JSS MAHAVIDYAPEETHA

JSS Science and Technology University

Sri Jayachamarajendra College of Engineering

JSS Technical Institutions Campus, Mysuru – 570 006

Polymer Testing Lab Instructional Manual

For 6th Semester B.E. degree

Department of Polymer Science and Technology

Sri Jayachamarajendra College of Engineering

VISION: Be an international leader in engineering education, research and application of knowledge to benefit society globally.

MISSION

M1: To synergistically develop high-quality manpower and continue to stay competitive in tomorrow's world.

M2: To foster and maintain mutually beneficial partnerships with alumni, industry and government through public services and collaborative research

M3: To create empowered individuals with sense of identity.

Department of Polymer Science and Technology

VISION: To excel in polymer engineering education and research and to serve as valuable resource for multi-faceted industry and society.

MISSION

M1: To provide well balanced curriculum and conducive environment to excel in polymer and allied engineering disciplines.

M2: Creating state-of-the-art facilities for polymer research and make the best use of the facilities

M3: To undertake collaborative projects for long term interactions with academia and industries.

Program Outcomes (POs) [Graduate Attributes]

Engineering Graduates will be able to:

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

Graduates receiving the Bachelor of Engineering in Polymer Science and Technology will be-

PSO1: able to address the issues related to polymeric material design with the knowledge of synthesis, structure property relationships and compounding.

PSO2: able to utilize the knowledge of polymer processing, testing, characterization, product and mold design to produce acceptable engineering products.

PSO3: capable of taking up research/ higher education in premier institutes and employment in polymer industries viz. rubbers, plastics, composites, adhesives, paints, etc.

Program Educational Objectives (PEOs)

PEO1: Provide graduates with strong fundamentals of science and engineering for a successful career in Polymer Science & Technology.

PEO2: Enable graduates to pursue higher education and take up innovative research so as to solve multidisciplinary issues.

PEO3: Equip graduates with technical skills and moral values for being responsible individuals.

Program Specific Criteria (PSCs)

PSC1: Apply chemistry, physics to understand structure, properties, rheology, processing, performance of polymeric materials systems, for selection and design of suitable components and process to address the concerned issues.

PSC2: Career development of members through research, consultancy and professional activities.

PSC3: Provide collaborative learning opportunities through professional societies, industries, institutes and alumni fraternity for promoting PST education along with professional growth of associated individuals.

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EXPERIMENT – 1

HARDNESS

AIM: To determine Durometer Hardness for different polymers in accordance with ASTM D 2240.

SCOPE: This test method covers two types of durometers, shore A and D. The procedure for determining the indentation hardness of homogeneous materials ranging from soft vulcanized rubber to some rigid plastics.

Type A is used for soften materials and **Type D** is used for harder materials.

This test method permits hardness measurements on either initial indentation or indentation after specified periods of time or both.

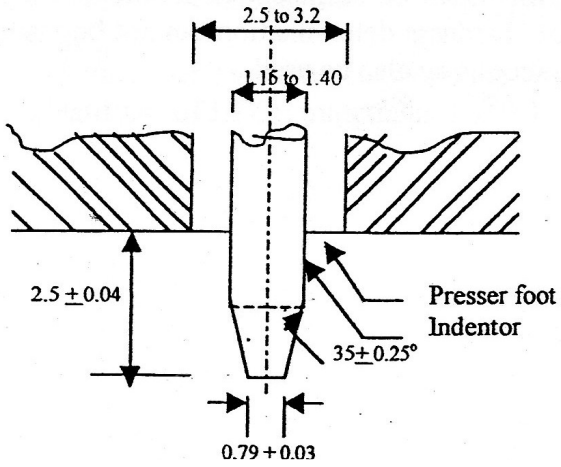
SIGNIFICANCE AND USE:

This test method is based on the penetration of a specific indentor forced into the material under specific conditions. The indentation hardness is inversely related to the penetration and is dependent on the elastic modulus and viscoelastic behaviour of the material. The shape of the indentor and the force applied to it influence the results. This test is intended for quality control purposes.

APPARATUS:

Durometer consists of following components:

1. ***Presser Foot*** with a hole of diameter between 2.5 and 3.2 mm centered at least 6mm from any edge of the foot.
2. ***Indentor*** formed from hardened steel rod with a diameter between 1.15 and 1.40 to the shape and dimensions as shown in figure (1) and (2).



Note: 1) Not to scale
2) All dimensions are in mm

Figure. 1 Indentor for Type A Durometer

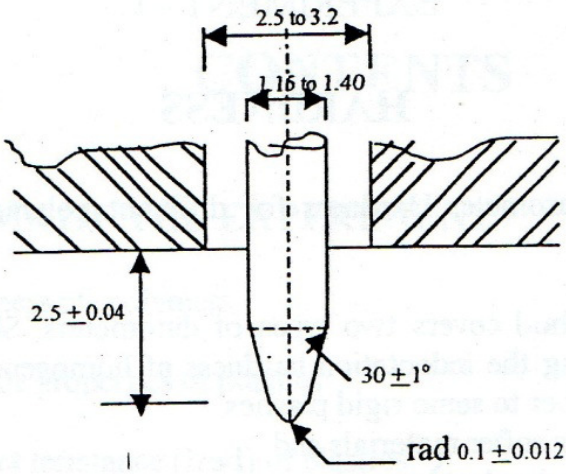


Figure.2 Indentor for Type D Durometer

3. ***Indicating device*** on which the amount of extension of the point of indentor is read in terms of graduations ranging from zero for full extension of 2.46 to 2.54 mm to 100 for zero extension obtained by placing presser foot and indentor in firm contact with a flat piece of glass.
4. ***Protector for indentor***
5. ***Calibrated spring*** for applying force to the indentor in accordance with one of the following equations:

Force (N) = 0.4445 HD ---------- (1)

Force (N) = 0.550+0.075 HA ---------- (2)

Where,

HD is the hardness reading on a type D durometer

HA is the hardness reading on a Type A durometer

6. ***Standard check guage.***

SPECIMEN: The test specimen shall be at least 6 mm in thickness. The lateral dimensions of the specimen shall be sufficient to permit measurements at least 12 mm from any edge. A suitable hardness determination cannot be made on a rounded, uneven or rough surface. Plied pieces may also be used.

PROCEDURE:

- Calibrate the durometer by using standard check gage. If there is any error, note down the zero correction.
- Place the specimen on a hard, horizontal surface.
- Hold the durometer in a vertical position with point of indentor at least 12 mm from any edge of the specimen.
- Apply presser foot to the specimen as rapidly as possible without shock
- Apply just sufficient pressure to obtain firm contact between presser foot and specimen.
- Read the scale within 1 sec the presser foot is in firm contact with the specimen, unless the maximum reading indicator type Durometer is used. If a reading after a time interval is specified, hold the presser foot in contact with the specimen without change in position of pressure and read the scale after the period specified.

  Durometers having only a maximum indicator cannot be used to obtain hardness values at various time intervals, nor in testing vinyl plastics which require the reading to be taken at 15 s.

  When values less than 20 are obtained with type D durometer, the measurement be made with type A durometer. And when values above 90 are obtained with type A durometer, the measurements be made with type D durometer. Values below 10 Shore A are inexact and should not be reported.

- Make five measurements at different positions on the specimen at least 6 mm apart and determine the median value or arithmetic mean.

REPORT:

Reading may be reported in any of the following forms:

1. Hardness of ……..…… Material is …… Shore A or Shore D
2. Hardness of …….. Material is ……. (Type of durometer / Hardness value/ time interval in S)

E.g: 1. Hardness of Tire tube compound is 50 Shore A

2. Hardness of HDPE material is Shore D.

EXPERIMENT – 2

TENSILE PROPERTIES OF PLASTICS

AIM: To determine tensile properties such as Tensile Strength, Modulus of Elasticity, Percent Elongation of plastics in accordance with ASTM D638M

SCOPE: This test method is the metric counterpart of test method D638. This covers the determination of tensile properties of plastics of any thickness up to 10mm. however, for sheeting and film of less than 1 mm thickness test method D882 is preferred.

SIGNIFICANCE AND USE:

This test method is designed to produce tensile property data for control and specification of plastic materials. These data are useful for qualitative characterization, engineering design and R&D purposes.

APPARATUS:

1. Tensile testing machine or UTM of constant rate of grip separation type comprising of fixed member, movable member, grips, drive mechanism, load and extension indicators.
2. Plotter and Micrometer.

TEST SPECIMEN:

The dimensions of dumbbell shaped test specimen for sheet, plate and molded plastics are given in Table 1 and the speed of testing is given in Table2.

i. ***Rigid and semirigid plastics****:* The type M-I is preferred where sufficient material having thickness of 10 mm or less is available. Type M-III shall be used where limited material having a thickness of 4 mm or less is available or where a large number of specimens are to be exposed in a limited space (aging tests etc.). Type M-II should be used when direct comparisons are required between materials in different rigidity cases (that is nonrigid and semirigid).

ii. ***Nonrigid plastics:*** Type M-I must be used for 4 to 10mm thickness materials and type M-II shall be used for materials with a thickness of 4mm or less.

iii. ***Reinforced composites:*** Type M-I specimen shall be used.

