet under test, but not to exceed 1/4".

Approximately equivalent to ASTM D 732-46 (1969) except that Method 305B is more restrictive.

BS 4370: Part 2: 1973 (Methods of Test for Rigid Cellular Materials)
Method 6
DETERMINATION OF SHEAR STRENGTH AND SHEAR MODULUS

This method is for determining the shear strength and shear modulus of rigid cellular materials. The test consists in subjecting a test specimen of a given shape to a shear stress transmitted to the test specimen through metal supports to which it is bonded, and in determining the corresponding stress-strain diagram.

There is no comparable ASTM method. The method is identical with ISO/R 1922.

5. Hardness

ASTM D 785-65 Standard Method of Test for
ROCKWELL HARDNESS OF PLASTICS AND ELECTRICAL INSULATING MATERIALS
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers two procedures for testing the indentation hardness of plastics and related plastic electrical insulating materials by means of the Rockwell hardness tester.

Procedure A - Rockwell Hardness number

Procedure B - " Alpha Hardness number

The Rockwell hardness number (Proc. A) is derived from the net increase in depth of impression as the load in an indenter is increased from a fixed minor load to a major load and then returned to a minor load.

The Rockwell alpha hardness number represents the maximum possible remaining travel of the short-stroke machine from the net depth of impression, as the load on the indenter is increased from a fixed minor load to a major load (Proc. B).

Indenters are round steel balls of specific diameters.

A Rockwell hardness number is directly related to the indentation hardness of a plastic material.

This method has no BS equivalent.

ASTM D 2240-68 Standard Method of Test for
INDENTATION HARDNESS OF RUBBER AND PLASTICS BY MEANS OF A DUROMETER
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers two types of durometers, A and D, and the procedure for determining the indentation hardness of materials ranging from soft vulcanized rubbers to some rigid plastics. Type A is used for measuring the softer materials and Type D for the harder materials.

This method has no BS equivalent.

ASTM D 2583-67 (1972) Standard Method of Test for
INDENTATION HARDNESS OF PLASTICS BY MEANS OF A BARCOL IMPRESSOR
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of indentation hardness of both reinforced and nonreinforced rigid plastics using a Barcol Impressor, Model 934-1. The apparatus consists of an indenter and an indicating device. It is portable.

This method has no BS equivalent.

BS 2782: Part 3: 1970

Method 307A

SOFTNESS NUMBER OF FLEXIBLE POLYVINYL CHLORIDE EXTRUSION COMPOUND

This method is for determining the softness at 23°C of flexible polyvinyl chloride extrusion compound. In the method a steel ball of 3/32" diameter is pressed on to the surface of a sheet of the material under a force of 294 mN (30gf). The softness number of the material is defined as the vertical displacement of the ball, in units of 0.01 mm, which occurs when the force is increased to 5.55 M (565 gf).

This method has no ASTM equivalent.

6. Thickness

ASTM D 374-74 Standard Methods of Test for
THICKNESS OF SOLID ELECTRICAL INSULATION (in Part 35, 1974 Annual Book
of ASTM Standards)

These methods cover the determination of the thickness of several types of solid electrical insulation materials employing recommended techniques. These methods are to be used, except as otherwise required by a materials specification. The methods are:

Method A - Machinist's Micrometer Caliper with Ratchet or Friction Thimble

Method B - Machinist's Micrometer without Ratchet

Method C - Manually-Operated Dead-Weight Dial-Type Thickness Gage

Method D - Motor-Operated Dead Weight Dial Gage

The method may be used for:

1. Plastic sheet and film
2. Papers
3. Rubber and other elastomers

This method is similar to BS 2782 Method 512B, although it is much broader than the BS.

ASTM D 1593-61 (1969) Standard Specification for
NONRIGID VINYL CHLORIDE PLASTIC SHEETING (in Part 36, 1974 Annual Book
of ASTM Standards)

This specification covers nonrigid, unsupported vinyl chloride plastic sheeting in which the resin portion of the composition contains at least 90% vinyl chloride. The sheeting must be 3-10 mils (.003-.010") in thickness. The thickness is determined by a gravimetric method in which the specific gravity must be determined and a sample weighed. (For routine testing, standard dead weight methods may be used.)

Approximately equivalent to BS 2782, Method 512A.

ASTM D 2103-73 Standard Specification for
POLYETHYLENE FILM AND SHEETING (in Part 36, 1974 Annual Book of ASTM
Standards)

This specification covers the classification of polyethylene film and sheeting up to .03 mm (0.012" or 12 mils) in thickness, inclusive. For routine measurement, use the General Method, using a dead weight dial micrometer (ASTM D 374, Method C). For high accuracy or for arbitration purposes, use a gage specially designed to an accuracy of better than 0.00005" which has been calibrated for use with polyethylene sheeting. The gage type is not specified.

This method is similar to BS 2782, Method 512B.

ASTM E 252-67 Standard Method of Test for
THICKNESS OF THIN FOIL AND FILM BY WEIGHING (in Part 35, 1974 Annual
Book of ASTM Standards)

This method is designed particularly for aluminum foil, but can also be used for polyethylene film. The method recommended is gravimetric and requires a determination of the density of the film, as in ASTM D 1593-61 (1965) for PVC sheeting.

This method is similar to BS 2782, Method 512A.

BS 2782: Part 5: 1970
Method 512A
GRAVIMETRIC THICKNESS OF FLEXIBLE SHEET

This method is for determining the thickness of sheet by calculation for mass, area, and relative density (i.e. specific gravity). It is of particular value as a means of determining the average thickness of embossed sheet.

This method is similar to ASTM D 1593-61 (1969) and ASTM E 252-67, for PVC and PE, respectively.

BS 2782: Part 5: 1970
Method 512B
THICKNESS BY DIRECT MEASUREMENT OF FLEXIBLE SHEET

This method is for measuring the thickness of flexible sheet with a micrometer. It is not suitable for use with embossed sheet.

This method is similar to ASTM D 374-74 and ASTM D 2103-73.

7. Compressive Strength

ASTM D 695-69 Standard Method of Test for
COMPRESSIVE PROPERTIES OF RIGID PLASTICS (in Part 35, 1974 Annual Book
of ASTM Standards)

This method covers the determination of the mechanical properties of rigid plastics when loaded in compression at relatively low uniform rates of straining or loading. Test specimens of standard shape are employed. Compressive properties include: modulus of elasticity, yield stress, deformation beyond yield point, and compressive strength (unless the material merely flattens and does not fracture).

The apparatus may be any suitable testing machine capable of control of constant-rate-of-crosshead movement and comprising: drive mechanism, load indicator, extensometer, compression tool, supporting jig, and micrometers.

This is a very general method and appears to be the equivalent of BS 2782, Method 303A, B and C.

ASTM D 1621-73 Standard Method of Test for
COMPRESSIVE PROPERTIES OF RIGID CELLULAR PLASTICS (in Part 36, 1974
Annual Book of ASTM Properties)

This method describes two procedures for determining the compressive properties of rigid cellular materials, particularly expanded plastics, as follows.

Procedure A - employs crosshead motion for determining compressive properties.

Procedure B - employs strain-measuring devices mounted on the specimen.

The method provides information regarding the behavior of cellular materials under compressive loads. Deformation data can be obtained, and from a complete load-deformation curve it is possible to compute the compressive stress at any load and the effective modulus of elasticity.

The apparatus is any suitable compression testing machine capable of operating at a constant rate of motion of the movable crosshead.

The method is comprehensive, but is similar in part to BS 4370, Method 3.

ASTM D 2586-68 Standard Method of Test for
HYDROSTATIC COMPRESSIVE STRENGTH OF GLASS-REINFORCED PLASTIC CYLINDERS
(in Part 36, 1974 Annual Book of ASTM Standards)

This method covers the determination of the compressive strength properties of filament-wound glass reinforced plastic cylinders of standard size in hydrostatic compression. The method is generally applicable to hollow cylinders made of glass-reinforced plastics, and particularly those formed by filament winding. The method may be applied to both unidirectional and orthotropic laminates, but is limited to constructions containing greater than 50% by weight of glass reinforcement.

A pressure vessel is used in testing, along with specimen end plate closures.

There is no BS equivalent of this method.

BS 2782: Part 3: 1970
Method 303A
CRUSHING STRENGTH OF THERMOSETTING MOULDING MATERIAL

This method is for measuring the compressive stress necessary to crush a cylindrical molding specimen. The specimen is placed between 2 parallel flat anvils and a compressive force applied in a direction parallel to the axis of the cylinder.

This method is similar to ASTM D 695-69.

BS 2782: Part 3: 1970
Method 303B
CRUSHING STRENGTH OF THERMOSETTING SHEET

This method is for measuring the compressive stress necessary to crush a cube cut from thermosetting sheet. The specimen may be built up from sheet. The specimen is placed between 2 parallel flat anvils and a compressive force applied in a direction normal to a surface of the cube and to a molded surface of the original sheet.

This method is similar to ASTM D 695-69.

BS 2782: Part 3: 1970
Method 303C
CRUSHING STRENGTH OF CASTING AND LAMINATING RESIN SYSTEMS

This method is for measuring the compressive stress necessary to crush a cylindrical specimen made from casting and laminating resin systems. The specimen is placed between 2 parallel flat anvils and a compressive force applied in a direction parallel to the axis of the cylinder. The force should be increased steadily and at such a rate that the specimen fractures in 15-45 sec.

This method is similar to ASTM D 695-69.

BS 4370: Part 1: 1968 (Methods of Test for Rigid Cellular Materials)
Method 3
COMPRESSION TEST

This test is designed to determine (a) the compressive strength or (b) the compressive stress at 10% deformation of rigid cellular materials. The material is subjected to increasing compression at a fixed rate up to 10% deformation over its entire area, and the maximum stress sustained by the test specimen is calculated. If a maximum occurs before 10% deformation is reached, then the result is defined and reported as compressive stress. If a maximum is not attained below 10% deformation, then the result is defined and reported as compressive stress at 10% deformation.

The test specimen is a cube of 50 mm side. In testing compression is carried out at a rate of 10% of the original thickness per minute until the specimen is reduced to 90% of its original thickness.

There is no ASTM equivalent to this method, although it is similar in part to ASTM D 1621-73. The method is also similar to ISO/R844.

8. Tear Strength (Film and Sheet)

ASTM D 1004-66 (1970) Standard Method of Test for
TEAR RESISTANCE OF PLASTIC FILM AND SHEETING (in Part 35, 1974 Annual
Book of ASTM Standards)

This method covers the determination of the tear resistance of flexible plastic film and sheeting at very low rates of loading, 51 mm (2")/min. The test is designed to measure the force to initiate tearing. The specimen geometry of this method produces a stress concentration in a small area of the specimen. The maximum stress, usually found near the outset of tearing, is recorded as the tear resistance in kilograms-force (pounds)

This method is very similar to BS 2782, Method 308A, except that D 1004 has a rate of grip separation of only 2"/min, compared to 11"/min for Method 308A. Also, there is a difference in the number of test specimens tested. Results in D 1004 are expressed in pounds, while in Method 308A they are expressed as force per unit thickness.

BS 2782: Part 3: 1970
Method 308A

TEAR STRENGTH OF FLEXIBLE UNSUPPORTED POLYVINYL CHLORIDE SHEET

This method is for determining the resistance to tearing of flexible polyvinyl chloride sheets (sheeting) by measuring the maximum force required to tear a test specimen in two by the application of tension to its ends and dividing this by the thickness of the specimen. The specimen is so shaped that it tears across its width by the extension of a nick in one of its edges to the other edge.

This method is very similar to ASTM D 1004-66 (1970), except that Method 308A has a grip separation of 11"/min compared to only 2"/min for ASTM D 1004. Also, there is a difference in the number of test specimens tested. Results in Method 308A are expressed as force per unit thickness, while in ASTM D 1004 they are expressed in pounds.

According to Ives, Mead and Riley (1971), this test method is falling into disuse, probably because of the scatter of test results due to the difficulty in making a clean cut at the right angle of the crescent shape.

ASTM D 1922-67 (1972) Standard Method of Test for
PROPAGATION TEAR RESISTANCE OF PLASTIC FILM AND THIN SHEETING (in
Part 35, Annual Book of ASTM Standards)

This method covers the determination of the average force in grams per specimen required to propagate tearing through a specified length of plastic film or non-rigid sheeting. Two specimen types are called for, one a rectangular type, and the other with constant radius testing length. The latter is preferred. The apparatus is the pendulum impulse (Elmendorf) type.

This method is of value in ranking relative tearing resistance of various plastic films and thin sheeting of comparable thickness. Data are expressed as tearing force in grams, with specified thickness also reported. But sets of data specimens of dissimilar thickness are usually not comparable. Therefore, only data at the same thickness can be compared.

This method is similar to BS 2782, Method 308B, except that 308B uses only a rectangular specimen of somewhat different dimensions than D 1922. Also D 1922 reports tearing force in grams, but not per unit thickness, as called for in Method 308B.

BS 2782: Part 3: 1970

Method 308B

RESISTANCE TO TEAR PROPAGATION OF THIN FLEXIBLE SHEET

In this method using the Elmendorf apparatus a determination is made of the average force required to propagate a tear, through a specified distance and from a previously cut slit, on a piece of thin flexible sheet (film). The tearing force is applied by means of a pendulum acting under gravity and of known potential energy. The average force used in tearing the specimen is equal to the energy lost by the pendulum, divided by the distance through which the force is applied. This average force, divided by the thickness of the specimen, is reported as the resistance to tear propagation of the material. However, there is no direct relationship between tearing force and thickness.

This method is similar to ASTM D 1922-67 (1972), except that D 1922 uses two different specimen types, one of which is a rectangle similar to that called for in 308B, but of different dimensions. Also, 308B reports force per unit thickness, while D 1922 reports force alone.

ASTM D 1938-67 (1972) Standard Method of Test for
RESISTANCE TO TEAR PROPAGATION IN PLASTIC FILM AND THIN SHEETING BY
A SINGLE-TEAR METHOD (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the force in grams (ounces or pounds) necessary to propagate a tear in plastic film and thin sheeting (thickness of 1 mm (0.04" or less) by a single-tear method. A rectangular strip 3" long by 1" wide with a clean 2" slit is used for the specimen. This is called a "trouser" type specimen by the British.

This method is similar to BS 2739: 1967, "Thick PVC Sheeting (Flexible, Unsupported)", but the British method uses a much larger specimen and also reports tear strength in lb force/inch thickness, compared to the ASTM method simply reporting force.

BS 2739: 1967

THICK PVC SHEETING (FLEXIBLE, UNSUPPORTED)

(This standard was not supplied, but is reported in Ives, Mead and Riley (1971).)

In this method "trouser-type" specimens are used. Each is 7 x 2" and each has a single cut 3" long made centrally down the longitudinal axis, to give two 1" wide "legs". The results are reported as tear strength - the pounds of force required per unit thickness.

This method is similar to ASTM D 1938-67 (1972) but the ASTM method uses a much smaller specimen and also does not report tear strength on a unit thickness basis.

ASTM D 2582-67 (1972) Standard Method of Test for
RESISTANCE TO PUNCTURE PROPAGATION OF TEAR IN THIN PLASTIC SHEETING
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the dynamic tear resistance of plastic film and thin sheeting subjected to end-use snagging-type hazards. Failures due to snagging hazards occur in a variety of end uses, including industrial bags, liners and tarpaulins. The units measured by this instrument are kilograms-force (tear resistance). Test specimens are cut in any rectangular shape so long as they are approximately 8" long in the direction of tear and can be held by all five clamps of the drop tester.

There is no BS equivalent of this method.

9. Deformation of Plastics Under Load

ASTM D 621-64 Standard Methods of Test for
DEFORMATION OF PLASTICS UNDER LOAD (in Part 35, 1974 Annual Book of
ASTM Standards)

These methods cover the determination of the deformation under compression of nonmetallic sheet and molded plastic materials of all classes and all commercial thicknesses, intended for structural and insulating purposes. Two methods are included as follows:

Method A - for rigid plastics
" B - for nonrigid plastics

Testing is carried out at one or more of the following temperatures:
23°C, 50°C, 70°C.

Method A is essentially that of a parallel plate plastometer - a constant-force system in which a test specimen is conditioned if necessary, and is then placed between the parallel plots of a constant force device and the thickness observed over a required period of time at the stipulated temperature or temperatures. This method is designed to assess the ability of rigid plastics to withstand compressive load, e.g. when held by bolts without yielding and loosening the assembly.

Method B is essentially the same as Method A, except that the pressure is 0.69 MN/n² (100 psi) and the period of test for deformation is 3 hrs. The recovery is based on removing the specimen from compression and allowing it to remain at the stated temperatures for 1 hr and at room temperature for 1/2 hr, after which the amount of recovery is measured. This method is intended to determine the ability of nonrigid plastics to return to their original shape after having been deformed.

There is no close BS equivalent to this parallel plate plastometer method. However, BS methods for measuring deformation in bend of plastics under load include:

BS 2782, Method 102A. "Plastic Yield of Moulding Material" - a cantilever method.

BS 2782, Method 102B. "Deformation in Bend under Load at Elevated Temperature of Laminated Sheet" - also a cantilever method carried out at 90°C.

EFFECTS OF TEMPERATURE

10. Temperature of Deflection under Load

ASTM D 648-72 Standard Method of Test for
DEFLECTION TEMPERATURE OF PLASTICS UNDER FLEXURAL LOAD (in Part 35,
1974 Annual Book of ASTM Standards)

This is historically known as the "heat distortion temperature" method. The method covers the determination of the temperature at which an arbitrary deformation occurs when specimens are subjected to an arbitrary set of testing conditions. It applies to molded and sheet materials available in thickness of 3 mm (1/8") or greater and which are rigid at normal temperature. It is a three-part bending technique. A bar of rectangular cross section is tested as a simple beam with the load applied at its center to give maximum fiber stresses of 455 k Pa (66 psi) or 1820 k Pa (264 psi). The temperature at which the test bar is deflected 0.25 mm (.010") is determined as the deflection temperature under flexural load.

This method is closely equivalent to BS 2782 Methods 102G and 102H (and also DIN 53461). It is also equal to ISO/R75, which was derived from the ASTM method.

BS 2782: Part 1: 1970
Method 102G

TEMPERATURE OF DEFLECTION UNDER LOAD AT 1.81 MN/n^2 (18.5 kgf/cm²)

Similar to ASTM D 648-72 for maximum fiber stress of 1820 k Pa (264 psi).

BS 2782: Part 1: 1970
Method 102H

TEMPERATURE OF DEFLECTION UNDER LOAD AT 0.45 MN/n^2 (4.6 kgf/cm²)

Similar to ASTM D 648-72 for maximum fiber stress of 455 k Pa (66 psi).

11. Softening Temperature of Plastics

ASTM D 1525-70 Standard Method of Test for
VICAT SOFTENING POINT OF PLASTICS (in Part 35, 1974 Annual Book of
ASTM Standards)

This penetrometer method covers determination of the temperatures at which a specified needle penetration occurs when specimens are subjected to specified test conditions. It is useful for many thermoplastic materials. It is not recommended for ethyl cellulose, nonrigid PVC, polyvinylidene chloride, or other materials having a wide Vicat softening range.

The Vicat softening point is the temperature at which a flat-ended needle of 1 mm² circular cross section will penetrate a thermoplastic specimen to a depth of 1 mm under a specified load, using a selected uniform rate of temperature rise.

Two rates of temperature rise are permissible:

Rate A - 50 \pm 5°C/hr
" B - 120 \pm 12°C/hr

The weight load in the needle is 1000 g (1 kg) (+40 - 0 g).

Rate A of this method is approximately equivalent to BS 2782; Method 102D, ISO/R 306 and DIN 53460.

BS 2782: Part 1: 1970
Method 102D
VICAT SOFTENING POINT

This penetration method is for determining the temperature at which a rod with cross-sectional area of 1 mm² penetrates into a specimen to a depth of 1 mm under a load of 9.8 N (1 kgf). The specimen is immersed in a liquid bath, the temperature of which is raised uniformly at a rate of 50°C/hr.

This method is approximately equivalent to ASTM D 1525-70, Rate A.

BS 2782: Part 1: 1970
Method 102F
1/10 VICAT SOFTENING POINT

This penetrometer method is for determining the temperature at which a rod with cross-section area 1 mm² penetrates into a specimen to a depth of .1 mm (instead of 1 mm, as in 102D), under a load of 9.8 N (1 kgf). The specimen is immersed in a liquid bath, the temperature of which is raised uniformly at a rate of 50°C/hr.

This method has no ASTM equivalent because of the reduced penetration. It resembles ASTM D 1525-70, Rate A, in all other respects.

BS 2782: Part 1: 1970

Method 102J

VICAT SOFTENING POINT WITH 49 N (5 kgf) LOAD

The experimental details of this method are essentially the same as those of Method B of ISO/R 306. The load is 5 kgf instead of 1 kgf as in Methods 102D & F.

This method has no ASTM equivalent because of the increased load. It resembles ASTM D 1525-70, Rate A, in all other respects. (ISO/R 306, Method B)

BS 2782: Part 1: 1970

Method 102C

SOFTENING POINT OF THERMOPLASTIC MOULDING MATERIAL (BENDING TEST)

This method is for determining the temperature at which a test specimen in the form of a cantilever deflects through a specified angle. The temperature is increased at a specified rate. The dimensions of the specimen and the applied stress are also specified.

There is no ASTM equivalent of this method, although there is an ASTM Cantilever Method for Stiffness.

12. Melt Flow Index of Thermoplastics (NOTE: It would be better to call this heading "Flow Properties of Thermoplastics" because some of the methods described are not strictly melt flow indexes.)

ASTM D 569-59 (1971) Standard Method of
MEASURING THE FLOW PROPERTIES OF THERMOPLASTIC MOLDING MATERIALS
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the measurement of the following flow properties of thermoplastic molding materials:

Procedure A - The temperature at which a thermoplastic material attains a defined degree of flow when subjected to a prescribed pressure for a prescribed time in a specified extrusion mold.

or

Procedure B - The degree of flow that a thermoplastic material attains when subjected to a prescribed pressure and temperature for a prescribed time in a specified extrusion mold.

This method is the equivalent of BS 2782, Method 105A. According to Ives et al., it is a Rossi-Peakes test.

BS 2782: Part 1: 1970
Method 105A
FLOW TEMPERATURE OF THERMOPLASTIC MOULDING MATERIAL

This method is for measuring the temperature at which a thermoplastic molding material flows a specified distance under a specified pressure when tested in a standard apparatus. Determinations of flow temperature are used for clarifying molding materials and for checking uniformity of quality.

This method, a Ross-Peakes test, according to Ives et al., is the equivalent of ASTM D 569-59 (1971).

ASTM D 1238-73 Standard Method of
MEASURING FLOW RATES OF THERMOPLASTICS BY EXTRUSION PLASTOMETER
(in Part 35, 1974 Annual Book of ASTM Standards)

This method covers measurement of the rate of extrusion of molten resins through a die of specified length and diameter under prescribed conditions of temperature, load and piston position in the barrel as the timed measurement is being made. The method is particularly useful for quality control tests in thermoplastics having relatively low melt viscosities.

Procedure A - a manual cut-off operation used for materials having flow rates that fall between 0.15 and 50 g/10 min.

Procedure B - an automatically-timed flow rate measurement used for materials having flow rates from 0.50 to 300 g/10 min.

This method is very similar to BS 2782, Method 105C, except that the British method reports the results in different units than the ASTM method. The ASTM method employs only one jet diameter, but a range of temperatures and loads, according to whichever of a large number of thermoplastics are being tested.

BS 2782: Part 1: 1970

Method 105C

MELT FLOW INDEX OF POLYTHENE AND POLYTHENE COMPOUNDS

This method is for determining the fluidity of molten polyethylene and molten polyethylene compounds in arbitrary units based upon the amount extruded in 10 min. through a standard jet (Jet A) under a specific pressure (given by load A) and at 190°C.

Three procedures are described, the choice being dependent on the melt flow index (MFI) of the material under test:

Procedure A - with Jet A & Load A
for materials between 1 - 25 (& unknown) MFI

Procedure B - with Jet B and Load A
for materials between 25 - 250 MFI

Procedure C - with Jet A and Load C
for materials with MFI less than 1

This method is very similar to ASTM D 1238-73. The BS method, however, is restricted to polyethylene and polyethylene compounds. Only one temperature is used in the BS method (190 ± 5°C), compared to a number in the ASTM method.

13. Flammability

ASTM D 568-74 Standard Method of Test for
FLAMMABILITY OF FLEXIBLE PLASTICS (in Part 35, 1974 Annual Book of
ASTM Standards)*

This method covers a small-scale laboratory screening procedure for comparing the relative flammability of plastics in the form of flexible, thin sheets or films, tested in the vertical position. The method should be used to establish the relative burning characteristics of plastic materials and should not be used as a fire hazard test method.

A specimen of plastic, of standard length and width, the thickness of the sample as furnished, is suspended vertically and exposed to a gas flame at its lower end. Time and extent of burning are measured and reported if the specimen does not burn 38 cm. An average burning rate is reported if the specimen burns to the 38 cm mark.

There is no comparable BS method, although there is some similarity to BS 2782, Method 508B, also a vertical strip test.

ASTM D 229-72 Standard Method of Testing
RIGID SHEET AND PLATE MATERIALS USED FOR ELECTRICAL INSULATION
(in Part 35, 1974 Annual Book of ASTM Standards)

This method contains a test for flammability and flame resistance using: a slightly modified version of ASTM D 635-74. Two methods are given:

Method I - (Flammability) - A relatively simple test that requires inexpensive apparatus. It is intended primarily as a control test and for quickly screening materials that are flame-resistant from a population of various types.

Test specimens 5" x 1/2" x actual thickness
Test by ASTM D 635, with some modification

Method II - (Flame Resistance) - Intended primarily for use with materials that would be found non-burning or self-extinguishing, or both, by Method I. The equipment specified in Method II, which is relatively complex, allows more precise control of test conditions than Method I.

Test specimens - 1/2" x 1/2" x 10", or use nominal unmachined tolerance for thickness

Ignition Time - elapsed time in seconds required to produce ignition under conditions of this method.

*ASTM in September 1976 revised this specification and changed the title and designation as follows: ASTM D 568-76, Standard Method of Test for RATE OF BURNING AND/OR EXTENT AND TIME OF BURNING OF FLEXIBLE PLASTICS IN A VERTICAL POSITION.

Burning Time - elapsed time that the specimen burns after removal of the ignition heat source under conditions of this method.

Apparatus includes a flame cabinet, control cabinet, pyrometer, coil form, and coil spacing gage.

There is no BS equivalent of this method.

ASTM D 635-74 Standard Method of Test for
FLAMMABILITY OF SELF-SUPPORTING PLASTICS (in Part 35, 1974 Annual Book
of ASTM Standards)*

This method covers a small-scale laboratory screening procedure for comparing the relative flammability of self-supporting plastics in the form of bars, molded or cut from sheets, plates or panels, tested in the horizontal position. This method should be used to establish relative burning characteristics of plastic materials and should not be used as a fire hazard test method.

A bar of the material to be tested is supported horizontally at one end. The free end is exposed to a specified gas flame for 30 seconds. Time and extent of burning are measured and reported if the specimen does not burn 102 mm. An average burning rate is reported for a material if it burns to the 100 mm mark from the ignited end.

A test chamber, ring stand, and Bunsen burner are used.

The specimens are 125 mm long x 12.5 mm wide.

This method is very similar to BS 2782, Method 508A and UL94 Horizontal Burning Test for Classifying Materials 94 HB.

BS 2782: Part 5: 1970
Method 508A
RATE OF BURNING

In this method a strip of material is held horizontally with its transverse axis at an angle of 45° to the horizontal. A flame is applied for a short time to the free end of the strip and after its removal the time is taken for the flame of the burning specimen to travel a distance of 100 mm (4"). The rate of burning is expressed as the distance traveled by the flame in 1 minute. If the flame travels less than 100 mm (4") before going out, the material is reported as resistant to flame propagation, but if the material does not burn after the igniting flame has been removed and shows virtually no afterglow it is reported as self-extinguishing. The method can be used for cellulose acetate molding material.

This method is very similar to ASTM D 635-74.

*ASTM in July 1976 changed the title and designation as follows: ASTM D 635-76, Standard Method of Test for RATE OF BURNING AND/OR EXTENT AND TIME OF BURNING OF SELF-SUPPORTING PLASTICS IN A HORIZONTAL POSITION.

ASTM D 757-74 Standard Method of Test for
INCANDESCENCE RESISTANCE OF RIGID PLASTICS (in Part 35, 1974 Annual
Book of ASTM Standards)

This method provides for laboratory comparisons of the resistance of rigid plastics to an incandescent surface at $950 \pm 10^{\circ}\text{C}$. It may supplement tests using a flame source of ignition, such as ASTM D 635.

This method is essentially identical to BS 2782, Method 508E, except that the weight loss is not recorded in the ASTM method.

BS 2782: Part 5: 1970
Method 508E
INCANDESCENCE RESISTANCE OF RIGID THERMOSETTING PLASTICS

The experimental details of Method 508E are the same as those of ISO/R181, "Determination of Incandescence Resistance of Rigid Self-Extinguishing Thermosetting Plastics". In this method the end of a rectangular bar of the material under test is held for 3 minutes against an electrically-heated silicon carbide rod material at 950°C . The loss of mass of the test specimen and the length of the part that has been burned away or scorched) are determined and are jointly used for the evaluation of incandescence resistance.

This record is essentially identical to ASTM D 757-74 except that in the BS the weight loss is recorded. (Also identical to ISO/R181)

ASTM D 1433-74 Standard Method of Test for
FLAMMABILITY OF FLEXIBLE THIN PLASTIC SHEETING (in Part 35, 1974
Annual Book of ASTM Standards) *

This method covers the determination of the relative flammability of flexible plastics in the form of film or thin sheeting. Materials that shrink excessively upon ignition, or that melt to cause the flame to be carried away while dripping, cannot be evaluated by this method. Although the test is primarily intended for nonrigid plastic films, it may be used on rigid or nonrigid sheeting which can be bent through the 45° angle specified in the test procedure.

The specimens are 3" (76mm) x 9" (228 mm) and five are used in each material direction. The specimen is mounted in a special holder in a carefully specified cabinet with two nylon threads running across the specimen as gauge lines. These threads are connected to microswitches so that, when the flame front of the ignited specimen reaches the first thread and it burns through, the microswitch is activated to start a timing mechanism, and when the second nylon thread is reached, its microswitch stops the timer. By this means the average rate of burning between the gauge marks (6" apart) is measured.

There is no comparable BS method.

*ASTM in July 1976 changed the title and designation as follows: ASTM D 1433-76, Standard Method of Test for RATE OF BURNING AND/OR EXTENT AND TIME OF BURNING OF FLEXIBLE THIN PLASTIC SHEETING SUPPORTED ON A 45° INCLINE.

ASTM D 1692-74 Standard Method of Test for
RATE OF BURNING OR EXTENT OF BURNING OF CELLULAR PLASTICS USING A
SUPPORTED SPECIMEN BY A HORIZONTAL SCREEN (in Part 35, 1974 Annual
Book of ASTM Standards)*

This method covers a small-scale horizontal laboratory screening procedure for measuring the rate of burning or extent of burning of rigid or flexible cellular plastics. Materials that exhibit pronounced shrinking, curling or melting away upon heating cannot be evaluated by this test. The method is not applicable to materials that cannot be ignited under the conditions of this test, or to materials that exhibit progressive combustion without flame (continued glowing or charring).

The method employs ten specimens 5.1 x 15.2 cm (2 x 6"), with a normal thickness of 1.3 cm (1/2") or under, or cut to this value if over.

This method has no BS counterpart, although it has some resemblance to BS 2782, Method 508A for Rigid Plastics.

ASTM D 1929-68 Standard Method of Test for
IGNITION PROPERTIES OF PLASTICS (in Part 35, 1974 Annual Book of
ASTM Standards)

This method covers a laboratory determination of the self-ignition and flash-ignition temperatures of plastics using a hot-air ignition furnace. Three criteria are measured: flash ignition temperature, self-ignition temperature, and self ignition by temporary glow. Specimens (3 g) are molding pellets, or 2 cm x 2 cm pieces of sheet or molding, bound together by fine wire.

Similar in principle is ISO/R871, "Plastics, Determination of the Temperature of Evolution of Flammable Gases from Plastics", where, however, the decomposition temperature is defined as the lowest temperature at which the flash point type of igniting flame causes ignition of evolved gases to last at least 5 seconds.

There are no comparable BS methods.

ASTM D 2843-70 Standard Method for
MEASURING THE DENSITY OF SMOKE FROM THE BURNING OR DECOMPOSITION OF
PLASTICS (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers laboratory procedure for measuring and observing the relative amounts of smoke produced by the burning or decomposition of plastics. It is intended to be used for measuring the smoke-producing characteristics of plastics under controlled conditions of combustion or decomposition. Correlation with other fire conditions is not

*ASTM in July 1976 changed the title and designation as follows: ASTM D 1692-76, Standard Method of Test for RATE OF BURNING AND/OR EXTENT AND TIME OF BURNING OF CELLULAR PLASTICS USING A SPECIMEN SUPPORTED BY A HORIZONTAL SCREEN. Currently this standard is in the process of being withdrawn.

necessarily implied. The measurements are made in terms of the loss of light transmission through a collected volume of smoke produced under controlled, standardized conditions. The apparatus is constructed so that the flame and smoke can be observed during the test.

Two indexes are used to rate the material: maximum smoke produced, and the smoke density rating.

There are no comparable BS methods.

ASTM D 2863-74 Standard Method of Test for
FLAMMABILITY OF PLASTICS USING THE OXYGEN INDEX METHOD (in Part 35,
1974 Annual Book of ASTM Standards) *

This method describes a procedure for determining the relative flammability of plastics by measuring the minimum concentration of oxygen in a flowing mixture of oxygen and nitrogen that will just support flaming combustion. The method can be used for various forms of plastic, including film and cellular plastic. (NOTE: oxygen index values are now reported widely in the U.S. literature, including technical bulletins issued by plastics manufacturers on their products.)

There are no comparable BS methods.

ASTM D 3014-74 Standard Method of Test for
FLAMMABILITY OF RIGID CELLULAR PLASTICS (in Part 35, 1974 Annual Book
of ASTM Standards)

This method covers a small-scale laboratory screening procedure for comparing relative flammability of rigid cellular plastics. The method should be used solely to establish relative burning characteristics and should not be considered or used as a fire hazard classification.

The specimen is mounted on a vertical chimney with a glass front and ignited with a brush burner for 10 seconds. The height and durability of flame and the weight percent retained by the specimen are recorded.

This is a vertical method, compared to ASTM D 1692, a horizontal method. It is particularly useful for further investigation of materials which show only a short extent of burning by Method D 1692. The method has also been used for flexible cellular materials and other plastics, but no detailed studies have been carried out to determine its applicability to these materials.

There is no comparable BS method.

*ASTM in September 1976 changed the title and designation as follows: ASTM D 2863-76, Standard Method of Test for MINIMUM OXYGEN CONCENTRATION TO SUPPORT CANDLE-LIKE COMBUSTION OF PLASTICS (OXYGEN INDEX).

UL*94 TESTS FOR FLAMMABILITY OF PLASTIC MATERIALS FOR PARTS
(2nd Edition IN DEVICES AND APPLIANCES
May 2, 1975) * Underwriters Laboratories (US)

HORIZONTAL BURNING TEST FOR CLASSIFYING MATERIALS 94HB

This method is very similar to ASTM D 635 and BS 2782, Method 508A.

VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS 94 V-0, 94 V-1, or 94 V-2

This method is very similar to ASTM D 568-74, and has some similarity to BS 2782, Method 508D.

HORIZONTAL BURNING TEST FOR CLASSIFYING FOAMED MATERIALS 94 HBF, 94 HF-1 or 94 HF-2

This method is somewhat similar to ASTM D 3014. There is no comparable BS method.

VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS 94 5V

In this test with strips the burner is held 20° from the vertical at the lower end of the specimen. The test is also carried out with plaques.

There is no ASTM nor BS method comparable.

FLAME SPREAD INDEX TEST USING RADIANT PANEL

This method is identical to ASTM E 162-67 (1973), Test for SURFACE FLAMMABILITY OF MATERIALS USING A RADIANT HEAT ENERGY SOURCE. This ASTM method has not been listed above because it is not strictly a plastics method, but covers a wide variety of construction materials.

This method employs a radiant heat source consisting of a 12 x 18" (305 x 457 mm) panel in front of which an inclined 6 x 18" (152 x 457 mm) specimen of the material is placed. The orientation of the specimen is such that ignition is forced near its upper edge and the flame front progresses downward.

There is no comparable BS method.

BS 2782: Part 5: 1970
Method 508B

DEGREE OF FLAMMABILITY OF POLYVINYL CHLORIDE EXTRUSION COMPOUND

In this method a specimen 9" long x 1" wide cut from molded sheet and marked in 1/2" squares is affixed to a shield 12" square and 30" high and open at the top. The shield is fitted with vents and glass windows. A piece of celluloid is attached to the bottom of the

specimen and ignited. The time required for the flame to extinguish itself or completely to burn the test specimen is determined. The area of burning is also calculated.

There is no comparable ASTM method although there is some resemblance to ASTM D 568-74, a vertical strip test.

BS 2782: Part 5: 1970

Method 508C

DEGREE OF FLAMMABILITY OF THIN POLYVINYL CHLORIDE SHEETING

In this method a strip of the material is stretched in the form of an inverted "U" over a suitable frame. One end of the strip is subjected to the flame from a small specified volume of burning alcohol. The degree of flammability of the material is assessed by measuring the distance over which the strip is burned or charred under these conditions.

There is no comparable ASTM method.

BS 2782: Part 5: 1970

Method 508D

FLAMMABILITY (ALCOHOL CUP TEST)

In this method a specimen 150 mm (6") square and not exceeding 50 mm (2") in thickness is supported so that its major plane is at an angle of 45° with the horizontal. The specimen is subjected to a flame produced by burning a specified quantity of alcohol in a small cup, the flame impinging upon the middle of the lower side of the sheet. The material is judged to be flammable, of low flammability, or of very low flammability, by criteria that include the amount of charring of the surface of the specimen and the duration of flaming or glowing. This test is suitable for materials that cannot be tested by Methods 508A, 508B, or 508C, particularly those that are light or bulky. It is not suitable for testing materials that melt rather than char.

There is no comparable ASTM method.

BS 2782: Part 5: 1970

Method 508E

INCANDESCENCE RESISTANCE OF RIGID THERMOSETTING PLASTICS

Discussed above after the entry for ASTM D 757-44, to which it is essentially identical.

14. Coefficient of Thermal Expansion

ASTM D 696-70 Standard Method of Test for
COEFFICIENT OF LINEAR THERMAL EXPANSION (in Part 35, 1974 Annual
Book of ASTM Standards)

This method covers determination of the coefficient of linear thermal expansion for plastics by means of a vitreous silica dilatometer. At the test temperatures and under the stress imposed, the plastic materials shall have a negligible creep or elastic strain rate or both, insofar as these properties could significantly affect the accuracy of the measurements.

This method is experimentally very similar to that of BS 4618: Section 3.1: 1970, "Recommendations for the Presentation of Plastics Data", Part 3 Thermal Properties, Section 3.1 Linear Thermal Expansion, except that there is a difference in method of reporting. The ASTM method calls for calculation of the coefficient of expansion over the temperature range used, while the BS method calls for a plot of % thermal expansion vs temperature.

BS 4618: 1920
Recommendations for the Presentation of Plastics Data, Part 3. Thermal Properties
Section 3.1 APPENDIX A
LINEAR THERMAL EXPANSION

This method is experimentally very similar to that of ASTM D 696-70, except that there is a difference in method of reporting. The ASTM method calls for calculation of the coefficient of expansion over the temperature range used, while the BS method calls for a plot of % thermal expansion vs temperature.

ASTM D 864-52 (1971) Standard Method of Test for
COEFFICIENT OF CUBICAL THERMAL EXPANSION OF PLASTICS (in Part 35,
1974 Annual Book of ASTM Standards)

This method uses a glass dilatometer.

There is no comparable BS method.

15. Thermal Conductivity

ASTM C 177-71 Standard Method of Test for
THERMAL CONDUCTIVITY OF MATERIALS BY MEANS OF THE GUARDED HOT PLATE
(in Part 18, 1974 Annual Book of ASTM Standards)

This method covers the determination of the existing thermal conductivity of dry specimens of insulating, building and other materials during thermal conductance not exceeding $60 \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}$ and specified thicknesses. Two different types of guarded hot plate apparatus are used.

Guarded hot plate methods, widely used for low conductivity measurements, are not used extensively for solid plastics partly because the guarding is less effective under higher conductivity methods and partly because the simpler plain heater plate methods are fairly satisfactory anyway.

This method is very similar to Clause 10a, Thermal Conductivity - for Materials of Moderate or Low Thermal Conductivity, in BS 874: 1965, "Methods of Determining Thermal Properties with Definitions of Thermal Insulating Terms," and specifically for cellular plastics, to BS 4370 "Methods of Test for Rigid Cellular Materials": 1973, Method 7.

ASTM C 518-70 Standard Method of Test for
THERMAL CONDUCTIVITY OF MATERIALS BY MEANS OF THE HEAT FLOW METER
(in Part 18, 1974 Annual Book of ASTM Standards)

According to Ives *et al.*, this is the only U.S. test suitable for solid plastics. It is essentially a comparative method said to be suitable for temperatures between -45°C and $+540^{\circ}\text{C}$ (approx.). In essence the apparatus consists of a single cold plate and a plain hot plate with the material under test and a prepared specimen of known conductivity sandwiched in between.

There is no comparable BS method.