TABLE 1: SPECIMEN DIMENSIONS (mm)

Dimensions Tolerances	10 or under		4 or under	
	Type M-I	Type M-II	Type M-III	
W-width of narrow section ±0.5	10	6	2.5	
L-length of narrow section ±0.5	60	33	10	
WO- width overall(min) ±0.5	20	25	10	
LO- length overall (min) max.	150	115	60	No
G-Gage length ±0.25	50	--	7.5	
G-Gage length ±0.5	--	25	--	
D-distance between grips	115	80	25	±5
R- radius of fillet	60	14	15	±1
RO- Outer radius	--	25	--	±1

For Type M-I, having an overall width of 20 mm, an overall length of 215 mm is preferred.

Thickness, T shall be 3±0.4 mm for all types of molded specimens where possible.

TABLE 2: DESIGNATION FOR SPEED OF TESTING

Classification	Specimen Type	speed of testing mm/min	Nominal strain rate at testing mm/mm-mm
Rigid & semi rigid	M-I	5±25%	0.1
		50±10%	1.0
		500±10%	10.0
	M-II	5±25%	0.15
		50±10%	1.5
		500±10%	15.0
	M-III	1±25%	0.1
		10±25%	1.0
		100±25%	10.0
Non rigid	M-II	50±10%	1.5
		500±10%	15.0

Select the lowest speed that produces rapture in ½ to 5 min.

PROCEDURE:

- Measure the width and thickness of specimens with a suitable micrometer to the nearest 0.02 mm at several points along their narrow sections within the gage boundaries. Record the minimum values of cross-sectional area so determined.
- Mark gauge length on the specimen.
- Set the grip separation speed of the machine as indicated in Table 2. Fix the specimen straight between the grips.
- Tighten the grips evenly and firmly to the extent necessary to prevent slippage of the specimen during test and not to the point where the specimen would be crushed.
- Start the machine and record the load-extension curve
- Record the load and extension at yield and break point.
- Discard specimens that break at some obvious fortuitous flaw or that do not break between gauge marks.
- Test at least 5 specimens for each sample. Calculate the arithmetic mean of all values obtained and report it as average value of particular property.

CALCULATION:

1. Tensile stress (MPa) = $\dfrac{\text{Load (N)}}{\text{Original minimum cross-sectional area (mm}^2\text{)}}$

2. Strain (€) = $\dfrac{\text{Change in length (mm)}}{\text{Original (gauge) length (mm)}}$

3. Tensile strength (MPa) = $\dfrac{\text{Maximum load (N)}}{\text{Original minimum cross-sectional area (mm}^2\text{)}}$

*Report the result to 3 significant figures as "Tensile Strength at Yield" or "Tensile strength at break", which ever the term is applicable.

4. Percent Elongation = $\dfrac{\text{Extension (change in gauge length)}}{\text{Original length (gauge length)}}$ X 100

*If the specimen gives a load at yield higher than the load at break, calculate "Percent Elongation at yield", otherwise, calculate "Percent Elongation at break",

5. Young's modulus: Calculate the Modulus of Elasticity (Young's Modulus) by extending the initial linear portion of the load-extension curve and diving the difference in stress corresponding to any segment of section on this straight line by the corresponding difference in strain.

OBSERVATIONS AND RESULTS:

Sl. No.	Thickness (mm)	Width (mm)	c/s area (mm^2)	Grip separation speed (mm/min)	Gage length (mm)	Load at break (N)	Load at break (N)	Extn. At yield (mm)	Extn. At break (mm)	Tensile strength (Mpa)	% elongation at yield	% Elongation at break	Young's modulus (Mpa)
1													
2													
3													
4													
5													

EXPERIMENT-3

IMPACT RESISTANCE OF PLASTICS

AIM: To determine resistance to breakage by flexural shock of plastics and electrical insulating materials, as indicated by the energy extracted from standardized pendulum type hammers mounted on a standardized machines in breaking standard specimens with one pendulum swing.

SIGNIFICANCE AND USE: The value of this test method is used mainly in the areas of quality control and materials specification.

SCOPE:

In ASTM D 256, following types of test methods are described:

Test method A(Izod type): The specimen is held as a vertical cantilever beam and is broken by a single swing of the pendulum with the line of initial contact at a fixed distance from the specimen clamp and form the centerline of the notch and on the same face as the notch. The notch produces a stress concentration which promotes a brittle, rather than a ductile fracture.

Test method B (Charpy type): The specimen is supported as a horizontal simple beam and is broken by a single swing of the pendulum with the impact line midway between the supports and directly opposite the notch.

Test method C: is same as method A but includes a determination of the energy expended in tossing a portion of the specimen. The value reported is called "estimated net izod impact strength". Test method C is preferred over method A for materials that have an izod impact strength of less than 27j/m of notch. For materials higher than this value, the differences between test methods A and C become unimportant.

Test method D: provides a measure of notch sensitivity of a material. The stress concentration at the notch increases with decreasing radius. This effect is obtained by testing specimens with different notch radii.

Test method E: It is similar to method A, except that the specimen is reversed. The striker of the apparatus impacts the specimen on the face opposite the notch. It is used to give an indication of the unnotched impact strength of plastics.

In test methods A,C,D and E, the type of failure is recorded as one of the 4 coded categories defined as follows:

C complete break

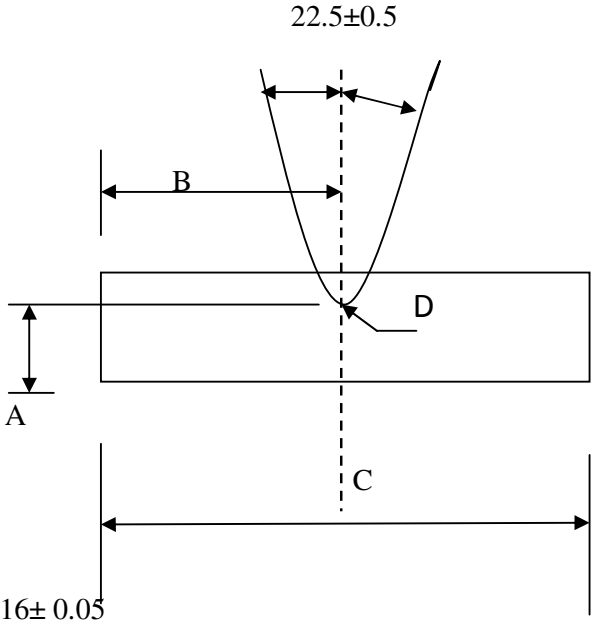
H hinge break: an incomplete break such that one part of the specimen cannot support itself above the horizontal when the other part is held vertically.

P partial break: an incomplete break that does not meet the definition for a hinge break but has fractured at least 90% of the distance between the vertex of the notch and the opposite side.

NB non break: fracture extends less than 90%.

TEST SPECIMEN:

The dimensions and geometry of Izod type test specimen is as shown in figure 3 . The width shall be between 3.17 and 12.7 mm for molded specimens. For sheet materials and molded specimens the width shall be the thickness.



Note: 1. Not to scale

2. All dimensions are in mm

A - 10.16± 0.05
B - 31.50 to 32.00 max.
C - 60.30 to 63.50 max.
D - 0.25 R ± 0.05
E - 12.70± 0.15
W - 3.17 to 12.7

Figure 3 Izod Type Test Specimen

PROCEDURE:

- At least 5 and preferably 10 or more individual determinations must be made on each sample.

- Before testing the specimen, with excess energy indicating pointer in its normal position but without specimen, release the pendulum from its normal position and note the reading as A.
- Measure the width (thickness) of each specimen in the region of the notch with a micrometer to the nearest of 0.025mm and record it.
- Position the specimen in the apparatus and clamp the vise.
- Release the pendulum and record the excess energy remaining in the pendulum after breaking the specimen.
- Subtract the correction from the indicated impact reading to obtain the energy delivered to the specimen.
- Divide the net value so found by the measured width of the specimen to obtain its impact strength in joules per meter of width.

RESULT: The impact strength of_____ material is_____ Joules/m.

EXPERIMENT- 4

IMPACT RESISTANCE OF PLASTIC FILM BY DART METHOD

AIM: To determine impact resistance of plastic film by measuring the kinetic energy lost by a free falling dart that passes through the film in accordance with ASTM D 4272

PRINCIPLE:

The velocity of a freely falling dart of specified shape that has passed through a sheet of plastic film is determined by means of a photoelectric speed trap. The kinetic energy corresponding to this energy is calculated and compared with the kinetic energy of the same dart measured without a plastic film. The loss in kinetic energy, suffered by that dart that ruptured the film is used as an index of impact resistance.

SIGNIFICANCE AND USE:

Evaluation of impact toughness of film is important in predicting the performance of a material in applications such as packaging, construction etc. The test results are mainly dependent on the method and conditions of film fabrication as well as type and grade of material.

Data obtained by this method cannot be compared directly with other methods. Data from this test method are only comparable for specimens that vary by no more than ±15% from the nominal or average thickness of the specimens tested.

Test method D 1709 represents failure initiated energy. This energy is expressed in terms of the weight of the dart falling from a specified height which would result in 50% failure of specimens tested. While test method D 4272 is initiation plus completion energy.

APPARATUS:

The apparatus consists of following components:

Specimen clamp: consists 2 piece annular specimen clamps having inside diameter of 127 mm. the lower stationary half of the clamp shall be mounted rigidly so that the plane of the specimen is horizontal. The upper or movable part of the clamp shall be designed to maintain positive and plane contact with the lower clamp when in position. Suitable clamps shall be provided to hold the film firmly in place during test.

Rubber gasket: of 3.1 mm thick, 127 mm inside diameter and 152 mm outside diameter with 50 to 60 Shore A hardness, may be affixed to the specimen contact surfaces of both clamps.

Electromagnet: capable of supporting a two kg weight for use in supporting and releasing the dart assembly. It shall be equipped with a centering device to ensure reproducible drop and a suitable source of electric power which may be interrupted to energize and de-energize the electromagnet.

Positioning device: Means shall be provided for positioning the dart at a drop height of 0.660 m from the impinging surface of the dart head to the surface of the test specimen.

Time counter*:* with a sensitivity to measure in 10^{-5} s.

Light sensitive speed trap: to activate the time counter device.

Cushioning and shielding device: to avoid damaging the impinging surface of the dart.

Collar: with inside diameter of approximately 7 mm with set screw for securing collar to dart shaft.

Darts: shall have hemispherical head fitted with a 6.4 mm diameter shaft at least 115 mm long to accommodate removable incremental weights. Dart shall be 38±0.13 mm in diameter hemispherical head. Dart weight equals 227 g. Five dart weights each 227 g are provided. Stem diameter of 9.52 mm has been found satisfactory to resist bending.

Micrometer: accurate to ±0.0025 mm for measuring specimen thickness.

TEST SPECIMENS: The minimum size is 165 by 152.5 mm. the sample shall be of free of pinholes, wrinkles, folds or any other obvious imperfections.

PROCEDURE:

- Turn on the computer and power supply for the light-sensing unit and allow to warm up in sufficient time to reach equilibrium.
- Make sure that the dart retrieval drawer (cushioning) is in its place.
- Without prior knowledge of the impact resistance of the film tested, use a 908 g dart weight at 0.660 m height.
- Position the dart vertically in the holding device. Allow a few seconds for any vibration to subside.
- Release the dart and record the free fall time. Repeat this for five more times. Average the five measured times and record it as t_1. The time reading of each of the five free-falls should be within ±30 μs of the average.
- Measure and record the thickness of the film to the nearest 0.0025 mm. Reject samples that vary by more than 15% from the nominal or a average thickness.

- Place the specimen over the bottom part of the clamp, making sure that it is uniformly flat, free of wrinkles, folds etc.
- Place the top part of the clamping ring on the specimen and tighten it with the help of wing nuts such that the film is firmly held and there is no slippage.
- Position the dart vertically with the electromagnet. Wait a few seconds for any vibrations to subside.
- Set the counter to zero by pressing the reset button.
- Release the dart by pressing the start button.
- Note down the counter reading for the dart fall and record it as t_2.
- Calculate the energy to rupture for the film sample as the average of the five energy values for the test specimens.

CALCULATION:

Calculate the energy to rupture for each test specimen as follows:

$$E = \frac{m}{2}\left(d^2 \left\{ \frac{1}{t_1^2} - \frac{1}{t_2^2} \right\} + \frac{g^2}{4}\left(t_1^2 - t_2^2 \right) \right)$$

Where,

E= energy to rupture, J

m = dart mass, kg

g = gravitational constant, 9.81 m/s^2

d= distance between sensing elements, m

t_1 = average free-fall time, s

t_2= test- fall time, s.

DERIVATION OF FORMULA:

The kinetic energy of a dart of mass (m) travelling at a velocity of v is as follows:

Kinetic energy = ½ mv^2

If the time of the free-fall to travel between 2 light sensing elements is t_1, the distance traveled is d, and the velocity entering the speed trap is v_1, then:

$d = ½ gt_1^2 + v_1t_1$

solving for v_1:

$v_1 = (d/t_1) – (gt_1/2)$

if the time of the dart to travel between the sensing elements after breaking the film is t2 then:

$d = ½ gt_2^2 + v_2t_2$

and $v_2 = (d/t_2) – (gt_2/2)$

We define the impact energy as the kinetic energy lost in breaking the film as follows:

Impact energy = ½ $m(v_1^2 – v_2^2)$

$$= \frac{m}{2}\left(d2\left\{ \frac{1}{t12} - \frac{1}{t2^2} \right\} + \frac{g^2}{4}(t1^2 - t2^2) \right)$$

RESULT:

The Impact energy of _____ film is _____ J

EXPERIMENT - 5

FLEXURAL PROPERTIES OF PLASTICS

AIM: To determine flexural properties of plastics including high modulus composites and electrical insulating materials in the form of rectangular bars in accordance with ASTM D 790.

SCOPE: This test method is generally applicable to rigid and semirigid materials. However, flexural strength cannot be determined for those materials that do not break for that do not fail in the outer fiber. Two methods are described as follows:

1. ***Test method I*** **:** A 3 point loading system utilizing center loading on a simply supported beam.
2. ***Test method II*****:** A 4 point loading system utilizing 2 load points equally spaced from their adjacent support points, with a distance between load points of either one third or one half of the support span.

The basic difference between two test methods is in location of the maximum bending moment and maximum axial fiber stresses. The maximum axial fiber stresses occur on a line under the loading nose in Test method I and over the area between the loading nose in the Test method II.

Materials that do not fail at the point of maximum stress under Test method I should be tested by Test method II.

Either test method can be used with two procedures that follow:

1. ***Procedure A:*** is designed principally for materials that break at comparatively small deflections. The rate of straining at the outer fibers is 0.01 mm/mm-min.
2. ***Procedure B:*** is designed particularly for those materials that undergo large deflections during testing. The strain rate is 0.10 mm/mm-min. for some materials the increase in strain rate provided under procedure B may induce the specimen to yield or rupture or both within the required 5% strain limit. Beyond 5% strain, this test methods are not applicable.

Comparative tests may be run according to either test method or procedure, provided that test method or procedure is found satisfactory for the material being tested.

SIGNIFICANCE AND USE:

Flexural properties are useful for quality control and specification purposes. Flexural properties may vary specimen depth, temperature, atmospheric conditions and the difference in rate of straining as specified in procedures A and B.

APPARATUS:

- Testing machine (UTM) that can be operated at constant rates of crosshead motion with load and deflection indicating device.
- The loading nose and supports shall have cylindrical surfaces. In order to avoid excessive indentation or failure due to stress concentration directly under the loading nose, the radius of the nose and supports shall be at least 3.2 mm.

TEST SPECIMEN:

The specimens may be cut from sheets, plates or molded to the desired finished dimensions. For flat wise tests the depth of the specimen shall be the thickness of the material.

The recommended specimen for molding material is 127 by 12.7 by 3.2 mm tested flatwise and support span to depth ratio (L/D) is 16 to 1. For composite materials, the dimension of specimen shall be 130 by 13 by 6.4 mm.

PROCEDURE:

Test Method I:

- Measure the width and depth (thickness) of the specimen to the nearest of 0.03 mm at the center of the support span.
- Determine the support span to be used and set the support span to within 1% of the determined value. The support span to depth ratio shall be chosen such that failures occur in the outer fibers, due only to the bending moment. As a general rule, support span to depth ratios of 16:1 are satisfactory when the ratio of tensile strength to shear strength is less than 8:1, but the support span to depth ratio must be increased to 32:1 or 40:1 for composite laminates having relatively low shear strength in the plane of the laminate and relatively high tensile strength parallel to the support span. The laminate and relatively high tensile strength parallel to the support span. However, for some highly anisotropic composites shear deformation can significantly influence

modulus measurements, even at 40:1 ratio. Hence, for these materials 60:1 is recommended.

- Calculate the rate of crosshead motion as follows:

$$R = ZL^2/6d$$

Where, R= rate of cross head motion, mm/min,

L= support span, mm

d = depth of beam, mm

Z= rate of straining of the outer fiber, mm. (Z shall be 0.01 for smaller deflection materials and 0.10 for comparatively larger deflection materials).

- Set the machine for the calculated rate.
- Align the loading nose and support so that the axes of the cylindrical surfaces are parallel and the loading nose midway between the supports.
- Center the specimen on the supports, with the long axis of the specimen perpendicular to the loading nose and supports.
- Apply the load to the specimen at the specified crosshead rate.
- Take simultaneous load-deflection data.
- The specimen is deflected until rupture or 5% strain is attained, whichever occurs first. Terminate the test if the maximum strain in the outer fiber has reached 5%. The deflection at which this strain occurs is calculated as follows:

$$D = rL^2/6d$$

Where, D = mid span deflection, mm r = strain (0.05 mm/mm)

L= support span, mm d= depth of specimen, mm.

- At least 5 specimens shall be tested for each sample. Arithmetic mean of all values obtained shall be calculated to 3 significant figures and reported as the “average value” for the particular property.