BS 874: 1965 Methods for Determining Thermal Properties, with
Definitions of Thermal Insulating Terms
Section 4. Methods for Determining Thermal Properties
Clause 10. THERMAL CONDUCTIVITY
10a. For materials of moderate or low thermal conductivity

This is a guarded hot-plate technique, very similar to ASTM C 177-71. It is also essentially identical to BS 4370, Method 7, for cellular plastics.

BS 4370: 1973 Methods of Test for Rigid Cellular Materials
Part 2
Method 7. MEASUREMENT OF THERMAL CONDUCTIVITY (GUARDED HOT PLATE METHOD)

This procedure uses BS 874, Clause 10a, with slight modification. It is comparable to ASTM C 177-71.

16. Low Temperature Properties

ASTM D 746-73 Standard Method of Test for
BRITTLINESS TEMPERATURE OF PLASTICS AND ELASTOMERS BY IMPACT (in
Part 35, 1974 Annual Book of ASTM Standards)

This method determines the temperature at which 50% of test specimens fail under conditions of the test. Two calculation methods are described, a Standard Method and an Alternate Graphic Method.

According to Ives et al., this method is very similar to BS 903: Part A 25: 1968, "Methods of Testing Vulcanised Rubber, Part A 25. Determination of Impact Brittleness Temperature" (not seen), where the test piece and equipment are essentially the same, but the brittleness temperature is defined differently.

ASTM D 759-66 (1970) Standard Recommended Practice for
DETERMINING THE PHYSICAL PROPERTIES OF PLASTICS AT SUBNORMAL AND
SUPERNORMAL TEMPERATURES (in Part 35, 1974 Annual Book of ASTM
Standards)

This recommended practice is for determining the physical properties of plastics by means of appropriate ASTM test methods, at temperatures from -269 to +550°C (-452 to +1022°F). No test methods are given.

There is no comparable BS method.

ASTM D 1043-72 Standard Method of Test for
STIFFNESS PROPERTIES OF PLASTICS AS A FUNCTION OF TEMPERATURE BY MEANS
OF A TORSION TEST (in Part 35, 1974 Annual Book of ASTM Standards)

This method covers the determination of the stiffness characteristics of plastics over a wide temperature range by direct measurement of the apparent modulus of rigidity, G , sometimes called the shear modulus of elasticity. This is a variant of the Clash and Berg apparatus.

BS 2782 Methods 104B and 104D use the apparatus described in this method, although each is for a specialized set of conditions.

ASTM D 1593-61 (1969) Standard Specification for
NONRIGID VINYL CHLORIDE PLASTIC SHEETING (in Part 36, 1974 Annual Book
of ASTM Standards)

This specification covers a type of vinyl chloride plastic sheeting, Paragr. 8.1.10 on Low Temperature Impact specifies a test method using an impact machine made of cold-rolled steel, except for the bolts, screws and rubber stopper. Specimens are cut 2" x 5 3/4" and folded lengthwise with a normal loop at RT. The specimen is in contact with a card. In the apparatus resembling a stapling machine, the free end is allowed to fall onto the test loop. The test temperature is -18 to

-20°C (0 to -2°F) for calendered and extruded sheeting and -10 to -12°C (+14 to +12°F) for cast sheeting.

There is no comparable BS. The method is similar to that used for film in ASTM D 1790-62 (1970).

ASTM D 1709-67 (1972) Standard Methods of Test for
IMPACT RESISTANCE OF POLYETHYLENE FILM BY THE FREE FALLING DART
METHOD (in Part 36, 1974 Annual Book of ASTM Standards)

These methods cover the determination of the energy that causes polyethylene film to fracture under specified conditions of impact of a free-falling dart. Two test methods are used, depending upon the strength of the polyethylene films.

Method A - used for impact strengths of 300 g or less.

Method B - " " " " of greater than 300 g up to about 1300 g.

Both are dart methods, but Method B has a larger dart. Methods A & B are used to establish the weight of the dart when 50% of the specimens fail under the conditions specified. As in ASTM D 746-73, two calculation methods are described, a Standard Method and an Alternate Graphic Method.

Ordinarily this method is used at room temperature, but other temperatures (as low temperatures) may be specified.

Method A is approximately equivalent to BS 2782, Method 306F.

BS 2782: Part 3: 1970

Method 306F

IMPACT RESISTANCE OF FLEXIBLE FILM WITH FALLING DART

This method is for measuring the toughness of thin flexible sheet (film up to 0.3 mm (.012") thick. A dart with a hemispherical head is dropped from a specified height on to a disc of film 127 mm (5") in diameter formed by clamping the film across an annular specimen holder. The impact resistance is the mass in grams of the dart that would be expected to break half of a large number of test specimens. The weight falls through 660 mm (26").

The test is normally carried out at room temperature, but other temperatures, as low temperatures, may be specified.

This method is approximately equivalent to ASTM D 1709-67, Method A.

ASTM D 1790-62 (1970) Standard Method of Test for
BRITTLINESS TEMPERATURE OF PLASTIC FILM BY IMPACT (in Part 36, 1974
Annual Book of ASTM Standards)

This method covers the determination of that temperature at which plastic film 0.25 mm (10 mils) or less in thickness exhibits a brittle failure under specified impact conditions. Strip specimens are cut with the 2" x 5 3/4" die and tested by allowing an impact arm to fall onto a fold in the specimen. The brittleness temperature is that temperature where 50% of the specimens would fail 95% of the time when a stated minimum number are tested by this method. Two methods of calculation are used, a Standard Method, and an Alternate Graphic Method.

The method is similar to the method prescribed for low temperature impact of plastic sheeting in ASTM D 1593-61 (1969).

There is no comparable BS.

BS 2782: Part 1: 1970

Method 104A

COLD BEND TEMPERATURE OF FLEXIBLE POLYVINYL CHLORIDE EXTRUSION COMPOUND

This is a flex cracking method. The method measures the lowest temperature, measured in multiples of 5°C, at which none of a set of three test specimens fractures or cracks when wound onto a standard mandrel.

There is no comparable ASTM method.

BS 2782: Part 2: 1970

Method 104B

COLD FLEX TEMPERATURE OF FLEXIBLE POLYVINYL EXTRUSION COMPOUND

This torsional stiffening method is for assessing the effect of low temperature on the stiffness of polyvinyl chloride compounds by measuring the temperature at which a test specimen is twisted through an angular displacement of 200° by a specified torque. The method is a variant of the Clash and Berg apparatus.

ASTM D 1043-72 is a general method which uses the apparatus specified in this method. BS 2782 Method 104D uses the same test method after the test specimens have been heated at 100°C for 24 hrs over activated carbon to assess resistance to aging.

BS 2782: Part 1: 1970

Method 104C

LOW TEMPERATURE EXTENSIBILITY OF FLEXIBLE POLYVINYL CHLORIDE SHEET

This method measures the extensibility in tension at specified temperature (-5°C). The method is used for PVC sheets not exceeding 0.9 mm (0.035") in thickness.

There is no comparable ASTM method.

BS 2782: Part 1: 1970

Method 104D

COLD FLEX TEMPERATURE AFTER AGEING OF FLEXIBLE POLYVINYL CHLORIDE EXTRUSION COMPOUND

In this method the cold flex temperature test described in Method 104B is applied to flexible PVC compound after it has been through a process of heating for 24 hrs at 100°C over activated carbon under the conditions of Method 107F. A comparison of the cold flex temperature so obtained with that obtained in material that has not been subjected to a heating process gives an indication of the likelihood of the material to deteriorate in service through loss of plasticizer.

There is no comparable BS method (except see comments under Method 104B).

MISCELLANEOUS

17. Conditioning Plastics and Electrical Insulating Materials for Testing

ASTM D 618-61 (1971) Standard Methods of
CONDITIONING PLASTICS AND ELECTRICAL INSULATING MATERIALS FOR TESTING
(in Part 35, 1974 Annual Book of ASTM Standards)

This is a general discussion of ASTM requirements for conditioning subject materials before testing. Detailed information is given for achieving required temperatures and humidities. Standard Laboratory Temperature is defined as 23°C (73.4°F) with a normal tolerance of $\pm 2^\circ\text{C}$ ($\pm 3.6^\circ\text{F}$) and a closer tolerance of $\pm 1^\circ\text{C}$ ($\pm 1.8^\circ\text{F}$) if required. Standard Laboratory Atmosphere is defined as an atmosphere with the standard laboratory temperature and a relative humidity of 50%, the latter with a normal tolerance of $\pm 5\%$, and a closer tolerance of $\pm 2\%$ when required.

There is no comparable BS method. As Ives *et al.* point out, "There is no one standard condition for plastics testing, for example, even in BS 2782, and the relevant individual materials and products specifications must be consulted for details of the levels of temperature and humidity to be used in each case. As stated previously, at the moment these may vary from one document to another, but, as new standards are produced or old ones revised, the levels are generally being reconciled with ISO recommendations."

18. Surface Irregularities of Flat Transparent Plastics Sheets

ASTM D 637-50 (1970) Standard Method of Test for
SURFACE IRREGULARITIES OF FLAT TRANSPARENT PLASTICS SHEETS (in Part 35,
1974 Annual Book of ASTM Standards)

This method covers the measurement of the surface irregularities of flat transparent plastic sheets that are ordinarily used to cover openings through which visual and instrumental observations are made. The method measures the distortion and the deviation of line of sight through flat sheets of transparent plastics. The method makes use of the prismatic or optical wedge deflection of a beam of light as it passes through a distortion spot or wave in the body of or on the surface of the material being inspected.

There is no comparable BS method. It should be noted that this method is the responsibility of ASTM Committee D-20, Subcommittee D20.40 on Optical Properties. For this reason, and considering its content, it should be listed under Optical Properties rather than Miscellaneous.

19. Specific Gravity and Density of Plastics by Displacement

ASTM D 792-66 (1970) Standard Methods of Test for
SPECIFIC GRAVITY AND DENSITY OF PLASTICS BY DISPLACEMENT (in Part 35,
1974 Annual Book of ASTM Standards)

These methods cover the determination of the specific gravity and density of solid plastics by displacement of liquid and determination of the change in weight. The methods are as follows:

Method A-1. For testing solid plastics in water (specimens 1 - 50 g). Suitable for plastics that are wet by, but not otherwise affected by water. Also the plastics must be lighter than water.

Method A-2. For testing solid plastics in liquids other than water (specimens 1 - 50 g). Used for plastics that are affected by water or which are lighter than water. Uses a pycnometer.

Method A-3. For testing solid plastics (specimens > 50 g). Suitable for plastics to be tested by immersion of the entire item - nondestructively. Any appropriate liquid may be used.

Method B. For testing molding powders, pellets and flake, using a pycnometer.

Method A-1 is essentially the same as BS 2782, Method 509A. Among other slight differences, the BS method is for samples of not less than 5 g mass, while the ASTM method permits samples down to 1 g. Methods A-2 and A-3 have no close counterparts.

Method B has no BS counterpart.

BS 2782: Part 5: 1970
Method 509A
DENSITY OF SOLID PLASTICS

This method is for determining the density in grams per milliliter of solid plastics materials at $20 \pm 2^{\circ}\text{C}$ or at $23 \pm 2^{\circ}\text{C}$. In this method the relative density of a specimen is found by the conventional method of weighing in air and in water, but the results of the determination are reported as density, the error so introduced being negligible for most purposes.

This method is essentially identical to ASTM D 792-66 (1970), Method A-1, but the ASTM method determines the mass of the wire under partially immersed conditions and gives the actual density of water at the test temperature (23°C) for a more accurate result to be calculated. The ASTM method is for specimens of 1 - 50 g.

20. Density of Plastics by the Density-Gradient Technique

ASTM D 1505-68 Standard Method of Test for
DENSITY OF PLASTICS BY THE DENSITY GRADIENT TECHNIQUE (in Part 35,
1974 Annual Book of ASTM Standards)

This method covers determination of the density of solid plastics, including films. The method is based on observing the level to which a test specimen sinks in a liquid column exhibiting a density gradient, in comparison with standards of known density.

The method is similar to BS 2782, Method 509B, although the BS is for polyethylene film only, while the ASTM method is general for solid plastics, including film.

BS 2782: Part 5: 1970

Method 509B

DENSITY OF POLYTHENE FILM USING DENSITY GRADIENT COLUMN

In this method a test specimen of PE film is allowed to float in a column of liquid the density of which increases uniformly from top to bottom. The position at which the specimen comes to rest indicates its density.

The method is comparable to ASTM D 1505-68, which covers all solid plastics, including film.

21. Apparent Density, Bulk Factor, and Pourability of Plastic Materials

ASTM D 1895-69 Standard Methods of Test for
APPARENT DENSITY, BULK FACTOR, AND POURABILITY OF PLASTIC MATERIALS
(in Part 35, 1974 Annual Book of ASTM Standards)

These methods cover the measurement of apparent density, bulk factor and, where applicable, the pourability of plastic materials such as molding powders. Different procedures are given for application to the various forms of these materials that are commonly encountered, from fine powders and granules to large flakes and cut fibers.

Apparent Density

Method A - for fine granules and powders that can be poured readily through a small funnel.

Method B - for coarse, granular materials, including dice and pellets, that either cannot be poured, or that pour with difficulty through a small funnel.

Method C - for coarse flakes, chips, cut fibers or strands that cannot be poured through the funnels described in Methods A & B. These materials are bulky when loosely poured and are usually compressible, so a measure of their density under a small load is appropriate and useful.

Bulk Factor

Determined as a ratio of average apparent density prior to molding or forming, and the average density of the molded or formed specimen.

Pourability

The funnel used in Method A is used to measure the time required to pass through a sample weighing 100 times its density, in grams, after molding or forming.

For apparent density, Method A of this method is similar, but differs somewhat from ISO/R60 and BS 2782, Method 501A in the dimensions and shape of the funnel, the measuring cylinder, and the mounting of the funnel. The results can be expected to differ by -0.01 to +0.03 apparent density units, according to the ASTM method.

Method B of this method has no BS equivalent.

Method C of this method is essentially identical with ISO/R61, which is the same as BS 2782, Method 501B and DIN 53467. All are for coarse flakes, chips, fibers and strands which cannot be poured through the funnels described in Methods A and B. The funnels are measuring cylinders somewhat different in the two methods.

The bulk factor method in ASTM D 1895-69 is comparable to BS 2782, Method 501C and DIN 53466.

The pourability procedure in ASTM D 1895-69 has no BS equivalent.

ASTM D 1457-73 Standard Specification for
TFE-FLUOROCARBON RESIN MOLDING AND EXTRUSION MATERIALS (in Part 36,
1974 Annual Book of ASTM Standards)

This is a materials specification, but it provides a procedure for determining Apparent Density of polytetrafluoroethylene, which, because of the nature of the particles, is not capable of being measured by ASTM D 1895-67. The method is a variant of the funnel technique.

This method has no BS equivalent.

BS 2782: Part 5: 1970
Method 501A
APPARENT DENSITY OF MOULDING MATERIAL THAT CAN BE Poured FROM A FUNNEL

This method describes the procedure for determining the apparent density, i.e. the mass per unit volume, of loose molding material that can be poured from a funnel of specified design.

This method is similar to ISO/R60 and somewhat similar to ASTM D 1895-69, although the dimensions and shape of the funnel, the measuring cylinder and the mounting of the funnel are somewhat different. The results can be expected to differ by -0.01 to +0.03 apparent density units, according to the ASTM method.

BS 2782: Part 5: 1970
Method 501B
APPARENT DENSITY OF MOULDING MATERIAL THAT CANNOT BE Poured FROM
A FUNNEL

This method is for determining the apparent density, i.e. the mass per unit volume, of loose molding material that cannot be poured from the funnel specified in Method 501A.

This method is essentially identical with ASTM D 1895-69 and ISO/R61. The funnel is slightly different and the measuring cylinder much smaller in the BS method.

BS 2782: Part 5: 1970
Method 501C
BULK FACTOR OF MOULDING MATERIAL

This method gives the procedure for calculating the bulk factor of a molding material from its apparent density in the unmolded form and its density in the molded form.

This method is identical in experimental details to ISO/R171 and is comparable to ASTM D 1895-69 and DIN 53466.

22. Apparent Density of Rigid Cellular Plastics

ASTM D 1622-63 (1970) Standard Method of Test for APPARENT DENSITY OF RIGID CELLULAR PLASTICS (in Part 36, Annual Book of ASTM Standards)

This method covers the determination of the apparent density of cellular materials. It is intended primarily for rigid cellular plastics. The method involves measuring the dimensions of a simple shape whose volume can be calculated. The specimen is then weighed on an analytical balance.

This method is equivalent to BS 4370, Method 2 and ISO/R845. The ASTM method uses English units however, but gives a conversion factor to obtain the metric units.

BS 4370: Part 1: 1968 (Methods of Test for Rigid Cellular Materials) Method 2
DETERMINATION OF APPARENT DENSITY

This method covers a procedure for determining the apparent density of a rigid cellular material. It utilizes a balance and a means for measuring the dimensions of the specimen.

This method is equivalent to ASTM D 1622-63 (1970) and ISO/R845. The BS method, however, uses metric units, while the ASTM method uses English units, although a conversion factor is given.

23. Oven Heat Stability

ASTM D 2115-67 (1974) Standard Recommended Practice for OVEN HEAT STABILITY OF POLY(VINYL CHLORIDE) COMPOSITIONS (in Part 36, 1974 Annual Book of ASTM Standards)

This recommended practice lists procedures for determining the relative thermal stability of sheet or molded poly(vinyl chloride) compounds as indicated by discoloration due to exposure to an elevated temperature at controlled oven conditions.

There is no comparable BS method. This method is the equivalent of ISO/R305.

ELECTRICAL TESTS

24. Dielectric Strength

ASTM D 149-64 (1970) Standard Methods of Test for DIELECTRIC BREAKDOWN VOLTAGE AND DIELECTRIC STRENGTH OF ELECTRICAL INSULATING MATERIALS AT COMMERCIAL POWER FREQUENCIES (in Part 39, 1975 Annual Book of ASTM Standards)

Dielectric strength is called electric strength in the U.K. These blanket methods cover the determination of dielectric strength of electrical insulating materials at commercial power frequencies. Since some materials require special treatment, reference is made in an appendix to 47 ASTM methods applicable to the material to be tested. The dielectric strength is defined as the ratio of the dielectric breakdown voltage to the thickness of an insulating material. The dielectric breakdown voltage is defined as the voltage at which electrical breakdown of a specimen of electrical insulating material between two electrodes occurs under prescribed conditions of test.

A table is given with the type of metal, dimensions and geometry of typical electrodes for various insulating material types. The exact specifications can only be determined by referring to the 47 ASTM methods specifying dielectric strength tests. For sheets and film, rubber and rubber products, the electrodes are usually brass or stainless steel cylinders 2" in diameter and 1" in thickness, with edges rounded to 1/4" radius. For other solid materials the cylinder diameters are reduced to 1" and the radius to 1/8". For tapes and films, the electrodes are identical to those in BS 278, Methods 201. Either (a) or (b) are used. (a) has opposing cylindrical brass or stainless steel rods 1/4" in diameter with edges rounded to 1/32" radius. The upper movable electrodes shall weigh 50 ± 2 g. (b) has flat brass or stainless steel plates 1/4" wide and 4 1/4" long with edges square and ends rounded to 1/8" radius cylinders. The effective electrode length is 4".

When determining the dielectric breakdown voltage of a material any one of three different methods may be employed for applying the test voltage. These are: the Short-Time Test, the Slow Rate-of-Rise-Test, and the Step-by-Step Test. The Short-Time test is used for quick determination and the other two tests are used where duration of voltage application is important. In choosing the type of test, reference should be made to the ASTM method applicable to the material being tested.

An appendix is given discussing the significance of the dielectric strength test

Approximately equivalent to BS 2782, Methods 201 A-G.

FEDERAL TEST METHOD STD NO. 406/Method 4031
PLASTICS: METHODS OF TESTING - DIELECTRIC BREAKDOWN VOLTAGE
AND DIELECTRIC STRENGTH

This method, prepared in 1961, is in the process of being superseded by ASTM D 149-64 (1970). For this reason, it will not be discussed here. Supersession proceedings were known to be underway in the Fall of 1975.

ASTM D 1674-67 (1972) Standard Methods of Testing
POLYMERIZABLE EMBEDDING COMPOUNDS USED FOR ELECTRICAL INSULATION
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover electrical, mechanical, and thermal tests for polymerizable compounds used for encasing or embedding electrical and electronic components and assemblies. Sections 49-55 cover Dielectric Strength using the apparatus described in ASTM D 149-64 (1970). Sections 68-75 cover Dielectric Strength of Embedded Electrodes, using a unique apparatus. Sections 49-55 of this method resemble BS 2782, Method 201G. There does not appear to be any BS method comparable to Sections 68-75.