Sl. No	Material	Depth d (mm)	Width b (mm)	Support span length (mm)	L/d ratio used	Strain rate (mm/mm-min)	Rate of cross head motion (mm/min)	Load at yield (N)	Load at break (N)	Deflection at yield (mm)	Deflection at break (mm)	Flexural strength (MPa)	Flexural yield strength (MPa)	% strain at yield	% Strain at break	Flexural Modulus (MPa)
1																
2																
3																
4																
5																

CALCULATION (FORMULAE):

1. **Stress (MPa), $S = 3PL/2bd^2$** ---------- (1)

   Where:

   P= load, N

   L= support span, mm

   b= width of specimen, mm

   d= depth of specimen, mm

2. **Flexural strength:** is calculated using equation (1) by letting P equal to the load at break.
3. **Flexural yield strength:** Some materials that do not break at outer fiber, strains up to 5% may give a point at which load does not increase with an increase in deflection. In such cases the flexural yield strength may be calculated in accordance with equation (1) by letting P equal to the load at that point.
4. **Strain,** $r = 6Dd/L^2$

   Where, D= deflection, mm
5. **Flexural Modulus (Tangent Modulus of Elasticity) (MPa):** is the ratio, within the elastic limit of stress to corresponding strain. It is calculated by drawing a tangent to the steepest initial straight-line portion of the load-deflection curve and using the following equation.

   $$E_B = L^3m/4bd^3$$

   Where, m= slope of the tangent to the initial straight-line portion of the load-deflection curve, N/mm of defection.

EXPERIMENT – 6

ABRASION RESISTANCE OF PLASTICS

AIM: To determine resistance to abrasion of flat surfaces of plastic materials, measured in terms of volume loss, in accordance with ASTM D 1242.

SCOPE:

Test Method A: Loose abrasive

Test Method B: Bonded abrasive on cloth or paper (abrasive tape)

SIGNIFICANCE AND USE:

The abrasion resistance is affected by many factors such as the physical properties of the polymeric material, particularly hardness, resilience and the type and degree of added filler. It is also affected by conditions of the test such as nature of the abradant, action of the abradant over the area of the specimen abraded and development and dissipation of heat during the test cycle.

TEST METHOD A- LOOSE ABRASIVE:

APPARATUS:

It consists of a rotating disc, a specimen mounting plate holder, a cam arrangement for actuating the specimen holder, hopper and distributor for feeding fresh abrasive, hopper for collecting used abrasive, revolution counter, an added weight of 4.5kg and suitable mechanism for driving the disk at 23.5 rpm and the specimen holder at 32.5 rpm.

Specimen mounting plate, made of aluminum for mounting test specimens.

Analytical balance, for weighing specimen to a precision of 0.0001g.

Abradant, Aluminum oxide grit No. 80 TP may be used. Typical screen analysis on this grit has shown from a trace to 1% retained on the No. 60 (250μm) sieve and 5 to 15% passing the No. 100(149μm) sieve.

Suitable means or adhesive for fixing the specimens to the plate.

TEST SPECIMEN: The test specimen shall be of 50.8 by 76.2 (±0.4) mm in dimension.

PROCEDURE:

- Determine the density of the material to be tested.
- Fill the abrasive container with the grit and adjust the rate of feed to 44±2 g/min.
- Weigh the test specimen to the nearest 0.01 g (W_1) and attach to the specimen plate holder by means of the end clamp provided.

- Place the weight on the specimen shaft, brush off grit under the specimen.
- Run the machine for 1000 revolutions.
- Remove the mounted specimen, clean with a filtered air blast and reweigh (W_2).
- Calculate the abrasion loss. The average of the 6 measurements shall be taken as the abrasion loss for the material.

OBSERVATION:

Sl No.	Material	Density of Sample (D) (g/cc)	Initial weight W_1 (g)	Final weight W_2, (g)	Weight loss per 1000 revolutions, (g)	Volume loss per 1000 revelations (cc)
1.						
2.						
3.						
4.						
5.						

CALCULATION:

Calculate the abrasion resistance or the abrasion loss in volume at 1000 revolutions, as follows:

Volume loss (Cm^3) = $(W_1-W_2)/D$

Where,

W_1 = initial weight, g

W_2 = weight after abrasion, g

D = density of the material being abraded, g/cm^3.

RESULT:

The abrasion loss (volume loss per 1000 revolutions) of _____ material is _____ cc.

EXPERIMENT – 7

DIELECTRIC STRENGTH OF PLASTICS

AIM: To determine dielectric strength of solid insulating materials at commercial power frequencies, under specified conditions in accordance with ASTM D 149.

SUMMARY OF TEST METHOD:

Alternating voltage at a commercial power frequency is applied to a test specimen. This test method may be used at any frequency from 25 to 800 Hz. Voltage is increased from zero or from or from a level well below the breakdown voltage until dielectric failure of the test specimen occurs.

SIGNIFICANCE AND USE:

In many cases the dielectric strength of an electrical insulating material will be the determining factor in the apparatus in which it is to be used. This may be used for detecting changes or deviations from normal characteristics resulting from processing variables, aging conditions, other manufacturing or environmental situations. This test method is useful for process control, acceptance or research purposes.

APPARATUS:

Dielectric breakdown voltage tester with following capabilities:

Voltage source: Capable of maintaining the test voltage until dielectric breakdown occurs. Two electrodes and an output current capacity of 40 mA is usually satisfactory. The power rating for most tests will vary from 0.5 kVA for testing low testing low capacitance specimens at voltages up to 100 kV. Equip the voltage source with a circuit-breaking device that will operate within 3 cycles. The device shall disconnect the voltage-source equipment from the power service and protect it from overload as a result of specimen breakdown causing an overload of the testing apparatus. If prolonged current follows breakdown it will result in unnecessary burning of the test specimens, pitting of the electrodes.

Voltage measurement: A voltmeter must be provided.

TEST SPECIMEN:

When flat-faced electrode is to be used, thin materials such as film, sheet etc. may be used. It may be convenient to use specimens large enough to permit making more than one test on a single piece

PROCEDURE:

1. Switch on the apparatus
2. Measure the thickness of the specimen.
3. Place the specimen on flat surface of the electrode and hold the other electrode on the specimen.
4. Select the suitable current capacity.
5. By pressing the (red) knob in the top electrode, apply the voltage in any one the following methods.

METHODS OF VOLTAGE APPLICATION:

1. ***Method A*, short-time test:** Apply voltage uniformly to the test electrodes from zero at one of the following rates* until breakdown occurs.

   *Rates: 100,200,500,1000,2000,5000 V/s ±20%

   When establishing a rate initially, select a rate that will give an average time to breakdown of between 10 and 20 s. For many materials a rate of 500 V/s is used. If the time to breakdown cannot be adhered to, the time shall be made a part of the report.
2. ***Method B*, step-by step test:** Apply voltage to the electrodes at the preferred starting and in steps and duration until breakdown occurs.
3. ***Method C*, slow rate-of-rise test:** Apply voltage to the test electrodes from the starting voltage and at one of the following rates*

   *Rates: 1,2,5,10,12.5,20,25,50,100 V/s ±20%

   Unless otherwise specified, use the short-time test.

(Dielectric failure or dielectric breakdown consists of an increase in conductance, limiting the electric field that can be sustained. This is evidenced during test by abrupt rupture through the thickness of the specimen, which can be seen and heard, and which results in a visible puncture and decomposition of the specimen in the breakdown area.

If the breaker is set for too high a current, or it the breaker malfunctions, excessive burning of the specimen will occur.)

4. Note down the breakdown voltage in Voltmeter.
5. Divide the breakdown voltage by the thickness of the specimen to give dielectric strength in k V/mm or V/mil at breakdown.
6. Make 5 breakdown for a particular material and report the average value.

OBSERVATION:

Sl. No.	Material	Thickness, mm	Voltage application method	Breakdown voltage, kV	Dielectric strength, kV/mm
1.			A(manual)		
2.			"		
3.			"		
4.			"		
5.			"		

RESULT:

The dielectric strength of _____ Material is _____ kV/mm.

EXPERIMENT – 8

VICAT SOFTENING TEMPERATURE

AIM: To determine the Vicat Softening Temperature of thermoplastic materials in accordance with ASTM D 1525

PRINCIPLE:

Vicat softening point is defined as the temperature at which a flat ended needle of 1 sq.mm circular cross section will penetrate a thermoplastic specimen to a depth of 1 mm under specified load and uniform rate of temperature raise.

- Rate A: 50± 5^{o}C/h
- Rate B: 120 ± 12°C/h

SIGNIFICANCE AND USE:

Data obtained by this method may be used to compare the heat softening qualities of thermoplastic materials. This test is useful in the areas of quality control, development and characterization of materials.

APPARATUS: The equivalent essentially consists of the following:

Immersion bath: for heat transfer liquid with stirrer and heaters with controller to permit manual or automatic control of the selected bath temperature raise.

Heat transfer liquid: Liquids such as silicone oils, glycerine, ethylene glycol and mineral oil shall be used as heat transfer media. The liquid chosen should not affect the material being tested.

Specimen support: A suitable stand or support for the specimen to be placed in the bath.

Needle: Flat ended, circular cross section of 1 + 0.05 or -0.02 mm2 with flat tip and a length of 5 to 12.5 mm is used.