BS 2782: Part 2: 1970
Methods 201 A-G
ELECTRIC STRENGTH

These methods are for measuring the electric strength in oil of test specimens prepared from molding material, flexible extrusion compound, sheet, tube, rod and casting and laminating resin systems. The electric strength of a test specimen is defined as the maximum electric stress in kilovolts per millimeter (volts per mil) or the maximum voltage which the specimen will withstand without the occurrence of electrical failure by puncture of the specimen when the test is carried out under the conditions described in the individual methods. The value approximates the voltage which would cause breakdown at the end of one minute's application (usually known as the "Minute" value). The electric strength usually depends to a major extent upon the thickness of the test specimen and the test temperature. These methods are in conformity with those of the IEC publication 243, "Recommended Methods of Test for Electric Strength of Solid Insulating Materials at Power.

The 7 methods described below differ only in specimen preparation and thickness.

BS2782: Part 2: 1970
Method 201A
ELECTRIC STRENGTH OF MOULDING MATERIAL

The specimen shall be a molded disc not less than 100 mm (3 7/8") in diameter and 3 mm (1/8") thick, prepared under the conditions specified in the relevant British Standard for the material. The lower electrode shall consist of a solid cylinder of brass or other metal 75 mm (3") in diameter and approximately 15 mm (1/2") thick. The upper electrode shall consist of a solid cylinder of brass or other metal 25 mm (1") in diameter and not less than 25 mm (1") thick. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength shall be the maximum voltage which the specimen will withstand for 20 seconds without breakdown, divided by the thickness of the specimen, and shall be expressed in kilovolts per millimeter (volts per mil).

Approximately comparable to ASTM D 149-64 (1970) used as applied to ASTM D 700-75-PHENOLIC MOLDING COMPOUNDS, D 704-62 (1975)-MELAMINE-FORMALDEHYDE MOLDING COMPOUNDS, D 729-57 (1974)-VINYLIDENE CHLORIDE MOLDING COMPOUND, and D 1636-75-ALLYL MOLDING COMPOUNDS.

BS 2782: Part 2: 1970
Method 201B
ELECTRIC STRENGTH OF FLEXIBLE EXTRUSION COMPOUND

The specimen shall be not less than 100 mm (3 7/8") in diameter and, unless otherwise specified in the relevant British Standard for the material, shall be 3 mm (1/8") thick. The specimen shall be cut from sheet of the required thickness, molded under the conditions specified in the relevant British Standard for the material. The lower electrode shall consist of a solid cylinder of brass or other metal 75 mm (3") in diameter and approximately 15 mm (1/2") thick. The upper electrode shall consist of a solid cylinder of brass or other metal 25 mm (1") in diameter and not less than 25mm (1") thick. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength shall be the maximum voltage which the specimen will withstand for 20 seconds without breakdown, divided by the thickness of the specimen, and shall be expressed in kilovolts per millimeter (volts per mil).

Approximately equivalent to ATSM D 149-64 (1974). However, D 149 does not tabulate methods and specifications for flexible extrusion compounds, so the exact methods recommended are not known.

BS 2782: Part 2: 1970

Method 201C

ELECTRIC STRENGTH OF SHEET NORMAL TO PLANE OF SHEET

The specimen shall be not less than 100 mm (3 7/8") square. The thickness shall be the thickness of the sheet under test. The lower electrode shall consist of a solid cylinder of brass or other metal 75 mm (3") in diameter and approximately 15 mm (11/16") thick. The upper electrode shall consist of a solid cylinder of brass or other metal 25 mm (1") in diameter and not less than 25 mm (1") thick. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength shall be the maximum voltage which the specimen will withstand for 20 seconds without breakdown, divided by the thickness of the specimen, and shall be expressed in kilovolts per millimeter (volts per mil).

Approximately comparable to ASTM D 149-64 (1970) used as applied to ASTM D 229-72, Standard Method of Testing RIGID SHEET AND PLATE MATERIALS USED FOR ELECTRICAL INSULATION, Sections 23-27, including Section 24.1 Transverse Test. In D 229 Standard 51 mm (2") diameter electrodes are used instead of the 3" lower electrodes and 1" upper electrodes specified in Method 201C.

BS 2782: Part 2: 1970

Method 201D

ELECTRIC STRENGTH OF TUBE NORMAL TO AXIS OF TUBE

The specimen shall be a tube not less than 100 mm (4") long. The wall thickness of the specimen shall be that of the tube from which it was cut. Separate electrode specifications are given for 1. round tubes of i.d. not exceeding 100 mm (3 7/8"), 2. round tubes exceeding 100 mm (4"), and 3. tubes of rectangular cross section and of external side dimension not exceeding 180 mm (7 1/8"). The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength shall be the maximum voltage which the specimen will withstand for 20 seconds without breakdown, divided by the thickness of the specimen, and shall be expressed in kilovolts per millimeter (volts per mil).

Approximately comparable to ASTM D 149-64 (1970) used as applied to ASTM D348-75, Standard Methods of Testing RIGID TUBES USED FOR ELECTRICAL INSULATION, Sections 21-27, including Section 23.1 For Testing in Transverse Direction. The ASTM method is not as specific as BS 2782, Method 201D, however, in that the British method gives detailed requirements for electrodes for three different conditions, while the ASTM method has only one requirement.

BS 2782: Part 2: 1970

Method 201E

ELECTRICAL STRENGTH OF SHEET PARALLEL TO PLANE OF SHEET

The specimen shall be a rectangular bar 100 mm (3 7/8") long and 25 mm (1") wide. The thickness shall be the thickness of the sheet under test. The edges shall be parallel, smooth and plane. The specimen shall be held between flat metal plates forming the electrodes. The planes of the electrodes shall be perpendicular to the plane of the sheet specimen. The electrodes shall be 25 mm (1") apart and shall be of sufficient size to overlap by at least 15 mm the faces of the sheet specimen between which the voltage is to be applied. Precautions shall be taken to insure that the electrodes make good contact with the specimens. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength of the specimen shall be the maximum voltage in kilovolts which the specimen will withstand for 20 seconds without breakdown.

Approximately equivalent to ASTM D 149-64 (1970) used as applied to ASTM D 229-72, Standard Method of Testing RIGID SHEET AND PLATE MATERIALS USED FOR ELECTRICAL INSULATION, Sections 23-27, including Section 24.2 Parallel Test, Point-Plane Method, and 24.3 Parallel Test, Tapered Pin Method. The resemblance is only in function, however. In D 229, Section 24.2, the 13 mm (1/2") X 25 mm (1") specimen is tested parallel with the flat sides in a point-plane dielectric gap. This is obtained by drilling a hole to accommodate a snug-fitting metal pin electrode. In D 229, Section 24.3, the 50 mm (2") X 75 mm (3") specimen is exposed in such a manner that the full thickness of the insulation is exposed to a voltage stress parallel to the flat sides between pin-type inserts. This method is used primarily as a proof-type test.

BS 2782: Part 2: 1970

Method 201F

ELECTRIC STRENGTH OF TUBE AND ROD PARALLEL TO AXIS OF TUBE OR ROD

For round tubes of external diameter not exceeding 100 mm (3 7/8"), for tubes of rectangular cross section and of external side dimension not exceeding 180 mm (7 1/8") and for rod, the specimen shall be 25 mm (1") long. For round tubes of external diameter exceeding 100 mm (3 7/8 ") the specimen shall be a 100 mm (3 7/8") portion of a ring of axial length 25 mm (1"). The specimen shall be held between flat metal plates forming the electrodes. The planes of the electrodes shall be perpendicular to the axis of the specimen of tube or rod. The electrodes shall be

25 mm (1" apart and shall be of sufficient size to overlap by at least 15 mm the ends of the tube or rod between which the voltage is to be applied. Precautions should be taken to insure that the electrodes make good contact with the specimens. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength of the material under test shall be the maximum voltage in kilovolts which the specimen will withstand for 20 seconds without breakdown.

Approximately comparable to ASTM D 149-64 (1970) used as applied to ASTM D 348-75, Standard Methods of Testing RIGID TUBES AND RODS USED FOR ELECTRICAL INSULATION, Sections 21-27, including Section 23.2 for Testing Parallel with Laminations. The D 348 sample is smaller, however (only 1/2" long) and has a hole drilled into one end to accommodate a snug-fitting metal-pin electrode. The material is, in effect, tested parallel with the lamination in a point-plane gap.

BS 2782: Part 2: 1970

Method 201G

ELECTRIC STRENGTH OF CASTING AND LAMINATING RESIN SYSTEMS

The specimen shall be a disc not less than 100 mm (3 7/8") in diameter or a square of side not less than 100 mm (3 7/8"). The specimen shall be 3 mm thick (1/8") and shall be prepared under the conditions specified in the relevant British Standard for the material. The lower electrode shall consist of a solid cylinder of brass or other metal 75 mm (2 7/8") in diameter and approximately 15 mm (11/16") thick. The upper electrode shall consist of a solid cylinder of brass or other metal 25 mm (1") in diameter and not less than 25 mm (1") thick. The test shall be made with alternating voltage of a nominal frequency of 50 Hz. The electric strength of the specimen shall be the maximum voltage in kilovolts which the specimen will withstand for 20 seconds without breakdown.

This method is similar to ASTM D 1674-67 (1972), Sections 49-55.

25. Insulation Resistance

ASTM D 257-75a Standard Methods of Test for
D-C RESISTANCE OR CONDUCTANCE OF INSULATING MATERIALS
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover direct-current procedures for the determination of d-c insulation resistance, volume resistance, volume resistivity, surface resistance, and surface resistivity of electrical insulating materials, or the corresponding conductances and conductivities. Insulation resistance, R_i , is defined as the resistance between two electrodes that are in contact with, or embedded in, a specimen. It is the ratio of the direct voltage applied to the electrodes to the total current between them. The insulation resistance is dependent upon both the volume and surface resistances of the specimens. The resistance or conductance of a material specimen or of a capacitor is determined from a measurement of current or of voltage drop under specified conditions. The measurement is of greatest value when the specimen has the form, electrodes and mounting required in actual use. Bushings, cables, and capacitors are typical examples for which the test electrodes are part of the specimen and its normal mounting means. For materials, such as plastics, the test specimen may be of any practical form. Flat plates, tapes, rods and tubes are most commonly used. Figures are given for suggested electrode arrangements. Comparison of materials when using different electrode arrangements is frequently inconclusive. A number of different electrode materials may be used, and these are discussed in the standards. The actual measurement of insulation resistance or conductance is made by a comparison method using a galvanometer.

Ives *et al.* point out that the ASTM D 257 insulation resistance methods are somewhat similar to the BS ones. Thus for sheet material, nuts, bolts and washers are used spaced 32 mm (1 1/4") apart in a line, or sometimes in a circle (e.g. ASTM D 700-75, "Phenolic Molding Compounds"), or alternatively, taper pins with a geometry similar to BS 2782, Method 204C are specified, and this latter arrangement is also used for tube or rod, as in Method 204D. The preconditioning treatment is 96 hours at 35°C and 90% RM and measurements are made in situ, usually at 500 V after one minute.

BS 2782: Part 2: 1970
Methods 204A-D
INSULATION RESISTANCE

These methods are for measuring the electrical resistance of laminated sheet, tube and rod materials after specimens have been immersed in water for 24 hours. For sheet materials the resistance is measured between metal inserts of specified dimensions and at a specified distance apart. For tube and rods, flat metal electrodes are applied to the ends of pieces of specified length.

BS 2782: Part 2: 1970
Method 204A
INSULATION RESISTANCE OF LAMINATED SHEET

The specimen shall be a sheet of laminate 69.8 mm (2.75") by 65.5 mm (2.582"). The electrodes shall consist of brass screws and washers fitted into holes drilled through the specimen. The specimen with electrodes is heated for 24 hrs at 50°C, cooled in a desiccator, then immersed in distilled water for 24 hrs at 25°C. Finally, the specimen shall be dried with a cloth. The electrical resistance shall be measured at 20°C between each pair of electrodes at a potential of 500 V d.c. after electrification for 1 min. Measurements shall be taken within 5 min. after removal from water.

This method appears to be slightly comparable to the insulator resistance procedure in ASTM D 257-75a (actually D 257-66 (1972) issue). There is a difference in the conditioning procedure. The BS method calls for heating 24 hours at 50°C before conditioning at 25°C, then soaking in water for 24 hrs before drying. The procedure and specimen mounting also appear to be quite different in both methods.

BS 2782: Part 2: 1970
Method 204B
INSULATION RESISTANCE OF LAMINATED TUBE AND ROD

The specimen shall be a piece 25 mm (1") long of the rod or tube under test. The specimen is heated for 24 hrs at 50°C, cooled in a desiccator, then immersed in distilled water for 24 hrs at 25°C. Finally the specimen shall be dried with a cloth, including the inside, if a tube. The specimen shall be held between electrodes consisting of flat metal plates, with its axis at right angles to the surfaces of the electrodes. The electrical resistance in ohms shall be measured between the electrodes at a potential difference of 500 V d.c. after electrification for 1 min at 20°C. Measurements shall be taken within 5 min after removal from water.

This method appears to be slightly comparable to the insulation resistance procedure in ASTM D 257-75a (actually D 257-66 (1972) issue). There is a difference in the conditioning procedure. The BS method calls for heating 24 hrs at 50°C before conditioning at 25°C, then soaking in water for 24 hrs before drying. The procedure and specimen mounting also appear to be quite different in both methods.

BS 2782: Part 2: 1970

Method 204C

INSULATION RESISTANCE OF LAMINATED SHEET, USING IEC TAPER PINS

The specimen shall be rectangular, 77 mm (3") long X 52 mm (2 1/16"). Its thickness shall be that of the sheet under test. Two holes shall be drilled completely through the specimen in a manner described in detail to accommodate IEC taper pins. The electrodes shall be clean brass or steel taper pins with prescribed dimensions. The electrodes are fitted tightly into the holes in the specimens so that they extend at least 2 mm on each side of the specimen. The test specimen is heated for 24 hrs at 50°C, cooled in a desiccator, then immersed for 24 hrs in distilled water at 23°C. Finally, the specimen is dried with a cloth. The electrical resistance between the electrodes is measured at 20°C (+15 to -5°C) in an atmosphere of not more than 75% RH at a potential difference of 500 V d.c. after electrification for one minute. This method complies with the requirement of a Recommendation (Publication 167) published by the International Electrotechnical Commission (IEC) under the title "Methods of Test for the Determination of the Insulation Resistance of Solid Insulating Materials." It should be noted, however, that Method 204C requires that the test specimen be immersed in water for 24 hrs before the resistance is measured, while the draft IEC method does not do so specifically.

The method is quite comparable to ASTM D 257-75a (actually D 257-66 (1972) issue) for plate specimens. The latter calls for specimens 75 mm (2 7/8") long X 50 mm (1 31/32") wide, almost identical to the BS specimens (77 X 52 mm). The holes for the taper-pin electrodes are drilled in the same manner in both methods. There is a difference in the conditioning procedure. The BS method calls for heating at 50°C before conditioning at 25°C, then soaking in water for 24 hrs before drying.

BS 2782: Part 2: 1970

Method 204D

INSULATION RESISTANCE OF LAMINATED TUBE AND ROD, USING IEC TAPER PINS

This method is similar to that of Method 204C, except that the specimen is a portion of tube or rod 77 mm (3") long, not less than 10 mm (13/32") in o.d., and for tube not less than 8 mm (5/16") in i.d. The area of the two tapered holes lie on parallel diameters of the tube or rod. For tube specimens the holes are drilled through one wall thickness only, and the bores are dried with an air jet when it is not practical to use a cloth. Conditioning and testing are as in Method 204C.

This method is quite similar to that of the procedure for insulation resistance in ASTM D 257-75a (actually D 257-66 (1972) issue). There is a difference in specimen configuration dimensions, however. The ASTM method uses 75 mm (vs 77 mm) length, but calls for an i.d. minimum of 20 mm (13/16") for tubing (vs 8 mm) and an O.D. minimum of 20 mm (13/16") for rod (vs 10 mm). Conditioning and testing are as in Method 204C.

ASTM D 876-71 Standard Methods of Testing
NONRIGID VINYL CHLORIDE POLYMER TUBING (Sections 43-48)
(in Part 39, 1975 Annual Book of ASTM Standards)

This test requires that a U-shaped specimen filled with a dilute salt solution be immersed in a salt water bath and the resistance measured between a wire inserted through the length of the specimen and the external water. This method is similar to both ASTM and BS methods for measuring the insulation or sheath of cables (cf. BS 6004: 1969, "PVC-Insulated Cables (non-armoured) and Flexible Cords for Electrical Power and Lighting"). (Note: copy of BS 6004 not available for study. This comment is by Ives et al.)

ASTM D 2305-72 Standard Methods of Testing
POLYMERIC FILMS USED FOR ELECTRICAL INSULATION (Sections 25-29)
(in Part 39, 1975 Annual Book of ASTM Standards).

This test is carried out after conditioning at one or more of three specified conditions. Insulation resistance is carried out as specified in ASTM D 257-75a, using strip electrodes as shown in Fig. 2 of that method. An electrification time of 1 min at 100 V d.c. is used, unless otherwise specified. No BS method specifically covers the measurement of insulation resistance of films.

FED TEST METHOD STD. NO. 406/Method 4052
PLASTICS: METHODS OF TESTING - ELECTRICAL INSULATION
RESISTANCE OF PLASTIC FILMS AND SHEETS

This method, prepared in 1961 and applicable only to plastic materials in the form of film or sheet having a maximum thickness of one inch, is in the process of being superseded by ASTM D 257-75a. For this reason it will not be discussed here. Supersession proceedings were known to be underway in the Fall of 1975.

FED TEST METHOD STD. NO. 406/Method 4041
PLASTICS: METHODS OF TESTING - ELECTRICAL RESISTANCE
(INSULATION, VOLUME, SURFACE)

This method, prepared in 1961 and still in force, is based on ASTM D 257-58, although it lacks the detailed information on the significance of the test, equipment, test procedures, and general principles of measurement found in the ASTM method (D 257-75a version). There are some differences in geometry of test specimens (or taper pin electrodes for tubular specimens.)

26. Volume Resistivity

ASTM D 257-75a Standard Methods of Test for
D-C RESISTANCE OR CONDUCTANCE OF INSULATING MATERIALS
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover direct current procedures for the determination of d-c insulation resistance, volume resistance, volume resistivity, surface resistance, and surface resistivity of electrical materials, or the corresponding conductances and conductivities. Volume resistivity, ρ_v , is detailed as the ratio of the potential gradient paralleled to the current in the material to the current density. In the metric system, volume resistivity of an electrical insulatory material in ohm - cm is numerically equal to the volume resistance, R_v , in ohms between opposite faces of a 1-cm cube of the material. In the procedure the dimensions of the electrodes and width of the guard gap are measured. The volume resistivity or conductivity is measured with a suitable device having the required sensitivity and accuracy. Unless otherwise specified, the time of electrification shall be 60 secs and the applied direct voltage 500 V. The test specimen may have any practical form that allows the use of a third electrode to guard against error from surface effects. The general methods are similar to BS 2782 methods, but rather more scope is allowed in D 257. For instance, the electrode materials in the ASTM method encompass conducting silver paint, sprayed or evaporated metal, foils, mercury, graphite and conducting rubber. Graphite is only permitted where a relatively dry preconditioning treatment is involved. Electrode sizes are not stipulated, nor even the shape, since round, square or rectangular types are permitted. The expressions for the resistivity are as in BS 2782, except that the effective area for volume measurements is that corresponding to the mid-diameter of the gap. For electrodes corresponding to the smallest British size, Ives *et al.* point out that the ASTM calculations would give a volume resistivity about 40% greater than the BS expressions. This may sound serious, but it serves to put the accuracy of resistivity measurements into some perspective. The ASTM method gives a great deal of additional information about the techniques and hazards of measurement and also covers methods for tubing, flexible tapes and films.

BS 2782: Part 2: 1970
Methods 202A-B
VOLUME RESISTIVITY

These methods are for measuring the electrical resistance of materials as determined from the current flowing through the material when a voltage is applied to the opposite force of a sheet of the material.

BS 2782: Part 2: 1970
Method 202A
VOLUME RESISTIVITY WITH GUARD RING

This method is intended for general application. The method is based on the same electrode system as BS 2782 Method 202B and 203A, but this system may vary widely in size. Only mercury, metal foil and graphite are permitted as electrode materials. In the case of the latter, two thick brass backing plates are required. This method is similar to ASTM D 257-75a, as discussed under that document above.

BS 2782: Part 2: 1970
Method 202B
VOLUME RESISTIVITY WITHOUT GUARD RING

This method may be used when it is known that the addition of a guard ring has no significant effect on the test result, i.e. when the surface resistance is high in comparison with the volume resistance. There is no comparable ASTM procedure. The guard ring is specified in ASTM D 257-75a.

A Section 2.3 on Volume Resistivity under BS 4618; 1970, "Recommendations for the Presentation of Plastics Design Data," is supposed to be in preparation and may have been issued at the time of this writing.