Weights: A set of weights of suitable sizes so that the net load on the needle point is equal to 1000+ 40 or – 0g when the apparatus is assembled.

Penetration measurement device: A dial gage or any other device capable of measuring differences of 0.01 mm or better may be used.

Temperature measuring device: A thermometer or thermocouple adequate to cover the range being tested may be used.

TEST SPECIMEN:

Use at least two specimens to test each sample. Flat specimen with minimum thickness of 3 mm and at least 12 mm square is used.

PROCEDURE:

1. Start the test at room temperature.
2. Mount the specimen horizontally and approximately center under the needle and gently lower the needle rod so that the needle rests on the surface of the specimen and holds it in position.
3. Place the thermometer such that the bulb of the thermometer should be as close as practical to the specimen.
4. Carefully immerse the assembly into the bath.
5. Apply the load, set the dial gage to zero and switch on the heater and stirrer. Selection of rate of raise of temperature shall be as agreed upon by the interested parties. Check the rate at 2 min intervals and make necessary adjustments to the heater controls.
6. Record the temperature when the dial gage reads 1 mm penetration.

OBSERVATION:

Sl. No.	Material	Thickness (mm)	Width (mm)	Rate of raise of temperature (^{0}C/hr)	Load (kg)	VST (^{0}C)
1.						
2.						

RESULT:

The Vicat Softening Temperature (VST) of _____ material is _____ ^{0}C

EXPERIMENT – 9

HEAT DISTORTION TEMPERATURE

AIM: To determine the temperature at which an arbitrary deformation occurs when plastics are subjected to an arbitrary set of testing conditions, in accordance with ASTM D 648.

PRINCIPLE:

A bar of rectangular cross section is tested as a simple beam with the load applied at its center to give maximum fibre stress of 455 kPa or 1820 kPa. The specimen is immersed in a heat transfer medium with a means of raising the temperature at 2 ± 0.2^0C/min. the temperature is recorded when the test bar has deflection 0.25 mm, which is the HDT of the test specimen.

SIGNIFICANCE AND USE:

This test is particularly suited to quality control and research and development work and ranking materials for short term heat resistance.

APPARATUS:

The equipment essentially consists of the following:

Immersion bath: for heat transfer liquid with stirrer and heaters with controller to permit manual or automatic control of temperature raise at a uniform rate of $2 \pm 0.2$0C/min.

Heat transfer liquid: Liquids such as silicone oil, mineral oil shall be used as heat transfer media. The liquid chosen should not affect the material being tested.

Specimen supports: A suitable stand with two metal supports for the specimen which is 100 mm apart, allowing load to be applied on top of the specimen vertically and midway between the supports

Deflection measurement device: A dial gage or any other device capable of measuring differences of 0.01 mm or better may be used.

Temperature measuring device: A thermometer or thermocouple adequate to cover the range being tested may be used.

Weights: A set of weights of suitable sizes so that the specimen can be loaded to a maximum fiber stress of 1820 or 455 ± 2.5 % kPa. The weight of the rod and force exerted by the spring or dial gage is determined and included as part of the total load.

The load is calculated using the equation:

$$P = 2Sbd^2/3L \text{ and } P' = P/9.80665 \quad \text{……..(1)}$$

Where,

P = load, N

S = maximum fiber stress in the specimen, N/mm^2

b = width of specimen, mm

d = depth of specimen, mm

L= width of span between supports, mm

and P' = load in kgf, when P is in N

TEST SPECIMEN:

The dimensions of test specimen shall be 127 mm in length, 13 mm in depth by any width from 3.17 to 13 mm. test at least two specimens from each sample and report the average value.

PROCEDURE:

- Measure the depth and width of the test specimen.
- Place the specimen on specimen support assembly with its 13mm dimension vertical.
- Immerse the assembly in oil bath.
- Place the thermometer such that the bulb of the thermometer should be within 3.2mm distance from the specimen and does not touch it. The bath temperature should be about room temperature at the start of test, unless previous tests have shown that for the particular material under test, no error is introduced by starting at a higher temperature.
- Adjust the load as calculated using equation (1).
- 5 minutes after applying the load, set the dial gage to zero. Switch on the heater and stirrer. This waiting period may be omitted when testing materials that show no appreciable creep during the initial 5 min.
- Record the temperature when the indicator reads 0.25 mm deflection which is the HDT of the test specimen at the specified fiber stress.

OBSERVATIONS:

Sl. No.	Material	Depth (mm)	Width (mm)	Fiber stress, (kPa)	Load used (kg)	Rate of raise of temperature (^{0}C/min)	HDT (^{0}C)
1							
2							
3							
4							
5							

RESULT:

The Heat Distortion Temperature (HDT) of _____ material is _____ ^{0}C

EXPERIMENT-10

MELT FLOW INDEX

AIM: To determine Melt Flow Index for different grades of a Polymer as per the standard ASTM D1238

APPARATUS REQUIRED:

MFI Tester (Plastometer), Die, Weighing balance, funnel, stop clock, a tool for cutting off the extruded sample, piston , die retainer plate, screw driver or tester, weights (1.2,2.16,3.8,5.0,10.0 Kgs) etc.

THEORY:

MFI is the weight in grams of the molten polymer extruded through a standard die in 10 minutes under prescribed conditions of temperature, load and piston position in the barrel.

SIGNIFICANCE:

This test method serves to indicate the uniformity of the flow rate of the polymer as made by an individual process.

The flow rate obtained with the extrusion plastometer is not a fundamental property of polymer. It is an empirically defined parameter critically influenced by the physical properties and molecular weight of the polymer and the conditions of measurement. Since the rheological characteristics of polymer melts depend on a number of variables, the test results may not correlate directly with processing behavior.

APPARATUS:

The description of different parts of the apparatus is given below:

Cylinder: The dimensions of the cylinder are as given below:

Diameter : 50.8mm

Length : 162 mm

Hole Diameter : 9.5504± 0.0076 mm

A plate is attached to the bottom of the cylinder to retain the die. A hole in this plat centered under the die and countersunk from below, allows free passage of the extrudate. This cylinder is vertically fitted to a support.

Die: The outside of the steel die is such that it will fall freely to the bottom of the 9.5504mm diameter hole in the cylinder. The length of the die is 8.000 ± 0.025 mm and the diameter of the smooth straight bore is 2.0955 ± 0.0051 mm.

Piston: The piston is made of steel with an insulating bushing at the top as a barrier to heat transfer from the piston to the weight. The piston is scribed with the reference marks 4 mm apart in such fashion that when the lower mark coincides the top of the cylinder, the bottom of the piston is 48 mm above the top of the die.

Heater and Temperature controller: The apparatus is provided with electric heater to maintain the temperature within ± 0.2 ^{0}C. A thermocouple with temperature indicator cum controller is provided. Two temperature setting knobs are provided for coarse and fine setting of the temperature.

TEST SPECIMEN:

The specimen may be in any form that can be introduced into the bore of the cylinder for example, powder, granules, pellets etc.

TEMPERATURE SETTING PROCEDURE:

1. Initially to get the barrel heated very fast, the knobs can be turned can be turned to the maximum position. Wait till a temperature of about 10^{0}C below the required limit is obtained.
2. At this point bring the coarse knob to about 20% setting and the fine knob to about 50%. The temperature increases gradually and will reach the set temperature.
3. Wait for about 15 minutes for the temperature to settle down. The temperature may initially go above the set temperature and then come down. But a steady temperature is obtained within 15 to 20 minutes after this setting.
4. If the temperature is still going up or down steadily, then the coarse knob has to be adjusted accordingly i.e., if the temperature is steadily coming down, the setting has to be increased and vice versa.
5. If the temperature is moving up and down varying more than the allowable tolerance i.e., ±0.5 ^{0}C then the fine knob will have to be at a higher setting.
6. Again if the temperature remains steadily for some time and very slowly goes up, the fine setting will have to be put at a slightly lower setting. In short, the temperature can be very finely set by manipulation of both the coarse and fine setting knobs.

EXPERINMENTAL PROCEDURE:

1. Select the condition of temperature and load from Table 3 such that flow rates will fall between 0.15 to 50 g/ 10 min. Ensure that the barrel is cleaned.
2. Set the temperature as given in Table1. Once the temperature is attained, push the die retainer plate in forward direction and insert the die and piston. The temperature of the barrel with piston and die in place should have been at the test temperature for about 15 minutes before the test is begun.
3. Charge the material. The weight of the material is as given in Table 2.
4. Material is compressed by using hand pressure on the piston.
5. 6 to 8 minutes after completing the introduction of the sample, during which time the temperature should have returned to that selected, the selected load is placed on the piston.
6. The piston is allowed to descend under gravity pressure or pushed down faster using hand pressure, until a bubble free extrudate is extruded and the lower mark is 5 to 10mm above the top edge of the cylinder. The extrudate is cut off and discarded.
7. The piston with load is then allowed to descend under gravity. Only when lower mark has reached the top edge of the cylinder, the time is recorded and the extrudate portion cut off simultaneously with the cutting tool.
8. Successive cut offs are then collected in order to ensure the extrusion rate at time intervals depending on the flow rate as given in Table 2.
9. Stop cutting when upper mark of the piston stem reaches the top edge of the cylinder. Any cut off containing visible air bubble is discarded.
10. By pulling back the retainer plate, the die and remainder of the material in the barrel has to be removed. Clean the barrel and piston with cloth and die with die cleaning tool when it is hot.
11. Weigh the extrudate to the nearest 1 mg when cool. If the difference between maximum and minimum value of the individual weighing exceeds 10% of the average, the result is discarded and the test is repeated.