27. Surface Resistivity

ASTM D 257-75a Standard Methods of Test for
D-C RESISTANCE OR CONDUCTANCE OF INSULATING MATERIALS
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover direct - current procedures for the determination of d-c insulation resistance, volume resistance, volume resistivity, surface resistance and surface resistivity of electrical insulating materials, or the corresponding conductances and conductivities. Surface resistivity, ρ_s , is defined as the ratio of the potential gradient parallel to the current along its surface to the current per cent width of the surface. The surface resistivity of a material is numerically equal to the surface resistance between two electrodes forming opposite sides of a square. The size of the square is immaterial. In the procedure the electrode dimensions and the distance between the electrodes are measured. The surface resistance or conductance between electrodes No. 1 and 2 are measured with a suitable device having the required sensitivity and accuracy. Unless otherwise specified, the time of electrification shall be 60 secs and the applied direct voltage shall be 500 V, as in the corresponding British test.

The test specimen may be of any practical form consistent with the particular objective, such as flat plates, tapes or tubes. Suggested electrode arrangements are given. The general methods are similar to BS 2782, Method 203A, but rather more scope is allowed in D 257. For example, the electrode materials in the ASTM method encompass conducting silver paint, sprayed or evaporated metal, foils, mercury, graphite and conducting rubber. Graphite is only permitted where a relatively dry preconditioning treatment is involved. Electrode sizes and shapes are not stipulated, since round, square or rectangular types are permitted. The gap between guard ring and center electrode is made approximately equal to twice the specimen thickness.

The ASTM method gives a great deal of additional information about the techniques and hazards of measurements and also covers methods for tubing, flexible tapes and films.

As described above, the methods specified in this procedure are very similar to the method given in BS 2782, Method 203A.

BS 2782: Part 2: 1970
Method 203A
SURFACE RESISTIVITY

This method is for measuring the electrical resistance across the surface of material as determined from the current flowing when a voltage is applied to electrodes on the surface of the material. The specimen shall be a circular flat sheet of dimensions such that the electrodes can be accommodated on it. The electrodes shall be of mercury or sprayed or evaporated metal or graphite and shall be coaxial with one another. The surface resistance between the electrodes shall be measured at the temperature specified in the relevant British Standard for the material, after electrification at a potential difference of 500 v for 1 min.

As described above under the ASTM method, this method is quite similar to ASTM D 257-75a.

A Section 2.4 on Surface Resistivity under BS 4618: 1970, "Recommendations for the Presentation of Plastics Design Data" is supposed to be in preparation and may have been issued at the time of this writing.

28. Loss Tangent and Permittivity

ASTM D 150-74 Standard Methods of Test for
A-C LOSS CHARACTERISTICS AND DIELECTRIC CONSTANT (PERMITTIVITY)
OF SOLID ELECTRICAL INSULATING MATERIALS
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover the determination of dielectric constant, dissipation factor, phase angle, and loss angle of specimens of solid electrical insulation when the standards used are lumped impedances. The frequency range that can be covered ranges from less than 1 Hz to several hundred megahertz. Since some materials require special treatment, reference should also be made to ASTM methods applicable to the material to be tested (as ASTM D 1673 for cellular plastics and ASTM D 1674 for polymerizable embedding compounds).

D 150 is the blanket ASTM specification covering dielectric measurements. Some confusion has existed in the past between American and British terms used in connection with dielectrics. Dielectric constant is the preferred U.S. term for permittivity, but the latter term is probably more widely used in the U.K. $\tan \delta$ (or loss tangent in the U.K.) is called dissipation factor in the U.S. and given the symbol D. The product permittivity \times loss tangent, which is a measure of the energy loss in a material, is now called the loss index internationally, according to Ives *et al.*, but formerly was known in the U.S. as the loss factor. D 150 is written in quite general terms and makes very few specific recommendations about methods or apparatus. For example, no electrode sizes are even suggested and the only recommendations made are that the guard gap should be as small as possible and the guard width should be at least twice the specimen thickness. No particular type of apparatus is specified, but an appendix gives details of a number of bridge and other circuits which are suggested. Some details are given of the liquid immersion (fluid displacement) technique, but this method is dealt with at some length in ASTM D 1531-62 (1970).

This method is approximately comparable to BS 2782, Methods 205A-D and 206A-D, although the British methods are much more specific.

ASTM D 1531-62 (1970) Standard Method of Test for
DIELECTRIC CONSTANT AND DISSIPATION FACTOR OF POLYETHYLENE
BY LIQUID DISPLACEMENT PROCEDURE
(in Part 39, 1975 Annual Book of ASTM Standards)

This method provides procedures that are particularly suited to the precise determination of the dielectric constant of polyethylene compounds, in the vicinity of 2.28, at frequencies from 1000 Hz to 2 MHz and at a temperature of 23°C. It may be extended to cover a much wider dielectric constant and higher frequency range. The method covers a dissipation factor range from about 0.00001 to 0.1. By this method the change in capacitance of a fixed-plate two-terminal self-shielded test cell containing a liquid, such as benzene, is determined when two identical molded polyethylene test specimens are immersed in the liquid between the plates. This capacitance difference is used in conjunction with the approximate specimen thickness, the plate thickness, the plate spacing, and the precisely known dielectric constant of the liquid, to calculate the dielectric constant of the test specimens. The dissipation factor is calculated from measurements of the cell with the liquid alone and with the specimen immersed in it. Since the thickness of the test specimens does not have to be known accurately, and it is not necessary to apply electrodes, there is an over-all saving in testing time.

An alternative fluid to benzene is liquid silicone of a specified viscosity. Test specimens, unless otherwise specified, are conditioned for 40 hrs at 23°C (73.4°F) and 50% R.H. No one type of test apparatus is presented, but equations are given for direct reading bridges and Q meters.

This method has no BS counterpart.

ASTM D 1673-73 Standard Methods of Test for
DIELECTRIC CONSTANT AND DISSIPATION FACTOR OF EXPANDED
CELLULAR PLASTICS USED FOR ELECTRICAL INSULATION
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover procedures for determining the dielectric constant and dissipation factor of flat sheets or slabs of expanded cellular plastics of both the rigid and flexible types, at frequencies from 60 Hz to 100 MHz. Provision is made for measurements on specimens up to 2" (50 mm) in thickness, but it is recommended that specimens greater than 1" (25 mm) in thickness shall be tested at frequencies up to a maximum of only about 1 MHz.

Although fundamentally similar to methods used for solid electrical insulating materials in sheet or plate form, certain modifications in the procedures and measurement techniques are necessary for the proper determination of the dielectric constants and dissipation factors of foamed or expanded cellular plastics. This is because in many, if not most, instances, expanded cellular materials have surfaces that preclude the use of

conventional electrodes such as metal foil attached by petrolatum and similar adhesives, or conducting silver paint applied by brushing or spraying. Furthermore, it is generally true that slabs or plates of expanded cellular materials are available only in substantially greater thicknesses than those commonly used for test specimens of solid insulation.

Prefabricated rigid metal plate electrodes are usually used, either of the direct contact or a noncontacting type. Reference is made to ASTM D 150-74 for test apparatus and definitions.

This method has no BS counterpart.

ASTM D 1674-67 (1972) Standard Methods of Testing
POLYMERIZABLE EMBEDDING COMPOUNDS USED FOR ELECTRICAL INSULATION
(in Part 39, 1975 Annual Book of ASTM Standards)

These methods cover electrical, mechanical, and thermal tests for polymerizable compounds used for encasing or embedding electrical and electronic components or assemblies. Sections 40 to 48 cover the determination of the dielectric constant and dissipation factor of an embedding compound from 60 Hz to 100 kHz over a range of temperatures. In the method of a simple two-terminal electrode system suitable for elevated temperatures up to 300°C is described. Two procedures, a Fixed Temperature procedure and a Rising Temperature procedure are used.

This method is roughly comparable to BS 2782, Method 205D.

BS 2782: Part 2: 1970
Method 205A-D
LOSS TANGENT AND PERMITTIVITY AT 50 hertz

These methods are for determining the loss tangent (previously known as power factor) and the permittivity of molding material, sheet, tube and laminating and casting resins systems at 50 Hz. The loss tangent of a material at this frequency often shows some correlation with its electric strength at power frequencies if the temperature of measurement is the same. Use may be made of this correlation, as the measurement of loss tangent can, under certain circumstances, be carried out on large sheets or tubes without damaging the material by cutting a special test specimen from it.

These methods are somewhat similar to ASTM D 150-74, although the latter is much more general.

BS 2782: Part 2: 1970
Method 205A
LOSS TANGENT AND PERMITTIVITY OF MOULDING MATERIAL AT 50 Hz

Specimens shall be between 1.6 mm (1/16") and 3.2 mm (1.8") thick, according to the relevant British Standard for the material. Circular electrodes of mercury, metal foil or brass shall be used. The measurement of loss tangent and permittivity shall be made with a Schering Bridge provided with a Wagner earth.

BS 2782: Part 2: 1970
Method 205B
LOSS TANGENT AND PERMITTIVITY OF SHEET AT 50 Hz

Specimens shall be the thickness of the sheet under test. Circular electrodes of mercury, metal foil or brass shall be used. The measurement of loss tangent and permittivity shall be made with a Schering Bridge provided with a Wagner earth.

BS 2782: Part 2: 1970
Method 205C
LOSS TANGENT AND PERMITTIVITY OF TUBE AT 50 Hz

Specimens shall be tube of the same internal and external diameter as the tube from which it is cut. The length must be long enough to accommodate the electrodes specified. The outer electrode shall be a band of metal foil and the inner electrode shall be mercury, a band of metal foil or a metal mandrel. The measurement of loss tangent and permittivity shall be made with a Schering Bridge provided with a Wagner earth.

BS 2782: Part 2: 1970
Method 205D
LOSS TANGENT AND PERMITTIVITY OF CASTING AND LAMINATING RESIN SYSTEMS AT 50 Hz

The specimen shall be a cast sheet. The thickness and method of preparation shall be as specified in the relevant British Standard for the material. Circular electrodes of mercury, metal foil or brass shall be used. The measurement of loss tangent and permittivity shall be made with a Schering Bridge provided with a Wagner earth.

BS 2782: Part 2: 1970
Methods 206A-D
LOSS TANGENT AND PERMITTIVITY AT 800 TO 1600 hertz

These methods are for determining the loss tangent (previously known as power factor) and permittivity at 800 to 1000 Hz of molding material, sheet, tube and casting and laminating resin systems. (A frequency of 1000 Hz is preferred). For material of

a given formulation, loss tangent at these frequencies often shows some correlation with other electrical properties. Use may be made of this correlation by a manufacturer in maintaining uniformity of electrical properties since the test is non-destructive and can, under certain circumstances, be carried out on large sheets or tubes without cutting special test specimens.

These methods are somewhat similar to ASTM D 150-74, although the latter is much more general. The individual methods listed below appear to be identical to methods 205A-D described above, except for the difference in frequency.

BS 2782: Part 2: 1970
Method 206A
LOSS TANGENT AND PERMITTIVITY OF MOULDING MATERIAL AT 800 Hz TO 1600 Hz

BS 2782: Part 2: 1970
Method 206B
LOSS TANGENT AND PERMITTIVITY OF SHEET AT 800 Hz TO 1600 Hz

Bs 2782: Part 2: 1970
Method 206C
LOSS TANGENT AND PERMITTIVITY OF TUBE AT 800 Hz TO 1600 Hz

BS 2782: Part 2: 1970
Method 206D
LOSS TANGENT AND PERMITTIVITY OF CASTING AND LAMINATING RESIN SYSTEMS AT 800 Hz TO 1600 Hz

BS 2782: Part 2: 1970
Methods 207A-C
LOSS TANGENT AND PERMITTIVITY AT 10 kilohertz TO 100 megahertz

These methods are for determining the loss tangent (previously known as power factor) and permittivity of molding materials, by means of the apparatus described by Hartshorn and Ward, described in detail in BS 2067, "Determination of Power Factor and Permittivity of Insulating Materials (Hartshorn and Ward method). BS 2067 has not been seen by this writer. Note that there is no procedure for casting and laminating resins, as given for the lower frequencies in Methods 205 and 206.

These methods are somewhat similar to ASTM D 150-74, although the latter is much more general. The Hartshorn and Ward apparatus is not described under that name in D 150, although a literature reference (8) to these authors is given for their micrometer-electrode system (Section 5.32 in D 150). This system is described in Fig. A10 in D 150, labelled "Voltmeter-Wattmeter-Ammeter Method," for use at power (high) frequencies.

BS 2782: Part 2: 1970

Method 207A

LOSS TANGENT AND PERMITTIVITY OF MOULDING MATERIAL AT 10 kHz TO 100 MHz

The specimen shall be a disc 53 mm (2 3/32") in diameter. Recommendations are given as to thickness. The specimen shall be molded to shape under the conditions described in the relevant British Standard, and, if necessary, subsequently machined.

BS 2782: Part 2: 1970

Method 207B

LOSS TANGENT AND PERMITTIVITY OF SHEET AT 10 kHz TO 100 MHz

The specimen shall be a disc 53 mm (2 3/32") in diameter machined to shape.

BS 2782: Part 2: 1970

Method 107C

LOSS TANGENT AND PERMITTIVITY OF TUBE AT 10 kHz TO 100 MHz

The specimen shall be a round tube at least 40 mm (1 9/16") longer than the outer electrode, which shall be of such length that the capacitance of the specimen lies within the range 20 - 100 pF. A 150 mm (5 7/8") length will often be found suitable. Machining the specimen may be carried out.

BS 4542: 1970

DETERMINATION OF LOSS TANGENT AND PERMITTIVITY OF ELECTRICAL INSULATING MATERIALS IN SHEET FORM (LYNCH METHOD)

This method covers the determination of the loss tangent and permittivity of electrical insulating materials of frequencies from 1 - 100 kHz and is based on work by A.C. Lynch (1965). The method is intended to supplement BS 2067, "Determination of Power Factor and Permittivity of Insulating Materials (Hartshorn and Ward Method)," and covers a slightly different range of frequency. The method is based on the use of micrometer air gap electrodes.

The test specimen, which carries no electrodes of its own, is inserted in an electrode system in which the separation of the electrodes is variable, and changes in capacitance and conductance are observed by using a bridge network. The loss tangent is calculated from the change in conductance which occurs when the specimen is inserted. The permittivity is calculated from the increase in the separation of the electrodes necessary to restore the capacitance to its original value.

There does not appear to be any comparable ASTM method. ASTM D 150, although it covers the basic BS 2067 method, does not cover this variation.

29. Tracking

ASTM D 2132-68 (1973) Standard Method of Test for
DUST-AND-FOG TRACKING AND EROSION RESISTANCE OF ELECTRICAL
INSULATING MATERIALS
(in Part 39, 1975 Annual Book of ASTM Standards)

This method is intended to differentiate solid electrical insulatory materials with respect to their resistance to the action of electric arcs produced by conduction through surface films of a specified contaminant containing moisture. This is the earliest ASTM tracking method. 2" X 1/2" brass or copper electrodes are placed flat upon the surface of a test piece and the assembly is coated with a synthetic dust and subsequently wetted by fine water spray in an appropriate chamber. A relatively high voltage of 1500 V, 60 Hz applied to the electrodes induces tracking and/or erosion effects along the surface or through the thickness of the specimen, and the test is continued until a permanent track ensues or the specimen is penetrated, the time to such failure being recorded in hours. Classification of tracking and erosion resistance is broken down into several groups, a tracking-resistant or erosion-resistant material being defined arbitrarily as one withstanding respectively 100 hrs or 200 hrs without failure by the relevant mode. The specimen size is normally 5" X 5" X 1/16". Although the test is simple in principle, the test details relating to the dust formation, the fog deposition rate, the spray nozzle dimensions, the conductivity of the water used, etc. are carefully stipulated, as are the circuit details.

There is no comparable BS method.

ASTM D 2302-75 Standard Method of Test for
DIFFERENTIAL WET TRACKING RESISTANCE OF ELECTRICAL INSULATING
MATERIALS WITH CONTROLLED WATER-TO-METAL DISCHARGES
(in Part 39, 1975 Annual Book of ASTM Standards)

This method covers the evaluation in a very short time (a few minutes) of the tracking resistance of insulating materials exposed to conducting surface - water films and absorbed moisture. It is intended to be used to compare the tracking resistance of electrical insulating materials under the conditions specified, except possibly that of low-melting thermoplastic materials and very highly track-resistant materials such as glasses and ceramics. The method is relatively economical with respect to both time and apparatus, as compared to ASTM Methods D 2132 and D 2303. It is, therefore, most valuable for (although not necessarily limited to) obtaining screening information.

In the method a short surface length of a specimen is subjected to continuous electric discharges from water to a metal electrode in successive steps of increasing discharge power. The end point (tracking failure) is indicated by a reduction in voltage of a discharge over the surface of the specimen, and by a subsequent voltage proof test. The tracking resistance of a material is defined as the discharge power step at which tracking occurs.

This differential test is extremely rapid compared to the dust fog (ASTM D 2132) and the inclined plane (ASTM D 2303) tests. The test conditions are very severe and lead to failure in a matter of minutes.

There is no comparable BS method.

ASTM D 2303-73 Standard Method of Test for
LIQUID-CONTAMINANT, INCLINED PLANE TRACKING AND EROSION OF
INSULATING MATERIALS

This method covers the evaluation of the relative tracking and erosion resistance of insulating material using the liquid-contaminant, inclined-plane test. Two tracking and one erosion test procedure are described. The tracking methods include 1) A "variable " voltage method and 2) a "time-to-track" method. The erosion test procedure permits quantitative determination of erosion. A definite contaminant solution is prescribed, but the concentrations or types of contaminants with suitable voltages may be used to simulate different service or environmental conditions.

In the inclined plane test, a large flat specimen is inclined at 45° and electrolyte allowed to flow down its cover surface, forming a bridge between two electrodes pressed against it. The electrolyte stream boils under the influence of the test voltage, which can lie between 1 and 10 kV, and the resulting discontinuities occurring in the conducting path produce scintillation near the lower electrode. The test is stopped when a track has progressed up the specimen a distance of 1" from the bottom electrode. The advantage of this test is that the conditions can be carefully controlled so that steady scintillation occurs, unlike the the intermittent and somewhat uncontrolled scintillation which produces failure in "drop" tests.

There is no comparable BS method.

BS 3781: 1964
THE COMPARATIVE TRACKING INDEX OF SOLID INSULATING MATERIAL

This method is based on IEC Recommendation No. 112, "Recommended Method of Determining the Comparative Tracking Index of Solid Insulating Materials Under Moist Conditions." The test

method indicates the relative behavior of solid electrical insulating materials regarding their ability to form a permanent track on the surface when stressed electrically and at the same time exposed to moisture which may be contaminated by dirt or dust from the surrounding medium. The liability to track is expressed numerically as the comparative tracking index (CTI). Account is taken of other forms of damage, such as erosion, which may occur during the test even when there has been no failure by tracking.

Ives et al. have summarized the test and commented on it in detail. The test involves the application of two chisel-shaped electrodes of brass, 4 mm (5/32") apart, to the surface of a test specimen with a prescribed load (100 gf) at the tip and with a specified 50 Hz voltage between them. Drops of 0.1% NH_4Cl solution of size 20-25 mm^3 are allowed to fall at the rate of one every 30 secs until tracking occurs or until 100 drops have fallen, whichever is the sooner, tracking being defined arbitrarily by the current in the circuit reaching a specified level. The test is performed at a number different voltage levels and a curve drawn of the number of drops to track at each level. The comparative tracking index is defined by the asymptote to the curve, which is usually of roughly hyperbolic shape, or alternatively by the voltage at 50 drop level, and is expressed as a pure number, not as a voltage.

The test is really only suitable for test voltages up to 500 V. The significance of the test voltage and its relationship with practical use voltages has not been established, and the comparative tracking index obtained should not be regarded as a design level below which it is safe to operate. The index is expressed as a number to dissociate it from an actual voltage and to emphasize its true importance as a simple guide for comparing materials.

It is usually necessary to make measurements at about six different voltage levels to define a curve adequately, and the scatter of results is high. Electrode materials other than brass are permitted, providing such use is reported and it is accepted that different results may be obtained.

Some materials, such as polymethylmethacrylate, do not track, but can fail by erosion, material between the electrodes volatilizing to leave a crater. As in practice, such behavior would be undesirable, since terminals would become loosened. Erosion is recognized in the test as a mode of failure.

There is no comparable ASTM method.

BS 1322: 1956
AMINOPLASTIC MOULDING MATERIALS

This British Standard has not been seen by the writer, but, according to Ives *et al.*, a crude and simple, but rather spectacular tracking test appears in it. Two brass rod electrodes, 5 mm (7/32") in diameter, are molded into, or are otherwise made to fit tightly in holes drilled in a flat molding, at a separation of 1 1/4". The electrodes are connected to a 200-250 V, 50 Hz supply by means of an 8A fuse and a 10% NaCl solution poured onto the horizontal molding. After the initial soaking, fresh solution is added at five-minute intervals until 30 min has elapsed, or a track has occurred. In the absence of a track the molding is washed repeatedly, finally wiped free of moisture, and its insulation resistance measured between the terminals. The specification requirements are that the material shall not track and the insulation resistance test impractical and rather meaningless.