TABLE 1 STANDARD TEST CONDITIONS

Sl. No.	Material	Condition (Temp(^{0}C) /Load(kg)	
1	Acetals (Copolymer and Homopolymer)	190/2.16	190/1.05
2	Acrylics	230/1.2	230/3.8
3	Acrylonitrile-butadiene-styrene	200/5.0	230/3.8
4	Cellulose esters	190/0.325	190/2.16
		190/21.6	210/2.16
5	Nylon	275/0.325	235/1.0
		235/2.16	235/5.0
6	Polycholortrifluorethylene	265/12.5	
7	Polyethylene	125/0.325	125/2.16
		190/0.325	190/2.16
		190/21.6	190/10.0
		310/12.5	
8	Polycarbonate	300/1.2	
9	Polypropylene	230/2.16	
10	Polystyrene	200/5.0	230/1.2
		230/3.8	190/5.0
11	Polyterphthalate	250/2.16	210/2.16
		285/2.16	
12	Poly(vinyl acetal)	150/2.16	
13	Poly(phenylene sulfide)	315/5.0	
14	Thermoplastic Elastomer-ether-ester	190/2.16	220/2.16
		230/2.16	240/2.16

TABLE 2 STANDARD TEST CONDITIONS, SAMPLE WEIGHT AND TESTING TIME

Flow range (g/10 min)	Suggested weight of sample barrel(g)	Time interval (min)	Factor for obtaining flow rate (g/10 min)
0.15 to 1.0	2.5 to 3.0	6.00	1.67
1.0 to 3.5	3.0 to 5.0	3.00	3.33
3.5 to 10.0	5.0 to 8.0	1.00	10.00
10 to 25.0	4.0 to 8.0	0.50	20.00
25 to 50.0	4.0 to 8.0	0.25	40.00

OBSERVATIONS:

Sl. No.	Material	grade	Load (kg)	Temperature (^{0}C)	Time interval (sec)	Weight (g)	MFI (g/10 min)
1							
2							

CALCULATION:

Calculate the MFI as follows:

$$\text{MFI (g/10min)} = \frac{600 \times M}{t} \quad \text{---------- (1)}$$

Where, M is mass of the extrudate in g and

t is cut off time interval in seconds.

RESULT:

The MFI (T ^{0}C, L kgs) of _____ material is _____ g/10 min.

EXPERIMENT – 11

INITIAL TEAR RESISTANCE OF PLASTIC FILM

AIM: To determine initial tear resistance of plastic film and sheeting as per the standard ASTM D1004.

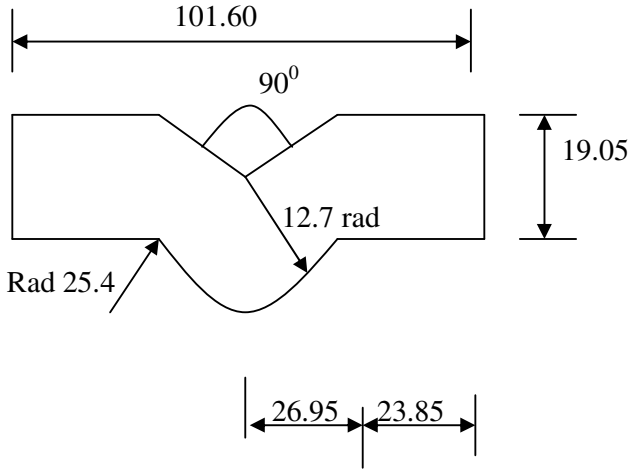
SIGNIFICANCE AND USE:

The data of this test method furnish comparative information for ranking the tearing resistance of plastic specimens. The resistance to tear of plastic film while partly dependent upon thickness has no simple correlation with specimen thickness. Hence, tearing forces measured cannot be normalized over a wide range of specimen thickness. Data from this test method are comparable only from specimens which vary by no more than ±10% from the nominal or average thickness of all specimens tested.

APPARATUS:

A power driven machine of constant rate of grip separation type, dial thickness gauge, die for cutting specimens, grips that minimizes both slippage and uneven stress distribution on the specimens shall be used.

TEST SPECIMENS: The shape and dimensions of test specimen is as shown below:



Note: 1) All dimensions are in mm

2) Drawing is not to scale

3) Tolerance is ± 0.051 mm

Figure 4 Die for Tear Test specimen

PROCEDURE:

1. Cut the specimen from film or sheet using the die. The 900 angle should be honed sharp with no radius or have a minimum practical radius. The cutting edge of the die shall be kept sharp and free from nicks to avoid leaving ragged edges on the specimen.
2. Measure the thickness of the specimen to the nearest of 0.0025 mm at several points and record the average thickness.
3. Set the jaw separation (distance between grips) to 25.4 mm
4. Place the specimen in the grips of the testing machine. Grips lined with thin rubber, or No. 80 emery cloth may be used.
5. Apply the load at 51 mm/ min rate of grip separation.
6. After complete rupture of the specimen, record the maximum tearing load. At least 10 specimens in case of isotropic and 20 specimens in case of anisotropic material (10 parallel with and 10 normal to the principal axis of anisotropic or maximum orientation) shall be tested.

Note: Resistance to tear may be expressed in pounds per mile of specimen thickness where correlation for the particular material being tested has been established. However, it should be realized that comparison between films of dissimilar thickness may not be valid.

RESULT: Tear strength of _____ film of _____ thickness is _____N

EXPERIMENT – 12

TEAR PROPAGATION RESISTANCE OF PLASTIC FILM

AIM: To determined Tear propagation resistance of plastic film and thin sheeting thickness of 1mm or less by a single tear method as per the standard ASTM D 1938.

APPARATUS: UTM, Thickness measuring device, cutter or sharp razor blade.

THEORY: This test method covers the determination of the force necessary to propagate a tear in plastic film and thin sheeting (thickness of 1 mm (0.04 in.) or less) by a single-tear method. The method is not applicable for film or sheeting material where brittle failures occur during testing.

SIGNIFICANCE AND USE:

1. This test method is of value in rating the tear-propagation resistance of various plastic films and thin sheeting of comparable thickness.
2. This test method shall be used for specification acceptance testing only after it has been demonstrated that the data for the particular material are acceptably reproducible.
3. The data obtained by this test method furnish information for ranking the tear-propagation resistance of plastic films and sheeting of similar composition. Actual use performance may not necessarily correlate with data from this test method. Sets of data from specimens of dissimilar thickness are usually not comparable.

TEST SPECIMEN: The test specimen shall be of 75 mm long by 25 mm wide.

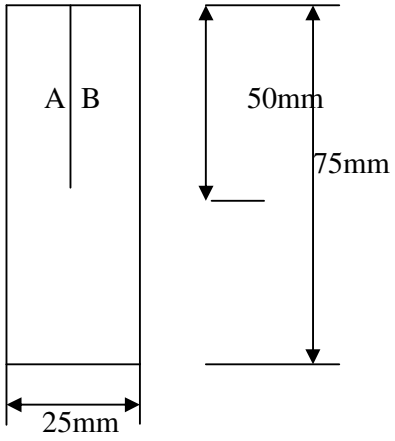


Figure 5 Single Tear specimen

PROCEDURE:

1. Cut the film to the standard dimensions given above.
2. Make a clean longitudinal slit of 50 mm ± 2% using sharp razor blade on the specimen.
3. Measure the thickness of the specimen below the slit in several places and record average of these values.
4. Fix one portion of slit film to one grip and another portion to other grip of testing machine. Align the specimen so that its major axis coincides with an imaginary line joining the centers of the grips.
5. Start the machine at a grip separation speed of 250 ± 5% mm/min.
6. Record the load necessary to propagate the tear through the entire unslit 25mm portion.

RESULT:

Maximum tear propagation force of _____ film having thickness _____ mm is _____ N.

EXPERIMENT – 13

SPECIFIC GRAVITY AND DENSITY OF PLASTICS

AIM: To determine specific gravity and density of solid plastics in accordance with ASTM D 792

PRINCIPLE:

Specific gravity and density determinations are performed by "Archimedes principle". This principle states that every solid body when immersed in a fluid apparently loses weight by an amount equal to the fluid it displaces.

A specimen of solid plastic is weighed in air. It is then immersed in a liquid of known density and its loss in weight upon immersed is determined. And its specific gravity is calculated.

Multiply the specific gravity of the sample to the density of the liquid used, to give density of the sample being tested.

SIGNIFICANCE AND USE:

The specific gravity or density of a solid is a property that can be measures conveniently to identify a material, to follow physical changes in a sample, to indicate degree of uniformity among different sampling units or to indicate the average density of a large item.

Changes in density of a single specimen may be due to changes in crystallinity, loss of plasticizer, absorption of solvent etc. Portions of a sample may differ in density because of difference in crystallinity, thermal history, porosity and composition (types or proportions of polymer, plasticizer, pigment or filler).

Density is useful for calculating strength-weight and cost-weight ratios.

APPARATUS:

1. ***Analytical balance****:* A balance with a precision within 0.1 mg and equipped with a stationary support for the immersion vessel above the balance pan.
2. ***Holder/sinker****:* Two numbers of holders for both floating and nonfloating solids. This shall be corrosion resistant.
3. ***Immersion vessel:*** a glass beaker beaker may be used for holding water.
4. ***Thermometer:*** A thermometer with an accuracy of $\pm 1^0$C is required.

TEST SPECIMEN: The test specimen shall be single piece of the material weighing approximately 1 to 50g.

PROCEDURE:

1. Switch on the Analytical (electronics) balance and do all the settings.
2. Weigh the specimen in air to the nearest 0.1 mg and note down the reading as ' W_1'.
3. Mount the immersion vessel on the support.
4. Take air-free distilled or demineralized water in a beaker and keep it on the support.
5. Immerse the specimen in water using a holder.
6. Record the weight in water of the specimen as 'W_2'.

CALCULATION:

1. Specific gravity $= \dfrac{W1}{(W_1 - W_2)}$

2. Density (g/cc) = Specific gravity X Q_0

   Where,

   W_1 – weight of the solid in air; g

   W_2- weight of the solid in water, g

   Q_0 – density of water at the given temperature, g/cc

OBSERVATION AND RESULT:

Sl.No.	Material	Temp.of water(g/cc)	Weight of sample in air (g)	Weight of sample in water (g)	Specific gravity	Density (g/cc)
1						
2						

EXPERIMENT – 14

TESILE PROPERTIES OF RUBBER

AIM: To determine tensile properties such as Tensile Strength, Modulus, Ultimate Elongation and Tensile set, of rubber in accordance with ASTM D 412

SIGNIFICANCE AND USE:

Rubber and rubber products must with stand tensile forces for adequate performance in certain applications. Tensile properties may or may not directly relate to the end use performance of the product because of the wide range of performance requirements in actual use. Tensile properties depend both on the material and the conditions of test such as extension rate, temperature, humidity, specimen geometry, environmental or mechanical preconditioning and therefore results should be compared only when tested under the same conditions.

Tensile set represents residual deformation which is partly permanent and partly recoverable after stretching and retraction.

APPARATUS: Universal Testing Machine with Plotter, Dial thickness gage, scale, stop watch etc.

TEST SPECIMEN:

Method A: Dumb-bell and straight specimen – should be cut so that the lengthwise portion of the specimen is parallel to the grain direction. Straight specimens are used only when it is not feasible to prepare another type of specimen.

Method B: Cut ring specimen – ring specimens average the tensile stress with and across the grain.

DUMB- BELL SPECIMEN: The dimensions of the specimen (Die C) is as shown below:

Length overall (C)	:	115 mm (minimum)
Length of narrow parallel section (L)	:	33 ± 2mm
Width overall (A)	:	25 ± 1mm
Width of narrow section (W)	:	6 +0.05 or – 0.00 mm

Unless otherwise specified, Die C shall be used to prepare the specimens. In the case of sheets prepared in accordance with ASTM D 3182, the thickness of the specimen shall be 2.0 ± 0.2 mm. Otherwise, cut the specimen from a sheet not less than 1.3 mm nor more than 3.3 mm thick.

Sl. No.	Sample	Thickness (mmm)	Width (mm)	c/s area (mm^2)	Gag length L_o (mm)	Load at 300% elongn (N)	Load at break (N)	Elongation at break (mm)	Tensile strength (MPa)	300% Modulus (MPa)	% elongation at break
1.											
2.											
3.											
4.											
5.											

Sl. No.	Sample	Distance between bench marks after 10 minutes retraction (mm)	Distance between bench marks 10 minutes afrer break (mm)	Tensile set (%)	Tensile set after break (%)
		Gag length L_o (mm)			

PROCEDURE:

1. ***Determination of tensile strength, modulus, ultimate elongation:***
    1. Cut the specimens from the sheet
    2. Mark the specimen with bench marker for a distance of 25 ± 0.25 mm
    3. Measure the thickness one at the center and one at each end of the reduced section (with in gage length) of the specimen. If the differences between maximum and minimum exceeds 0.08 mm discard the specimen.
    4. Place the specimen in the grips of the testing machine.
    5. Set the grip separation speed to 500 ± 50 mm/min and start the machine.
    6. Note the distance between two bench marks.
    7. Record the force at specified elongation and at the time of rupture in Table 5.
2. ***Determination of Tensile set:***
    1. Place the specimen in the grips of the testing machine.
    2. Separate the grips at a uniform rate, requiring 15 s to reach the specified elongation. Hold it for 10 minutes.
    3. Release quickly without allowing it to snap back, and allow it to rest for 10 min.
    4. Measure the distance between bench marks and record it in Table 6.
    5. For determining set after break, 10 min. after the specimen is broken, fit the two pieces carefully together so that they are in contact over the full area of the break.
    6. Measure the distance between bench marks and record it in Table 6.

CALCULATION:

1. **Tensile stress** = F/A …… (1)

   Where, F= observed force at specified elongation,

   A= cross-sectional; area of the unstretched specimen
2. **Tensile Strength :** is calculated using equation (1) where F is equal to the force required to break the specimen.
3. **300% Modulus :** is also calculated using equation (1) where F is equal to the force at 300 % elongation.
4. **Strain, E**= $(L-L_0)/L_0$ …… (2)

   Where, L= observed distance between bench marks on the stretched specimen

   L_0 = original distance between the bench marks.
5. **%Elongation at break** $= \frac{(L - L_0)}{L_0} \times 100$ ……. (3)

Where, L= distance between bench marks at the time of rupture.

6. **Tensile set:** is calculated using equation (3) where L is the distance between the bench marks after 10 min retraction period.
7. **Tensile set after break:** is calculated using equation (3), where L is the distance between bench marks when measured 10 minutes after break.

EXPERIMENT – 15

RESILIENCE BY VERTICAL REBOUND

AIM: To determine impact resilience of solid rubber from measurement of the vertical rebound of a dropped mass in accordance with ASTM D 2632.

PRINCIPLE:

Resilience is determined as the ratio of rebound height to drop height of a metal plunger of prescribed weight and shape which is allowed to fall on the rubber specimen.

SIGNIFICANCE AND USE:

1. Resilience is a function of both dynamic modulus and internal friction of a rubber. It is very sensitive to temperature changes and to depth of penetration of the plunger. Consequently, resilience values from one type of rebound instrument may not, in general, be predicted from results on another type of rebound instrument.
2. This test method is used for development and comparison of materials. It may not directly relate to end-use performance.

SCOPE:

1. This test method covers the determination of impact resilience of solid rubber from measurement of the vertical rebound of a dropped mass.
2. This test method is not applicable to the testing of cellular rubbers or coated fabrics.
3. A standard test method for impact resilience and penetration of rubber by a rebound pendulum is described in Test Method D1054.

APPARATUS:

Rebound resilience tester which includes means for suspending plunger of 28 ± 0.5 g weight at a given height and a scale for measuring rebound height. The drop height should be 400 ± 1 mm above the specimen surface and the resilience scale should be marked in 100 equally spaced divisions. The plunger fall and rebound is guided by a vertical rod with minimum friction.

TEST SPECIMEN:

The standard specimen shall have a thickness of 12.5 ± 0.5 mm. the specimen shall be cut such that, the point of plunger impact is a minimum distance of 14 mm from the edge of the specimen. (Specimen size : 36 X 36 X 12.5 mm^3)

PROCEDURE:

1. Level the instrument and raise the plunger to the top of its guide rod.
2. Position the resilience scale so that its full weight rests upon the specimen. Lock it in this position.
3. Release the plunger, making sure that it slides freely on its guide.
4. Do not record the first 3 rebounds. Record the height of each of the next 3 rebounds. Since the resilience scale is divided into 100 parts, the rebound height is equal to the resilience in percent.
5. Test 3 specimens from each sample and report the average of 3 results.

RESULT:

Resilience of _____ Rubber sample is _____ %

EXPERIMENT – 16

FLEX FATIGUE RESISTANCE OF RUBBER

AIM: To determine dynamic fatigue resistance of rubber in accordance with ASTM D 430.

SCOPE:

This test method covers testing procedures that estimate the ability of soft rubber compounds to resist dynamic fatigue. No exact correlation between these test results and service is given or implied because of varied nature of service conditions. Data obtained by this test procedure can be used for the comparative evaluation of rubber compounds.

SIGNIFICANCE AND USE:

This test is designed to simulate the repeated distortions produced by extension, compressive and bending forces or combinations of all, in service by rubber articles such as tyres, belts, footwear and various molded goods. The effect of distortions is to weaken the rubber until surface cracking or rupture and in case of coated fabric, is fabric separation. And hence this test is of the following 2 types:

Type I: tests designed to produce separation of rubber-fabric combinations used in belts, tires etc.