There is no comparable ASTM method.

OPTICAL PROPERTIES

30. Luminous Transmittance and Haze of Transparent Plastics

ASTM D 1003-61 (1970) Standard Method of Test for
HAZE AND LUMINOUS TRANSMITTANCE OF TRANSPARENT PLASTICS
(in Part 35, 1975 Annual Book of ASTM Standards)

Haze is that percentage of transmitted light which, in passing through the specimen, deviates from the incident beam by forward scattering. In this method, only light flux deviating more than 2.5 degrees on the average is considered to be haze. Luminous transmittance (or transmission) is the ratio of transmitted to incident light.

This method covers the measurement of the light-transmitting properties, and from these, the light-scattering properties, of planar sections of transparent plastic. Two procedures are given. Procedure A uses the Hazemeter, and Procedure B, the Recording Spectrophotometer. Procedure A employs a spherical hazemeter which is pivotable about a vertical axis through the specimen placed in contact with the entrance port. In the normal position the collimated incident light passes straight through the sphere, leaving through the exit port, which is closed by an absorbent light trap. Any light which is scattered by the instrument alone (specimen removed) or instrument plus specimen (specimen in) is reflected from the region around the edge of the exit port and finally collected by the photocell after multiple reflections from the highly reflective walls of the sphere.

When the sphere is rotated slightly so that the incident light hits the opposite highly reflecting wall of the sphere (which forms a reflectance standard) adjacent to the exit port, a measurement with and without specimen gives a measure of the total transmittance. The diffuse transmittance and haze can also be determined. Total transmittance, diffuse transmittance and haze can also be determined using the recording spectrophotometer (Procedure B) of the Hardy type.

This method is a small-scale test. Large-scale methods where additional scattering is involved are discussed below under 31 and 32. This method is essentially identical to BS 2782, Method 515A, except that the British method refers to haze only and not to light transmission. Method 515A uses CIE* Source C only, while D 1003 permits either Source A or C. (Note CIE Source A corresponds to incandescent light, B to noon sunlight, and C to overcast sky daylight.)

*International Commission on Illumination

BS 2782: Part 5: 1970
Method 515A
HAZE OF FILM

This method is for determining the haze of substantially colorless transparent films of nominally uniform thickness by the measurement of the percentage of transmitted light which, in passing through a specimen, deviates from the incident beam by more than an angle of approximately 2 1/2 degrees by forward scattering from both surfaces and from within the specimen. The method is a simplified form of ASTM D 1003-61 (1970), but measures haze only and not transmittance. See additional comments under ASTM D 1003-61 (1970) above.

BS 4618: 1972
RECOMMENDATIONS FOR THE PRESENTATION OF PLASTICS DESIGN DATA
Section 5.3
OPTICAL PROPERTIES

This method covers Haze under 2. Transparency and total transmittance factor (transmittance) under 4. Light Transfer. ASTM D 1003-61 (1970) is referred to for Haze. No particular method is listed for Light Transfer. The methods are discussed briefly under an Introduction and suggestions on information to be presented (form of presentation) are also given.

There is no comparable ASTM method.

FEDERAL TEST METHOD STD. NO. 406/Method 3022
PLASTICS: METHODS OF TESTING - LUMINOUS TRANSMITTANCE AND
HAZE OF TRANSPARENT PLASTICS

This method, prepared in 1961, is based on ASTM D 1003-59T, Method A. The method is a much-abridged version of the ASTM procedure. As such, it is comparable to BS 2782, Method 515A, except for the comments made above under the discussion for ASTM D 1003-61 (1970).

31. Light Diffusion

ASTM E 166-63 (1970) Standard Recommended Practice for
GONIOPHOTOMETRY OF TRANSMITTING OBJECTS AND MATERIALS
(in Part 46, 1975 Annual Book of ASTM Standards)

ASTM E 167-63 (1970) Standard Recommended Practice for
GONIOPHOTOMETRY OF REFLECTING OBJECTS AND MATERIALS
(in Part 46, 1975 Annual Book of ASTM Standards)

Goniophotometry is a general procedure for evaluating the manner in which materials geometrically redistribute light. These recommended practices are intended primarily for research work. These two methods combined are similar to a considerable extent to FEDERAL TEST METHOD STD. NO. 406/Method 3031, described below.

FEDERAL TEST METHOD STD. NO. 406/Method 3031
PLASTICS: METHODS OF TESTING - LIGHT DIFFUSION

This method, prepared in 1961, is designed for use in determining both reflective and transmissive diffusion characteristics of flat plastic specimens illuminated perpendicularly with collimated light by means of a simple goniophotometer. The method permits analytic comparison of the light-diffusing properties of specimens in terms of the theoretically perfect light-diffusing specimen with an estimated precision of $\pm 5\%$. Small differences in diffusion cannot be determined easily by this method. The instrument described is more useful for control than for research purposes, but the data obtained with it are accurate enough for most service conditions.

The instrument and procedure are designed to measure the reflective and transmissive diffusion of a beam of light by a flat test specimen of the plastic, the face of which is essentially normal to the axis of the light beam, with numerical means for rating the scattering or diffusion in terms of a theoretically perfect light-scattering surface or medium.

The procedure is based on both ASTM E 166-60T and ASTM E 167-60T, which cover transmitting and reflecting objects, respectively. There are apparently no British Standards covering Light Diffusion, as conceived in these two ASTM methods and the Federal Test Method Standards.

32. Diffuse Luminous Transmittance Factor of Reinforced Plastics Panels

ASTM D 1494-60 (1974) Standard Method of Test for
DIFFUSE LIGHT TRANSMISSION FACTOR OF REINFORCED PLASTICS PANELS
(in Part 36, 1975 Annual Book of ASTM Standards)

This method, a large-scale procedure, covers the determination of the diffuse light transmission factor of translucent reinforced plastics building panels. In the test the diffuse light transmittance factor of both flat and corrugated translucent building panels is determined by the use of simple apparatus and by employing as a light source a combination of fluorescent tubes whose energy distribution closely approximates CIE Source C (overcast sky daylight). The apparatus consists of a transmissometer, comprised of a light source, photometer and test cabinet.

The test specimens are 610 mm (24") maximum length, and 610 mm (24") in width, but not exceeding 711 mm (28"). The photocell measures the transmitted light and the transmittance is given as the ratio of photocell output - specimen in/specimen out.

This method is somewhat similar to BS 4154: 1967, and BS 4203: 1967, as discussed below.

FEDERAL METHOD STD. NO. 406/Method 3032
PLASTICS: METHODS OF TESTING - DIFFUSE LIGHT TRANSMITTANCE
FACTOR OF REINFORCED PLASTIC PANELS

This method, prepared in 1961, is based on ASTM D 1494-57T.

BS 4154: 1967
SPECIFICATION FOR CORRUGATED PLASTICS TRANSLUCENT SHEETS MADE
FROM THERMO-SETTING POLYESTER RESINS (GLASS FIBER REINFORCED)

A light transmission test for large panels (2ft.²) appears in this standard, which has not been seen, but is mentioned by Ives et al. This method is somewhat similar to ASTM D 1444-60 (1974), except that an additional test is given in the BS method, based on a simple slit diffusion photometer, and an appropriate correction is then calculated and applied to the total light transmission. This refinement is not required in BS 4203, described below, presumably because only transparent material is involved in that standard.

BS 4203: 1967
SPECIFICATION FOR EXTRUDED RIGID PVC CORRUGATED SHEETING

A light transmission test for large panels (2 ft.²) appears in this standard, which has not been seen, but is mentioned by Ives et al. This method is somewhat similar to ASTM D 1494-60 (1974).

33. Optical Uniformity and Distortion

ASTM D 637-50 (1970) Standard Method of Test for
SURFACE IRREGULARITIES OF FLAT TRANSPARENT PLASTIC SHEETS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method covers the measurement of the surface irregularities of flat transparent plastic sheets that are ordinarily used to cover openings through which visual and instrumental observations are made. The method measures the distance and the deviation of line of sight through flat sheets of transparent plastics. The method makes use of the prismatic or optical wedge deflection of a beam of light as it passes through a distortion spot or wave in the body of, or on the surface of, the material being inspected. The test provides empirical results useful for control purposes and for correlation with service applications. The accuracy is much greater than required for most applications, but it is not expected to measure microscopic defects or the optical perfection of surfaces in terms of wave length of light.

There is no comparable British Standard.

FEDERAL TEST METHOD STD. NO. 406/Method 3041
PLASTICS: METHODS OF TESTING - OPTICAL UNIFORMITY AND DISTORTION

This method, prepared in 1961, is based on ASTM D 637-50. There is no comparable British Standard.

34. Gloss

ASTM D 523-67 (1972) Standard Method of Test for
SPECULAR GLOSS
(in Parts 27 and 35, 1975 Annual Book of ASTM Standards)

According to Ives *et al.*, this is the recommended standard for measurements on plastics (excepting films). It uses a 20 degree (to the vertical) incident and reflected light beam geometry for high-gloss materials and 85 degree geometry for low-gloss materials. An intermediate 60-degree angle is used for inter-comparative purposes and for deciding which of the other angles should be used with a given specimen. Although the geometry of source and receiver is defined with close tolerances on the angles, the actual instrument to be used is not described in great detail. The primary standard of gloss is a highly-polished, plane, black-glass surface with a refractive index of 1.567, to which is assigned the arbitrary value of 100 gloss units for each of the three geometries. The specification requires that any measurements should be in accordance with CIE Source C (overcast sky daylight) values, without actually stating that this source should be used, the inference being that the type of source is not very critical. This method is apparently designed for paints, varnishes, lacquers, etc. and is actually under the cognizance of ASTM Committee D-1 in that area.

There is no comparable British Standard, except possibly for BS 3900, Part 2, which also covers paints and varnishes and bears some resemblance.

ASTM D 1471-69 Standard Method of Test for
TWO-PARAMETER, 60-DEG SPECULAR GLOSS
(in Part 27, 1975 Annual Book of ASTM Standards)

This method, also under the cognizance of ASTM D-1, gives results that agree well with estimates of gloss, while measurements taken in accordance with the 60-deg geometry of ASTM D 523-67 (1972) do not always correlate with gloss appearance. The method was developed for clear finishes on wood, although it may reasonably be used for other nonmetallic materials. A measurement obtained with a small receiver aperture supplements a measurement with the aperture of Method D 523 to give, by means of abridged gonio-photometry, an indication of the geometric distribution of reflected flux and, consequently, of the appearance characteristics. Appearance characteristics ascribable to gloss may be classified, in accord with appearance or with flux-scattering properties, into two extreme types, image forming and non-image-forming. Types intermediate between these two extremes are found.

There is no comparable British Standard.

FEDERAL TEST METHOD STD. NO. 406/Method 3051
PLASTICS: METHODS OF TESTING - GLOSS

This method, prepared in 1961, is based on ASTM D 1471-57T. The ASTM method shows a figure for a generalized apparatus of only one type, a generalized glossmeter for a collimated-beam type apparatus. This method adds a second type for a converging-beam type instrument.

There is no comparable British Standard.

ASTM D 2457-70 Standard Method of Test for
SPECULAR GLOSS OF PLASTIC FILMS
(in Part 35, 1975 Annual Book of ASTM Standards)

As pointed out by Ives et al., this method for films is based on ASTM D 523-67 (1971) for the 20 degree and 10 degree angle tests, but the third angle is 45 degrees, not 85 degrees, and the 45 degree test is based on a method for ceramics, ASTM C 346-59 (1972). The same black glass standard is used at 20 degrees and 60 degrees as in the ASTM D 523 test, but at 45 degrees the refractive index is 1.540 and the assigned gloss value is 54.5. A note warns of the possibility of obtaining gloss values on clear films of more than 100 units with any of the three geometries, because of reflection at both surfaces of the specimens. Three specimen-mounting devices are described for ensuring the flatness so essential in gloss measurements.

There is no closely comparable British Standard, but BS 2782, Method 515B, bears some resemblance. The BS method tests gloss only at 45 degrees, while ASTM D 2457-70 tests it at 20, 45 and 60 degrees. Method 515B, while bearing the title implying application only to sheet, can also be used for film, according to the introduction to the method.

BS 2782: Part 5: 1970
Method 515B
GLOSS (45°) OF SHEET

This method is for determining the gloss of sheet (including film), by photoelectric measurement of the intensity of the light reflected from a flat test specimen when a beam of light strikes its surface at an angle of 45 degrees. The method is primarily intended for testing uncolored or white materials. If used on strongly colored materials the results may be affected by the spectral response of the particular type of photocell used. Gloss is expressed in units of a scale in which the gloss of a polished black glass standard of refractive index 1.52 is 53. On this scale a perfectly reflecting glass mirror has a gloss value of 1000. The gloss head is similar to that of BS 3900 with important but

minor alterations to the aperture. For films a clamp is described which enables specimens to be held completely taut and free from wrinkles. The light source specified is CIE Source C (overcast sky daylight).

As discussed above, this method bears some resemblance to ASTM D 2457-70.

BS 3900: 1967
METHODS OF TEST FOR PAINTS
Part 2
GLOSS (SPECULAR REFLECTION VALUE)

This BS has not been seen, but it is described by Ives et al. It covers modern polymer-based paints and varnishes and is based on a well-known British defence specification, DEF 1053, Method No. 11, "Gloss (Specular Reflection Value)"; and employs a 45 degree geometry head as a "high gloss head". The standard is unique in quoting figures for the variation in gloss of blackened glass with refractive index in a table. The importance of flatness in the reflectance standard is underlined by the tolerance permitted, viz. plane to 2 fringes/cm. The standard itself is highly polished clear glass with its underside and edges roughened and coated with black paint. The refractive index is 1.523 and the gloss value assigned to it is 100 units. The head is placed on it and the photocell output or galvanometer input adjusted to 100 scale divisions. When placed on the test specimen, in this case coated plate glass, the gloss is given direct. Gloss values above 100 are evidently possible according to the operating procedure given.

There is no really comparable ASTM specification, although ASTM D 523-67 (1972), which is intended to cover paints and varnishes primarily, bears some resemblance.

BS 3962: 1965
METHODS OF TEST FOR CLEAR FINISHES FOR WOODEN FURNITURE
Part 1
TEST FOR LOW-ANGLE GLARE

This BS has not been seen, but it is described by Ives et al. Like BS 3900, it covers modern polymer-based varnishes. In the test the gloss head employs a 75°/75° (to the vertical) geometry and the Evans Electroselenium Ltd. Variable-Angle Glossmeter conforms to the requirements shown in a figure. This test is used to assess low angle glare emanating from clear finishes used on school furniture. The gloss standard is identical to that of BS 3900, and the procedure similar.

There is no comparable ASTM method.

BS 4618: 1972
RECOMMENDATION FOR THE PRESENTATION OF PLASTICS DESIGN DATA
Section 5.3
OPTICAL PROPERTIES

This section discusses the concept of gloss briefly and refers to BS 2782, Method 515B and ASTM D 523.

35. Transparency of Plastic Sheeting

ASTM D 1746-70 Standard Method of Test for
TRANSPARENCY OF PLASTIC SHEETING
(in Part 35, 1975 Annual Book of ASTM Standards)

This method covers the measurement of the transparency of plastic sheeting in terms of specular transmittance (T_s). Although generally applicable to any translucent or transparent material, it is primarily intended for use with nominally clear and colorless thin sheeting. The apparatus consists of a light source, source aperture, lens system, specimen holder, receptor aperture, photoelectric detector, and an indicating or recording system arranged to measure specular transmittance.

There is no comparable British Standard.

36. Index of Refraction of Transparent Organic Plastics

ASTM D 542-50 (1970) Standard Methods of Test for
INDEX OF REFRACTION OF TRANSPARENT ORGANIC PLASTICS
(in Part 35, 1975 Annual Book of ASTM Standards)

These methods cover the measurement of the index of refraction of transparent organic plastic materials including cast, hot-molded and sheet materials. Two procedures, refractometric and microscopical, are proposed in order to cover satisfactorily the maximum range of indices found in these materials. Both methods require optically homogeneous specimens of uniform index for ease of duplicability. The refractometric method, which is preferred, is based on the standard Abbé refractometer, almost universally used for liquids. For solids, the illuminating prism is removed and replaced by a small test specimen, 1/4" X 1/2" being convenient, which is kept in contact with the fixed prism by a drop of suitable liquid of refractive index of at least 0.01 units greater than the test piece. A variety of liquids for different plastic materials is suggested. The mating face of the specimen must be polished flat and also have one truly perpendicular edge. White light is suggested. According to Ives *et al.* DIN 53491, "Testing of Plastics; Determination of Refractive Index and Dispersion," gives useful advice on practical details relevant to Abbé measurements.

The second, less preferred method, is based on a standard microscope technique in which the apparent thickness of a uniformly thick specimen is determined by focusing on opposite faces alternatively and measuring the traverse. The refractive index is obtained by dividing the true thickness by the apparent thickness.

There is no comparable British Standard.

CHEMICAL TESTS

37. Acetone Extraction of Plastics

ASTM D 494-46 (1972) Standard Method of Test for
ACETONE EXTRACTION OF PHENOLIC MOLDED OR LAMINATED PLASTICS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method covers the determination of the amount of acetone-soluble matter in molded or laminated phenolic products. For molded phenolic products, acetone extraction should be considered solely as a quantitative expression of a property normally associated with degree of cure. For laminated phenolic products acetone extraction indicates change in stage of cure, change in resin content, change in type of resin used, and presence of plasticizers or other acetone-extractable addition agents

Samples of the product are taken, preferably as drillings, and are sieved through a No. 40 sieve (424 μm). That portion which will not pass through a No. 140 sieve (106 μm) shall be used in the test. The sample is then conditioned for at least 40 hrs at 23°C (73.4°F) and 50% RH. In the test a 3.000 g portion of the powdered sample is weighed into a tared, acid-hardened open-texture quantitative filter paper, or into a standard, single-thickness extraction thimble. The sample is then extracted for 4 hrs with 50 ml acetone in either of two types of extraction apparatus shown in figures. The first type is not named, but the second type is the Wiley-Richardson type. The first type is more suitable for use with small electric hot plates, since it uses a flat-bottomed Erlenmeyer flask. The Wiley-Richardson type apparatus, which is tube-shaped, is more suitable for use with oil or water baths. After extraction, with the siphon filling and emptying between 15-20 times per hour, the extracted material is dried to constant weight in a well-ventilated drying chamber at 50°C. The percent acetone extractable matter is then calculated.

This method is quite comparable to BS 2782, Method 401A. Minor differences are found in both methods. D 494 suggests 2 types of extraction apparatus, while 401A suggests three. There is a slight difference in one of the sieves used and in the extraction process.

FEDERAL TEST METHOD STD. NO. 406/Method 7021
PLASTICS: METHODS OF TESTING - ACETONE EXTRACTION TEST FOR
DEGREE OF CURE PHENOLICS

This method, written in 1961, is based on ASTM D 494-46, the procedure for which is described above.

BS 2782: Part 4: 1970
Method 401A
ACETONE SOLUBLE MATTER IN PHENOLIC MOLDINGS

This method is for determining the percentage of matter that can be extracted by acetone at a temperature near its boiling point from a finely ground sample of a phenolic molding. The extraction is carried out under specified conditions for a specified time, and while a high proportion of the soluble matter is determined, extraction is not necessarily complete. The test for acetone soluble matter is one means of determining the relative degree of cure of phenolic molding, but the results are only comparative, because the extracted material normally contains a proportion of substances other than any undercured resin which may be present, e.g. lubricants, coloring matter and plasticizers. The experimental details are substantially the same as those of ISO Recommendation R59, "Determination of the Percentage of Acetone Soluble Matter in Phenolic Moulding".

The sample is reduced to powder according to suggested procedures. The powder used for testing is that portion passing through a $425\mu\text{m}$ (36 mesh) screen but retained by a $250\mu\text{m}$ (60 mesh) screen. Extraction is similar to ASTM D 494, except that siphoning takes place at a rate of 20 - 30 times per hour for 6 hours. The extracted material is dried on a hot plate, the surface of which is kept at not over 50°C to evaporate most of the acetone. Drying is completed in an oven at 50°C until constant weight is reached, and the percent extracted matter calculated.

As indicated, this method is quite similar to ASTM D 494-46 (1972).

BS 2782: Part 4: 1970
Method 401B
ACETONE SOLUBLE MATTER IN PHENOLIC MOULDING MATERIAL AFTER MOULDING

This method is based on Method 401A, but is for determining whether a given phenolic molding material can be used to produce moldings that contain not more than a relatively small amount of acetone soluble matter. In this method a molding of specified dimensions is prepared under specified conditions from the molding material under test and the acetone soluble matter in this molding is determined in accordance with Method 401A.

There is no comparable ASTM method.

BS 2782: Part 4: 1970
Method 401C
ACETONE SOLUBLE MATTER (RESIN CONTENT) IN PHENOLIC MOULDING MATERIAL BEFORE MOULDING

This method is for determining the percentage of acetone soluble matter in molding material in its unmolded state. The value obtained is what is conventionally designated "resin content"

in some countries. While the extract consists mainly of phenolic resin and hexamine, other acetone-soluble components such as lubricants and dyestuffs are normally also present and will be reported as resin. The method applies only to molding materials based upon novolak resins and not to those based upon resols, as this type of resin may not be completely soluble in acetone.

The experimental details of Method 401C are the same as those of ISO Recommendation R 308 "Determination of the Acetone Soluble Matter (Resin Content of Material in the Unmolded State) of Phenolic Moulding Materials". In the extraction a 4-5g sample shall be extracted with 100 ml of acetone, siphoning at a rate of 20 - 30 times per hr for 16 hrs. Drying is accomplished in vacuo over concentrated sulfuric acid for 24 hrs.

There is no comparable ASTM method.

ASTM D 2587-68 (1972) Standard Method of Test for ACETONE EXTRACTION AND IGNITION OF STRANDS, YARNS AND ROVING FOR REINFORCED PLASTICS
(in Part 36, 1975 Annual Book of ASTM Standards)

This method covers the determination of the amount of acetone soluble and ignitable material on glass strands, yarns and roving used in reinforced plastics. The percentage extractable of an acetone-soluble size or finish on a glass strand yarn or roving is a measure of the degree of cure of some sizes and finishes. The percentage ignition loss is a measure of the ignitable material on the glass. In the method a specified weight of glass is exposed to acetone in an extraction apparatus for a determined length of time and the percentage extractable determined. The same specimen is then ignited and the weight percent ignition loss is calculated.

The test specimens are conditioned for at least 40 hrs prior to testing at 23°C (73.4°F) and 50% RH. These conditions are also used during testing. The specimen is formed into a 38 mm (1 1/2") to 51 mm (2") long bundle or skein. In the case of roving, a knot is tied in each end of the specimen to prevent fraying, and the bundle or skein is tied securely with the ends of the roving. The specimen is then weighed. Extraction is carried out for 2 hrs with acetone, using the apparatus described in ASTM D 494-46 (1972). After extraction the sample is placed in a marked crucible, which is then placed in an air-circulating oven at 65°C (150°F) for 30 min., then cooled in a desiccator for at least 30 min. The specimen is then removed from the crucible and weighed, then returned to the crucible. The crucible is placed in a muffle furnace at 620°C (1150°F) for 20 min., then removed and cooled in a desiccator for at least 1 hr, after which the specimen is removed again and weighed finally.

There is no comparable British Standard.

38. Water Absorption

ASTM D 570-63 (1972) Standard Method of Test for
WATER ABSORPTION OF PLASTICS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method covers the determination of the relative rate of absorption of water by plastics when immersed. The method is intended to be applied to the testing of all types of plastics, including cast, hot-molded, and cold-molded resinous products, and both homogeneous and laminated plastics in rod and tube form and in sheets 0.13 mm (0.005") or greater in thickness.

Seven procedures are included in this method, differing in their severity of duration and temperature, but not altered by the chemical nature of the material under examination. Different test specimens are used, however, according to the physical form thereof.

Molded plastics - disc 2" diam (50.8 mm) X 1/8" (3.2 mm) thick

Sheet - 1" (2.54 cm) for rods 1" in diam or under,
and 1/2" (1.27cm) for rods of greater diam

Tube - 1" (2.54 cm) long for tubes of i.d. less
than 3" (7.62 cm) or more, the specimen is
3" in length cut on the circumferential direc-
tion and 1" (2.54 cm) in width cut lengthwise.

Three test specimens are used. For materials the water absorption characteristics of which may be affected by temperature in the region of 110°C, conditioning is carried out at 50°C for 24 hrs, after which the specimen is cooled in a desiccator and then immediately weighed. For materials unaffected by a temperature of 110°C the conditioning is at 105-110°C for 1 hr.

The seven procedures are:

1. 24 hrs in distilled water at 23°C on edge
2. Ditto, but for 2 hrs
3. As in 2 followed by 1, total immersion period being 24 hrs
4. After 1, reimmerse, weigh at end of first week and thereafter at two-week intervals until equilibrium is substantially obtained (as defined)
5. 2 hrs in boiling distilled water, on edge; cool in distilled water at RT for 15 min
6. As 5, but for 30 min
7. As 5, but in distilled water at 50°C for 48 hrs

For comparing materials, it is specified that both procedures 1 and 4 be used. After all immersion treatments the specimens are wiped off with a dry cloth and weighed immediately. With specimens 1/16" or less in thickness, a weighing bottle must be used.

This method is approximately comparable to BS 2782, Methods 502A-G and Methods 503A-C.

FEDERAL TEST METHOD STD. NO. 406/Method 7031
PLASTICS: METHODS OF TEST - WATER ABSORPTION OF PLASTICS

This method, prepared in 1961, is based on ASTM D 570-59aT. It appears to be similar to the procedure for D 520-63 (1972).

BS 2782: Part 5: 1970
Methods 502A-G
WATER ABSORPTION AND WATER SOLUBLE MATTER

These methods are for determining the mass of water absorbed as a result of immersion in water for a specified time and at a specified temperature by either a molded or cast test specimen or one cut or machined to shape from sheet, rod or rectangular tube. Comparison of the water absorptions of materials is possible only when test specimens of identical dimensions are used.

BS 2782: Part 5: 1970
Method 502A
WATER ABSORPTION OF PHENOLIC MOULDING MATERIAL

In this method a molded disc 52.1 mm (2.05") in diameter and 11.94 mm (0.47") thick is machined and glass-paper finished on all surfaces to 48.26 mm (1.40") in diameter and 10.16 mm (.400") in thickness. The specimens are dried for 1 hr at 50°C, cooled in a desiccator and weighed after removal. The specimens are then immersed for 168 hrs (7 days) in distilled water at 25°C. Specimens are then removed, dried with a clean cloth or filter paper, and reweighed. The water absorption is then calculated.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 4, but the latter requires weighing at intervals until equilibrium is reached.

BS 2782: Part 5: 1970
Method 502B
COLD WATER ABSORPTION OF AMINOPLASTIC MOULDING MATERIAL

In this method, a molded disc 50.8 mm (2") in diameter and 3.2 mm (1/8") in thickness is used as a test specimen. The specimens are dried for 24 hrs at 50°C, cooled in a desiccator, and weighed after removal. The specimens are then immersed for 24 hrs in distilled water at 23°C. Specimens are then removed, dried with a clean cloth or filter paper, and reweighed. The water absorption is then calculated. Provision is made for correcting the water absorption figure for the amount of dry water-soluble matter that may be present.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 1.

BS 2782: Part 5: 1970

Method 502C

WATER ABSORPTION AND WATER SOLUBLE MATTER OF POLYVINYL CHLORIDE EXTRUSION COMPOUND

In this method a 50.8 mm (2") diameter disc is knife-punched from sheet 1.27 mm (.050") thick. All weighings are carried out in a weighing bottle. The test specimens are dried over CaCl_2 or other desiccant at RT and atmospheric pressure for 24 hrs, then weighed. The specimens are then immersed in distilled water for 48 hrs at 50°C, then removed, cooled at 20°C for 15-45 min, dried with a clean cloth or filter paper, and reweighed within 5 min after removal from water. After drying further over desiccant the samples are weighed at daily intervals to constant weight. The water absorption is then calculated. Provision is made for the amount of any water-soluble matter that may be present.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 7.

BS 2782: Part 5: 1970

Method 502D

WATER ABSORPTION OF LAMINATED SHEET

In this method two test specimens 38.1 mm (1 1/2") squares of thickness no greater than 25.4 mm (1") are used. The specimens are weighed, immersed in distilled water at 23°C for 24 hrs, removed, dried with a clean cloth or filter paper, and reweighed. The water absorption is then calculated.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 1.

BS 2782: Part 5: 1970

Method 502E

WATER ABSORPTION OF LAMINATED TUBE AND ROD

In this method two test specimens 38.1 mm (1 1/2") long are used. The dimensions of the cross section are measured and the specimen weighed and then immersed for 24 hrs in distilled water at 23°C. The specimens are removed, dried with a clean cloth or filter paper, and reweighed. The water absorption is then calculated.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 1.

BS 2782: Part 5: 1970
Method 502F
WATER ABSORPTION. PROCEDURE A OF ISO METHOD

The experimental details of this method are the same as those of Procedure A of ISO Recommendation R 62, "Determination of Water Absorption". As with ASTM D 570-63 (1972), different test specimens are used, according to the physical form thereof.

- Molding Material - disc 50 mm diam and 3 mm thick
- Extrusion Compound - disc 50 mm diam and 3 mm thick
- Sheet - 50 mm square
- Tube and Rod - 50 mm long
- Casting and Laminating
Resin Systems - 50 mm square and 3 mm thick

Three test specimens are used. They are dried for 24 hrs at 50°C, cooled in a desiccator, weighed, immersed in distilled water at 23°C for 24 hrs, removed, dried with a clean dry cloth or filter paper, and then reweighed. The water absorption is then calculated.

This method is reasonably similar to ASTM D 570-63 (1972), Procedure 1.

BS 2782: Part 5: 1970
Method 502G
WATER ABSORPTION. PROCEDURE B OF ISO METHOD

The experimental details of this method are the same as those of Procedure B of ISO Recommendation R 62, "Determination of Water Absorption". As with ASTM D 570-63 (1972), different test specimens are used, according to the physical form thereof.

- Molding Material - disc 50 mm diam and 3 mm thick
- Extrusion Compound - disc 50 mm diam and 3 mm thick
- Sheet - 50 mm square
- Tube and Rod - 50 mm long
- Casting and Laminating
Resin Systems - 50 mm square and 3 mm thick

Provision is made for correcting the water absorption figure for the amount of any water-soluble matter that may be present. Three test specimens are used. They are dried for 24 hrs at 50°C, cooled in a desiccator, weighed, immersed in distilled water at 23°C for 24 hrs, removed, dried with a clean cloth or filter paper, and then reweighed. The specimens are then redried in an oven for 24 hrs at 50°C, cooled in a desiccator, and again weighed. The water absorption, corrected as indicated above, is then calculated.

This method is reasonably similar to ASTM D 570-63 (1972), Procedure 1.

BS 2782: Part 5: 1970
Method 503A-C
BOILING WATER ABSORPTION

These methods are for determining the mass of water absorbed as a result of immersion in boiling water for a specified time by either a molded test specimen or one cut to shape from sheet, rod, or rectangular tube. Comparison of the boiling water absorptions of materials is possible only when test specimens of identical dimensions are used.

BS 2782: Part 5: 1970
Method 503A
BOILING WATER ABSORPTION OF AMINOPLASTIC MOULDING MATERIAL

In this method two test specimens consisting of molded discs 50.8 mm (2") in diameter and 3.2 mm (1/8") in thickness (same as Method 502B) are dried for 24 hrs at 50°C, cooled in a desiccator, and weighed after removal. The specimens are then immersed for 24 hrs in boiling distilled water. Specimens are then cooled for 15 min in water at 20°C, removed, dried with a clean cloth or filter paper, and reweighed. The water absorption is then calculated.

This method is reasonably similar to ASTM D 570-63 (1972), Procedure 5, except that the boiling period in the latter method is only 2 hrs, not 24 hrs.

BS 2782: Part 5: 1970
Method 503B
BOILING WATER ABSORPTION. PROCEDURE A OF ISO METHOD

The experimental details of this method are the same as those of Procedure A of ISO Recommendation R 117, "Determination of Boiling Water Absorption". As with ASTM D 570-63 (1972), different test specimens are used, according to the physical form thereof.

Molding Material - disc 50 mm diam and 3 mm thick
Extrusion Compound - disc 50 mm diam and 3 mm thick

Sheet - 50 mm square

Tube and Rod - 50 mm long

(Note that these specifications are as for Method 502F, except that Casting and Laminating Resins are not covered).

Three test specimens are used. They are dried for 24 hrs at 50°C, cooled in a desiccator, weighed, immersed for 30 min in boiling distilled water, removed, cooled for 15 min in water at 20°C, dried with a clean cloth or filter paper, and then reweighed. The water absorption is then calculated.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 6.

BS 2782: Part 5: 1970

Method 503C

BOILING WATER ABSORPTION. PROCEDURE B OF ISO METHOD

The experimental details of this method are the same as those of Procedure B of ISO Recommendation R 117, "Determination of Boiling Water Absorption". As with ASTM D 570-63 (1972), different test specimens are used, according to the physical form thereof.

Molding Material - disc 50 mm diam and 3 mm thick

Extrusion Compound - disc 50 mm diam and 3 mm thick

Sheet - 50 mm square

Tube and Rod - 50 mm long

(Note that these specifications are as for Method 502G, except that Casting and Laminating Resins are not covered, and except that there is a minor difference in the temperature tolerance).

Provision is made for correcting the water absorption figure for the amount of any water-soluble matter that may be present. (Note: This statement is not made, however). Three test specimens are used. They are dried for 24 hrs at 50°C, cooled in a desiccator, weighed, immersed for 30 min in boiling distilled water, removed, cooled for 15 min in water at 20°C, dried with a clean cloth of filter paper, and then reweighed. The specimens are then redried in an oven for 24 hrs at 50°C, cooled in a desiccator and reweighed. The water absorption is then calculated.

This method is reasonably close to ASTM D 570-63 (1972), Procedure 6, except that the British Standard corrects for water-soluble matter present.

39. Water Vapor Permeability

ASTM E 96-66 (1972) Standard Methods of Test for
WATER VAPOR TRANSMISSION OF MATERIALS IN SHEET FORM
(in Part 35, 1975 Annual Book of ASTM Standards)

These methods cover the determination of the rate of water vapor transmission (WVT) of materials in sheet form. The methods are applicable to materials such as paper, plastic films, and sheet materials in general. They are most suitable for specimens 1/8" (3.18 mm) or less in thickness, but may be used with caution for somewhat thicker specimens.

The material to be tested is fastened over the mouth of a dish, which contains either a desiccant or water. The assembly is placed in an atmosphere of constant temperature and humidity, and the weight gain or loss of the assembly is used to calculate the rate of water vapor movement through the sheet material. The procedures are as follows:

Procedure A - Desiccant Method at 23°C (73.4°F). 0% RH in dish, 50% RH outside dish. For use when the materials to be tested are employed in the low range of humidities. Similar to BS 2782, Method 513A, except that the BS uses 75% RH instead of 50% RH.

Procedure B - Water Method at 23°C (73.4°F). 100% RH in dish, 50% RH outside dish. For use when the materials to be tested are employed in the high range of humidities, but will not normally be wetted. There is no comparable British Standard method.

Procedure BW - Inverted Water Method at 23°C (73.4°F). 100% RH in dish (sheet is wet), 50% RH outside dish. For use when materials to be tested may in service be wetted on one surface, but under conditions where the hydraulic level is relatively unimportant and moisture transfer is governed by capillary and water vapor diffusion forces. There is no comparable British Standard method.

Procedure C - Desiccant Method at 32.2°C (90°F). 0% RH in dish, 50% RH outside dish. Conducted at an elevated temperature for use with materials employed in the low range of humidities, and intended to shorten the time of testing with highly impermeable materials. There is no comparable British Standard method.

Procedure D - Water Method at 32.2°C (90°F). 100% RH in dish, 50% RH outside dish. Conducted at an elevated temperature for materials employed in the high range of humidities, but not normally wetted, and intended to shorten the time of testing of highly impermeable materials employed in this range. There is no comparable British Standard method.

Procedure E - Desiccant Method at 37.8°C (100°F). 0% RH in dish, 90% RH outside dish. For use in measuring the WVT at an elevated temperature, with a very low humidity in one side of the sheet and a high humidity on the other. Similar to BS 2782, Method 513B.

ASTM E-96, in addition to defining water vapor transmission as identical to water vapor permeability in BS 2782, Methods 513A-B, also defines water vapor permeance as water vapor transmission divided by vapor pressure differential across the specimen surface, and water vapor permeability as the permeance reduced to unit thickness.

Similarities of individual procedures with BS methods under BS 2782 are discussed above under the individual procedures.

BS 2782: Part 5: 1970
Methods 513A-D
PERMEABILITY TO WATER VAPOUR

These methods consist of both metal dish and sachet (packet) tests. Methods 513A and 513B, which are taken from the relevant parts of BS 3177, "Method for Determining the Permeability to Water Vapor of Flexible Sheet Materials Used for Packaging", are for determining the permeability to water vapor of plastics as defined by the mass of water vapor in grams/sq met/24 hrs passing through a test specimen in film or sheet form under specific conditions of temperature and humidity. In these methods (513A & B) the test specimen is sealed with wax over the mouth of a dish containing a desiccant. Methods 513C and D are suitable only for testing thermoplastic materials in the form of film that can be heat-sealed and where the transmission through the seal is known to be considerably less than through the film. The methods of testing are similar to Methods 513 A and B, except that the desiccant is contained in a heat-sealed capsule (sachet) of the material under test, instead of in a metal dish.

BS 2782: Part 5: 1970
Method 513A
WATER VAPOUR PERMEABILITY (TEMPERATE CONDITIONS) USING METAL DISH

The procedure is as described above, for testing at 25°C and 75% RH, with 0% RH in the dish. This method is comparable to ASTM E 96, Procedure A, except that 50% RH is used in E 96.

BS 2782: Part 5: 1970
Method 513B
WATER VAPOUR PERMEABILITY (TROPICAL CONDITIONS) USING METAL DISH

The procedure is as described above, for testing at 38°C and 90% RH, with 0% RH in the dish. This method is comparable to ASTM E 96, Procedure E.

BS 2782: Part 5: 1970

Method 513C

WATER VAPOUR PERMEABILITY (TEMPERATE CONDITIONS) USING SACHET OF MATERIAL UNDER TEST

The procedure is as described above, for testing at 25°C and 75% RH, with 0% RH in the disc. There is no closely comparable ASTM method, although ASTM D 3079-72, "Water Vapor Transmission of Flexible Heat-Sealed Packages for Dry Products", bears some resemblance. The ASTM method does not use a standard pouch size, however, and calculations are on a package rather than an exposed-surface-area basis.

BS 2782: Part 5: 1970

Method 513D

WATER VAPOUR PERMEABILITY (TROPICAL CONDITIONS) USING SACHET OF MATERIAL UNDER TEST

This procedure is as described above, for testing at 38°C and 90% RH, with 0% RH in the dish. There is no closely comparable ASTM method, although ASTM D 3079-72, "Water Vapor Transmission of Flexible Heat-Sealed Packages for Dry Products", bears some resemblance. The ASTM method does not use a standard pouch size, however, and calculations are on a package, rather than an exposed-surface-area basis.

ASTM C 355-64 (1973) Standard Methods of Test for
WATER VAPOR TRANSMISSION OF THICK MATERIALS
(in Part 18, 1975 Annual Book of ASTM Standards)

These methods cover the determination of water vapor transmission of materials through which the passage of water vapor may be of importance, such as fiberboards, gypsum and plaster products, wood products, and plastics (particularly foams). The specimens are generally limited to specimens between 1/8" (3mm) and 1 1/4" (32 mm). Two methods are used:

Desiccant Method - in this method the test specimen is sealed to the mouth of a test dish containing a desiccant, and the assembly placed in a controlled atmosphere at 50% RH. Periodic weighings determine the rate of water vapor movement through the specimen into the desiccant.

Water Method - in this method the dish contains pure water and the weighings determine the rate of water vapor movement through the specimens from the water. The test chamber is also at 50% RH.

(Note: the vapor pressure differential is normally the same in both methods, but results by the Water Method are frequently much higher).

Definitions are given for terms used in the method, such as rate of water vapor transmission (WVT), water vapor permeance, and water vapor permeability. Test temperatures may be any temperatures between 70 and 90°F (21 and 32°C) although the latter is recommended.

The Desiccant Method is somewhat similar to BS 4370, Method 8. There are differences in the type of test units and the test conditions, however. The ASTM method calls for a test dish, usually shallow, while the BS method calls for a beaker. No water method is used in the BS procedure, and the most severe condition is 38°C (100°F) and 88 vs 0% RH. The alternate procedure calls for 25°C (77°F) and 75 vs 0% RH.

BS 4370: Part 2: 1973
METHODS OF TEST FOR RIGID CELLULAR MATERIALS
Method 8
MEASUREMENT OF WATER VAPOUR TRANSMISSION

This method is for determining the water vapor transmission of rigid cellular materials under the following conditions:

38°C (100°F) and 88 vs 0% RH
25°C (77°F) and 75 vs 0% RH

The apparatus consists of suitably-sized containers, such as 250-ml beakers of glass or metal, of 65 mm i.d., the tops being slightly belled out to admit a wax seal. Granular calcium chloride is used to provide the 0% RH condition. Appropriate salt solutions may be used to provide the 75 and 88% RH conditions. Weighings are carried out until a constant rate of gain is obtained, at which time the WVT is calculated.

As discussed above, this method is somewhat similar to the Desiccant Method under ASTM C 355-64 (1973). The differences were discussed under that specification.

FEDERAL TEST METHOD STD. NO. 406/Method 7032
PLASTICS: METHODS OF TESTING - WATER VAPOR PERMEABILITY

This method, prepared in 1961, is based on ASTM D 96-53T. Only two procedures are given (compared to six in E 96-66 (1972)), the Desiccant Method (Method A) and the Water Method (Method B). See ASTM E 96-66 (1972) discussion above for details.

ASTM D 1653-72 Standard Method of Test for
MOISTURE VAPOR PERMEABILITY OF ORGANIC COATING FILMS
(in Part 27, 1975 Annual Book of ASTM Standards)

This method covers determination of the rate at which moisture passes through films of paint, varnish, lacquer and other organic coatings. The films may be free films which have been prepared on and removed from glass, silvered glass, tin foil, tin plate, or other suitable substrate, or they may be on substrates, such as thin plywood, glass cloth, paper or cellophane. In the method a film of the coating under test is fastened over the mouth of a cup containing water, and the assembly is placed in a desiccated atmosphere. The assembly is weighed at intervals, and for the period in which the loss of weight is constant with time, the results are used to calculate the rate of water vapor movement through the film. The test cup is designed to have an exposed film surface area of 25 cm². One type of cup recommended is the Gardner-Parks Permeability Cup. Testing is usually carried out at 25°C, but 38°C has also been used for a slightly accelerated test which does not require cooling equipment during removal.

(Note: The only British Standards available to the writer were those involving plastics and not paint and varnish films, but it is possible and even probable that there is a British Standard reasonably comparable to this procedure.)

ASTM F 372-73 Standard Method of Test for
WATER VAPOR TRANSMISSION OF FLEXIBLE BARRIER MATERIALS USING
AN INFRARED DETECTION TECHNIQUE
(in Part 21, 1975 Annual Book of ASTM Standards)

This relatively new (1973) method covers a rapid procedure for determining the rate of water vapor transmission of flexible barrier materials in film or sheet form. The method is applicable to sheets and films up to 3 mm in thickness, consisting of single or multilayer synthetic or natural polymers and metal foils, including coated materials. In the procedure a dry chamber is separated from a wet chamber of known temperature and humidity by the barrier material to be tested. The time for a given increase in water vapor concentration of the dry chamber is measured by monitoring the differential between two bands in the infrared spectral region, one in which water molecules absorb and the other where they do not. This information is then used to calculate the water vapor movement through a known area of barrier material.

The apparatus used is available as the Mo Con IRD-2 from Modern Controls, Inc., Minneapolis, Minn. Correlation with ASTM E 96 techniques is very good. Testing is normally carried out at 38°C (100°F) and 90% RH.

There is no BS equivalent of this method.

40. Resin Content of Glass Reinforced Plastics

ASTM D 2584-68 (1972) Standard Method of Test for
IGNITION LOSS OF CURED REINFORCED RESINS
(in Part 36, 1975 Annual Book of ASTM Standards)

This method covers the determination of the ignition loss of cured reinforced resins. If only glass fabric or filament is used as the reinforcement of an organic resin that is completely decomposed to volatile materials under the conditions of this test and the small amount of volatiles (water, residual solvent) that may be present is ignored, the ignition loss can be considered to be the resin content of the sample. The method does not provide a measure of resin content for samples containing reinforcing materials that lose weight under the conditions of the test, or containing resins, such as silicones, that do not decompose to volatile materials released by ignition.

In the test the specimen contained in a crucible is ignited and allowed to burn until only ash and carbon remained. The carbonaceous residue is reduced to an ash by heating in a muffle furnace at 565°C (1050°F), cooled in a desiccator, and weighed.

This procedure is comparable to BS 2782, Method 107K.

ASTM D 3171-73 Standard Method of Test for
FIBER CONTENT OF REINFORCED RESIN COMPOSITES
(in Part 36, 1975 Annual Book of ASTM Standards)

This method covers the determination of the fiber content of resin matrix composites. The technique is based on the digestion of the matrix resin by oxidizing solvents, which do not attack the fibers excessively. The method consists of digesting the resin portion of a weighed composite specimen in a hot digestion medium, usually an oxidizing solution. The residue is filtered, washed, dried, and weighed. The weight percent of fiber can then be converted to a volume percent if the fiber density is known. A correction for the weight loss of fiber may be made. Two procedures are given. Procedure A is for resins such as epoxies, which are digestible by nitric acid. Procedure B is for resins such as polyimides or phenolics, which are digestible by aqueous sulfuric acid-hydrogen peroxide mixture. Although not so stated, this method is intended primarily for graphite fiber composites, the fibers of which would lose weight under ASTM D 2584-68 (1972). It may be used for glass-reinforced plastics where combustion furnaces are not available.

There is no comparable BS method.

BS 2782: Part 1: 1970

Method 107J

RESIN CONTENT OF SYNTHETIC RESIN IMPREGNATED GLASS FABRIC

This method is used for determining the percentage of combustible resin in synthetic-resin-impregnated glass fabric by igniting a 100 mm² sample of the material at 575°C (1067°F), finding the loss of mass, and subtracting from this the percentage of volatile matter determined by Method 107H, "Percentage of Volatile Matter in Synthetic Resin Impregnated Glass Fabric". The method is suitable for testing the product known as "pre-impregnated" glass fabric ("prepregs"), i.e., synthetic resin-impregnated glass fabric that can be purchased as such and used for the manufacture of moldings. It is not suitable for testing glass fabrics that are impregnated either with silicone resins or with systems containing filler that loses mass at 600°C (1112°F).

There is no comparable ASTM method.

BS 2782: Part 1: 1970

Method 107K

RESIN CONTENT OF GLASS-REINFORCED LAMINATES

This method is for determining the percentage of synthetic resin in laminates with glass filler by igniting a sample of the material at 575°C (1067°F) and finding the loss of mass. The method is not suitable for testing laminates bonded with silicone resins or with systems containing filler, such as graphite, that lose mass at 600°C (1112°F). Results obtained by this method on a material based on cloth that has not been de-sized, or on chopped strand mat, will represent both resin content and size or binder content. The test specimen may be of any convenient shape, provided that it is representative of the material and that its mass is not less than 5 g. A rectangular specimen with a surface area not less than 400 mm² (0.62 in²) and whose shorter edges are not less than 12 mm long, is usually suitable.

This method is comparable to ASTM D 2584-68 (1972).

41. Soluble Chlorides and Sulfates

BS 2782: Part 4: 1970
Methods 402A-G
ANALYSIS OF WATER EXTRACT OF PHENOLIC MOULDING

Method 402E
SULFATES IN PHENOLIC MOULDINGS

This method is for determining sulphates in hot-water extract of phenolic moldings. The values obtained are not intended to be absolute measures of the amounts of substances which are present in the molding. The percentage of sulphates shall be found by determining by any generally accepted method, the amount of sulphate in the filtered water extract prepared or in Method 402A, "Ammonia and Ammonium Compounds in Phenolic Mouldings". It shall be expressed as sodium sulphate (Na_2SO_4).

There is no comparable ASTM method.

BS 2782: Part 4: 1970
Method 402F
CHLORIDES IN PHENOLIC MOULDINGS

This method is for determining chlorides in a hot-water extract of phenolic moldings. The values obtained are not intended to be absolute measures of the amounts of the substances which are present in the molding. The percentage of chloride shall be found by determining, by any generally acceptable method, the amount of chlorides in the filtered water extract prepared as in Method 402A, "Ammonia and Ammonium Compounds in Phenolic Moldings". It shall be expressed as sodium chloride (NaCl).

There is no comparable ASTM method.

BS 2782: Part 4: 1970
Methods 406A-C
ANALYSIS OF WATER EXTRACT OF POLYTHENE COMPOUND

Method 406B
WATER-SOLUBLE SULPHATES IN POLYTHENE COMPOUND

This method is for determining the percentage of water-soluble sulphate in polythene (polyethylene in U.S. usage) by determining the amount present in a hot-water extract of a powdered sample of the material. The percentage of water-soluble sulphates shall be found by determining, by any generally accepted method, the amount of sulphates, calculated as sodium sulphate (Na_2SO_4), in the filtered water extract prepared as in Method 406A, "pH of Water Extract

of Polythene Compound". The result shall be expressed as a percentage of the mass of the sample of polythene compound that has been used for extraction.

There is no comparable ASTM method.

BS 2782: Part 4: 1970

Method 406C

WATER-SOLUBLE CHLORIDES IN POLYTHENE COMPOUND

This method is for determining the percentage of water-soluble chloride in polythene (polyethylene in U.S. usage) by determining the amount present in a hot-water extract of a powdered sample of the material. The percentage of water-soluble chlorides shall be found by determining, by any generally accepted method, the amount of chlorides, calculated as sodium chloride (NaCl), in the filtered water extract prepared as in Method 406A, "pH of Water Extract of Polythene Compound". The result shall be expressed as a percentage of the mass of the sample of polythene compound that has been used for extraction.

There is no comparable ASTM method.

42. Resistance of Plastics to Chemical Reagents

ASTM D 543-67 (1972) Standard Method of Test for
RESISTANCE OF PLASTICS TO CHEMICAL REAGENTS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method lays down general procedures for the testing of all plastic materials, including cast, hot-molded, cold-molded, laminated resinous products, and sheet materials, for resistance to chemical reagents. (Note: films are covered by ASTM D 1239 described below). Fifty (50) standard reagents are specified to establish results on a comparable basis. Provisions are made for various exposure times and exposure to reagents at elevated temperatures. Evaluation of chemical resistance is obtained by two methods, Procedure I. Weight and Dimension Changes, and Procedure II. Mechanical Property Changes. Standard test specimen configurations are given for each of these procedures, both for molding and extrusion materials and sheet materials. Specimens are conditioned before testing at 23°C (73.4°F) and 50% RH, and testing is ordinarily carried out under the conditions, unless otherwise specified (as 50°C and 70°C).

In Procedure I the thickness of each conditioned specimen is measured at the center and its length and width, or two diameters at right angles to each other, determined. In laminates, it may be necessary to measure thickness both at the center and at the edges. The specimens are then placed in the appropriate reagent for 7 days in the Standard Laboratory Atmosphere. Usually the specimens are suspended in the containers. The quantity of reagent used depends on the type of material being tested. The reagents are stirred every 24 hrs. After 7 days, or other agreed-on period, the specimens are removed, weighed in a weighing bottle, and remeasured. Specimens removed from acid, alkali or other aqueous solutions are washed with running water, wiped dry, and weighed. Directions are given for rinsing, if necessary, specimens removed from other types of reagents.

Notes are taken on the appearance and the percentage increase or decrease in length and width, or in the two diameters, and in the thickness, is calculated. The average percentage gain or loss in weight is also calculated.

In Procedure II, the specimens are placed in the appropriate reagents as in Procedure I. Mechanical property tests are made on both nonimmersed and immersed specimens prepared from the same sample or lot of material in the same manner, and run under identical conditions. Testing is carried out immediately after exposure. Tensile tests are recommended for most uses, but other mechanical properties may be more significant in special cases.

For example, for rigid plastic, flexure tests may be carried out, since they are particularly sensitive in detecting the development of surface cracks.

There is no fully comparable British Standard method, although BS 2782, Method 505A bears some resemblance for one specialized application, and BS 4618, Section 4.1 is generally quite similar.

FEDERAL TEST METHOD STD. NO. 406/Method 7011
PLASTICS: METHODS OF TESTING - RESISTANCE OF PLASTICS TO
CHEMICAL REAGENTS

This method, prepared in 1961, is based on ASTM D 543-60. Only 22 reagents (14 Standard and 8 supplementary) are listed, compared to the newer ASTM D 543-67 (1972), which lists 50. Undoubtedly there are other differences. The method should be replaced by the entire new ASTM method.

ASTM D 1239-55 (1971) Standard Method of Test for
RESISTANCE OF PLASTIC FILMS TO EXTRACTION BY CHEMICALS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method for resistance of plastic films to chemicals covers the measurement of the weight loss of film (sheeting not greater than 0.25 mm (0.010")) after immersion in chemicals. The method is intended to be a rapid empirical test to determine the loss of the plasticizer or other extractable components from the plastic film when immersed in liquids commonly used in households. Such chemicals may be distilled water, 1% soap solution, cottonseed oil, mineral oil, kerosene, 50% ethyl alcohol, or any of the other standard or supplementary reagents listed in ASTM D 543, described above.

Specimens, squares of side 50 mm, are first conditioned, then weighed and afterwards immersed by vertical suspension in 400 ml of the test liquid which has been already maintained for at least 4 hrs at the test temperature. After the period of immersion (24 hrs at 23°C in the standard), the specimens are rinsed in certain cases, gently wiped with soft cloth or absorbent tissue and reweighed. (For non-volatile media with good adhesion to the film, a technique is provided for estimating the "blank" absorption.

There is no fully comparable British Standard, although BS 4618, Section 4.1: 1972, "Chemical Resistance to Liquids," appears to be quite similar in many respects. BS 4618 does not prescribe a 24 hr test period however, but leaves the time flexible.

ASTM D 2299-68 Standard Recommended Practice for
DETERMINING RELATIVE STAIN RESISTANCE OF PLASTICS
(in Part 35, 1975 Annual Book of ASTM Standards)

This method describes how to carry out tests for determining relative stain resistance, not so much by chemicals as by the hazards of everyday life, such as coffee, tea, lipstick, shoe polish, etc. The specific hazard of sulfide staining is covered by ASTM D 1712-65 (1971), "Resistance of Plastics to Sulfide Staining".

The test specimens shall have a flat, smooth surface, long enough to permit a test area 25 mm^2 for visual evaluation, or larger, if necessary, for instrumental evaluation. Thermosetting decorative laminates are wet-rubbed with abrasive just sufficiently to remove surface gloss, then washed with a mild soap or detergent. Samples shall be conditioned at 23°C (73.4°F) and 50%RH for at least 40 hrs prior to testing. Testing shall also be carried out under these conditions, unless otherwise specified. For low-viscosity liquids, the specimen is immersed in the staining material in a glass container, which is then closed tightly. For viscous liquids and pastes, the specimen is placed under test on a flat surface and a thin coating (approx. 0.1 mm) applied with an applicator. For solid staining materials, such as wax crayon or lipstick, a uniform opaque coating is applied. The specimens are placed in an oven at 50°C for 16 hrs, then removed and excess staining material removed from the surface. The degree of stain is then rated by visual or instrumental means.

There is no comparable British Standard.

ASTM D 1712-65 (1971) Standard Method of Test for
RESISTANCE OF PLASTICS TO SULFIDE STAINING
(in Part 35, 1975 Annual Book of ASTM Standards)

This method covers the determination of the resistance of plastics to staining in the presence of sulfides. Plastic compositions containing salts of lead, cadmium, copper, antimony, and certain other metals (as stabilizers, pigments, driers, or fillers) may stain due to the formation of a metallic sulfide when in contact with external materials that contain sulfide. The external sulfide source may be liquid, solid or gas. Examples of materials that may cause sulfide stains are rubber, industrial fumes, foods, kraft paper, etc. This method provides a means of estimating the relative susceptibility of plastic composition to sulfide staining.

Test specimen shape is not important, but suggestions are given as to acceptable sizes. Conditioning and testing are carried out at 23°C (73.4°F) and 50% RH. In the test half of each specimen is immersed in a 250-ml beaker, or equivalent in saturated hydrogen sulfide solution for 15 min. It is recommended that a control specimen whose staining characteristics are known be included in each test series. After 15 min the specimens are removed, wiped dry, and examined for discoloration of the immersed

section, compared to a sample of the identical plastic composition not exposed to the hydrogen sulfide solution. The relative degree of staining for each material being tested in a series is compared and the relative order of sulfide stain resistance determined.

There is no comparable British Standard.

BS 2782: Part 5: 1970

Method 505A

RESISTANCE TO CONCENTRATED SULPHURIC ACID OF RIGID POLYVINYL CHLORIDE COMPOUNDS

This method is for determining the resistance to concentrated sulfuric acid of rigid polyvinyl chloride extrusion and molding compounds by comparing the shear strength of molded test specimens with that of similar specimens that have been immersed for 24 hrs in concentrated sulfuric acid at 95-100°C (203-212°F). The method is based on comparison of shear strength of discs 0.43 mm (0.17") thick and 25.27 mm (1") in diameter, before and after immersion in the acid. The shear strength test is essentially that of Method 305A of BS 2782. The results are expressed as the percentage retention of shear strength.

There is no comparable ASTM method. As indicated above BS 2782, Method 305A for measuring shear strength of molding material is approximately equivalent to ASTM D 732-46 (1969), except that Method 305A is more restrictive. ASTM D 543-67 (1972), "Resistance of Plastics to Chemical Reagents" can be used to test the effects of sulfuric acid exposure on mechanical properties, but exposure in this method is for 7 days instead of 24 hrs. Also, D 543 is written to cover many reagents and dimensional and weight changes in addition to mechanical properties.

BS 4618: 1972

RECOMMENDATIONS FOR THE PRESERVATION OF PLASTICS DESIGN DATA

Section 4.1

CHEMICAL RESISTANCE TO LIQUIDS

The aim of this Section is to lay down procedures for testing plastics materials without externally applied stresses, accepting as typical the amount of strain normally present in the materials as manufactured. The procedures include the reporting of test results so that quantitative comparisons can be made of changes in dimensions and mechanical properties, supplemented by quantitative comparisons of the changes in visual appearance. The section includes a comprehensive procedure covering a list of 41 chemical substances, based on ISO/R 175, "Plastics - Determination of the Resistance of Plastics to Chemical Substances".

Molding material specimens should be 3 mm (1/8") thick, or as cut from a molding. Sheet or film specimens should be the actual thickness of the sheet or film, but no greater than 20 mm (2 5/32") thick. The test specimens should be totally immersed in the chosen liquid. The ratio of the volume of the liquid to the total surface area of the specimen should ordinarily be not less than 8 ml to 100 mm². Test temperature should include 23°C (73.4°F) and the manufacturer's recommended maximum service temperature. Exposure periods are flexible, with a maximum of 16 weeks. Test specimens for changes in dimensions should be squares of 50 mm (1 31/32") sides or discs of 50 mm (1 31/32") diameter. Changes in the following properties should be recommended for studies in change of appearance: color, opacity, gloss or roughness of surface, development of cracking, crazing, blistering, pitting, material easily rubbed off the surface, tackiness, delamination, warping or other distortion. The extent of changes should be recorded in a scale of 4 ratings, indicating magnitude of change. Suggestions are given us to the types of mechanical properties tests to be carried out. Examples are given of ways of reporting results in tabular form (change in appearance) and in graphical form (changes in dimension and mechanical properties).

This procedure is quite comparable to ASTM D 543-67 (1972) and ASTM D 1239-55 (1971), although there are differences in details.

REFERENCES

American Society for Testing and Materials (ASTM)

The Annual Book of ASTM Standards (currently 1976), published by ASTM at 1916 Race Street, Philadelphia, PA 19103, is published in a number of clothbound volumes called Parts. Those Parts referred to in this report are as follows:

- Part 18. Thermal and Cryogenic Insulating Materials; Building Joint Sealants; Fire Tests; Building Constructions; Environmental Acoustics
- Part 21. Cellulose; Leather; Flexible Barrier Materials
- Part 27. Paint-Tests for Formulated Products and Applied Coatings
- Part 35. Plastics - General Test Methods; Nomenclature
- Part 36. Plastics - Materials, Films, Reinforced and Cellular Plastics; Fiber Composites
- Part 37. Rubber, Natural and Synthetic - General Test Methods
- Part 39. Electrical Insulation - Test Methods; Solids and Solidifying Liquids

It should be noted that the coverage in each Part may change from year to year. Thus, what is listed as covered in the 1974 issue of Part 35 may not be listed in the 1977 issue of Part 35, but may be issued in a different Part number.

Federal Test Method Standard No. 406

This standard may be purchased for \$1.50 by the general public from:

Specifications Sales (3 FRI)
Bldg 197, Washington Navy Yard
General Services Administration
Washington, D. C. 20407

Civil agencies of the Federal Government may request copies from the above agencies. Military agencies can obtain copies from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120, Attn: NPFC 105.

British Standards

In the UK copies may be obtained from:

BSI Sales Office
101 Pentonville Road
London N1 9 ND

In the U.S. copies may be obtained from:

American National Standards Institute (ANSI)
1430 Broadway
New York, N.Y. 10018

Underwriters Laboratories (UL)

UL 94 may be obtained from the Underwriters Laboratories, Inc.,
2550 Dundee Road, Box 247, Northbrook, ILL 60062.

DIN Specifications
IEC Recommendations
ISO Recommendations

These documents can ordinarily be obtained from:

Sales Department
American National Standards Institute
1430 Broadway
New York, N.Y. 10018

Literature Citation

Ives, G.C., J.A. Mead and M.M. Riley, HANDBOOK OF PLASTICS TEST METHODS, published for The Plastics Institute by Iliffe Books, London (paper cover) and by CRC Press in the U.S. (hard cover), 1971, 476 pages.

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