Type II: Tests designed to produce cracking on the surface of rubber by repeated bending or extension as occurs in service with parts such as tyre treads and sidewalls, rubber soles, shoe uppers, hose covers, diaphragms etc.

APPARATUS: There are 3 test methods using the following types of apparatus:

1. ***Method A-*** Scott Flexing Machine: is used for test of type I.
2. ***Method B-*** De Mattia Flexing Machine: is used for test of type II
3. ***Method C-*** E.I. Dupont de Nemours and co. Flexing Machine: is adapted to tests of either type I and II.

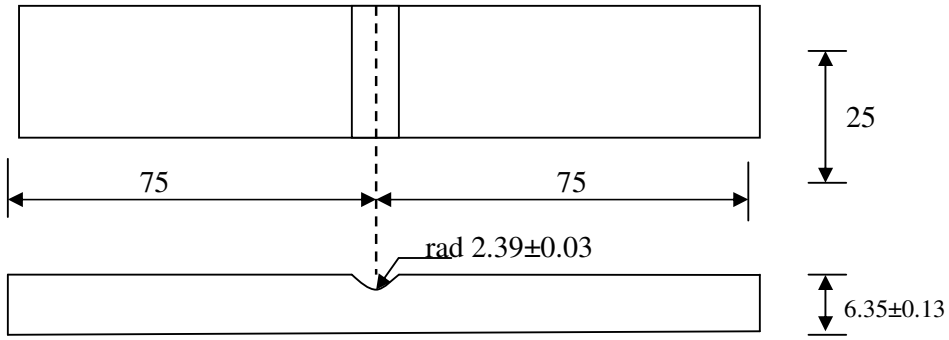
DEMATTIA FLEXING MACHINE:

This test method is used to test rubber specimens for resistance to cracking produced either by extension or bending. The machine has an adjustable stationary member with suitable grips to hold one end of the specimen and a similar reciprocating member to hold other end of the specimen. The speed of the movable head is 300 ± 10 flexing cycles per min. provision

for maximum travel of moving grip is 100mm and at least 6 specimens shall be tested at a time.

Extension Fatigue Cracking: when extension type of strain is used the standard test specimen shall be dumbbell shape (Die C) of test method D 412. The movable grip is adjusted so that it will approach the stationary grip 13 mm closer than the necessary to relieve the elongation stress in the specimen. The grips will separate a maximum distance sufficient to elongate the portion of the specimen between the page marks a predetermined and recorded amount. The elongation of the specimens between the gage marks shall not exceed ¼ of the ultimate elongation. For highly extensible rubbers a maximum elongation of 125% is suitable.

Bend Flexing: *The shape and dimensions of test specimen is as shown below:*



Note : 1) Not to scale

2) All dimensions are in mm

Figure 6. Flex Test Specimen

In this test, during each stroke of the machine the grips approach each other at a distance of 19.0 ± 0.1 mm and separate at a distance of 76.2 +0.3 or 0.00 mm.

PROCEDURE:

1. After necessary adjustment of the apparatus, fix the specimen.
2. Start the machine and record the time. Continue the test until the appearance of the first minute sign of cracking is detected, by frequent inspection, Record the time and calculate the number of cycles required for first sign of cracking by multiplying the observed time in minutes by the rate of 300 cpm. The first cracking may be evidenced as either very fine hair-line cracks or as slight pin holes.

3. Run the test for a known predetermined number of cycles, after which make the grading comparison. Compare by judging visually the length, depth and number of cracks. The standard comparison scale shall consist of 11 specimens equally graded and numbered from No. 0, showing no cracking, to No. 10 which is completely cracked through.

RESULT:

1. No. of flexing cycles required for crack initiation ……..
2. No. of flexing cycles required to attain a definition severity rating ……

EXPERIMENT – 17

CRACK GROWTH RESISTANCE OF RUBBER

AIM: To determine crack growth of vulcanized rubber subjected to repeated bend flexing as per the standard ASTM D 813.

SCOPE:

This test is particularly applicable for synthetic rubber compounds which resist the initiation of cracking due to flexing when tested in De Mattia type machine (ASTM D 430) and the small cuts or tears in service may propagate rapidly. Because of this characteristic of synthetic compounds particularly those of SBR type, this method in which the specimens are artificially punctured in the flex area and the cut length is measured at frequent intervals to determine the cut growth rate.

APPARATUS:

De Mattia Flexing Machine with specifications as described in test method ASTM D 430, measuring scale, piercing tool to make artificial crack at the center of groove of the specimen.

TEST SPECIMEN: The shape and dimensions of test specimen is shown in fig. (6).

PROCEDURE:

1. Make an artificial cut on the center of the groove of test specimen. The piercing tool shall be maintained perpendicular to both the transverse and longitudinal axes and the cut accomplished by a single insertion and withdrawal of the tool. The dimensions of the tool are given in the standard. While cutting, the tool shall completely penetrate the specimen and project at least 3.2 mm through the specimen. The initial cut produced by the punctured spear is 2 ± 0.1 mm in width.
2. Clamp the specimens in the grips of the machine such that the circular groove shall become outer surface. The positions of stationary and movable grip shall be adjusted so that during each stroke of the machine the grips approach each other to a distance of 19.0 ± 0.1 mm and separate at a distance of 75.9 + 0.3 or -0.0mm.
3. Start the machine and record the time. Stop the machine at 1000 cycle periods (the number of flexing cycles is calculated by multiplying the observed time in minutes by the machine rate (ie.300 cpm).

4. Measure the length of the developed crack to the nearest 0.3 mm with an accurate scale.
5. Continue the test until a crack at least 12.5 mm in length developed. Continuation to break may be desirable for aged specimens or when operating at elevated temperatures.

RESULT:

The crack growth data may be reported in any one of following 3 ways:

1. As the number of cycles required to reach the specified crack growth length for example, from 2 to 20mm or,
2. As the average rate of crack growth over the entire test period, or,
3. As the rate of cracking in millimeters per kilocycles during a portion of the test for example, (a) 2 to 4mm (b) 4 to 8 mm or (c) 8 to 12mm.

EXPERIMENT – 18

TEAR RESISTANCE OF RUBBER

AIM: To determine Tear Resistance of vulcanized rubber as per the standard ASTM D 624.

SIGNIFICANCE AND USE

1. Vulcanized rubber and thermoplastic elastomers (TPE) often fail in service due to the generation and propagation of a special type of rupture called a tear. This test method measures the resistance to tearing action.

2. Tear strength may be influenced to a large degree by stress-induced anisotropy (mechanical fibering), stress distribution, strain rate, and test piece size. The results obtained in a tear strength test can only be regarded as a measure under the conditions of that particular test and may not have any direct relation to service performance. The significance of tear testing must be determined on an individual application or product performance basis.

SCOPE

1. This test method describes procedures for measuring a property of conventional vulcanized rubber and thermoplastic elastomers called tear strength.

2. The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

3. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPARATUS: UTM, dial thickness gauge, die for cutting test specimen, razor blade etc.

TEST SPECIMEN:

There are 3 specimen shapes as follows:

1. **Die A:** A razor nicked crescent specimen
2. **Die B:** A razor nicked crescent specimen with tab ends (ISO/34 configuration)
3. **Die C:** An unnicked 90^0 angle specimen.

The thickness of the specimen should not fall outside the limits of 1.3 to 3.2 mm.

PROCEDURE:

1. Cut the specimen from the sheet such that the grain direction is long way of the specimen.
2. Make a single slit or nick at the center of the inner concave edge (for Die A and B) of the specimen. The cutting shall be done by a safety razor blade clamped in a holder with the extension of the blade beyond the surface of the holder regulated by a depth gage to produce a slit of 0.50 ± 0.05 mm in depth. Die C specimens are not nicked.
3. Measure the thickness in three places across the width of the specimen, near its center and record the median measurement.
4. Clamp the specimen in the grips of the testing machine and align with the center of the ends.
5. Separate the grips at a rate of 500 ± 50 mm/min.
6. Record the highest force and calculate the tear strength (resistance) as follows:

$$\text{Tear strength } T_S \text{ (N/mm)} = \frac{\text{Maximum load (N)}}{\text{Thickness (mm)}}$$

OBSERVATION:

Sl. No.	Sample	Thickness (mm)	Maximum load (N)	Tear Strength (N/mm)
1				
2				
3				

RESULT: Tear strength of _____ Sample given is _____ N/mm

EXPERIMENT – 19

SPECIFIC GRAVITY OF RUBBER

AIM: To determine specific gravity of rubbers using direct reading specific gravity balance.

APPARATUS: Direct reading specific gravity balance with following specifications:

Dial Scale reading: 0.9 to 2.0 graduated 0.01
2.0 to 2.5 graduated 0.02
2.5 to 3.0 graduated 0.05

TEST SPECIMEN: Test piece of 5 to 20 g weight.

CALIBRATION: Calibrate the balance as follows:

1. With needle and sinker in position slide the 2 weights to the bottom of the long arm.
2. Adjust the base level screw until pointer reads 1.00
3. Place the 3 calibration weights on the needle above sinker.
4. Adjust the sliding weights on long arm until the pointer is exactly on mark 'A',
5. Remove one weight from the sinker. Now the pointer should read 3.00 ± 0.02.
6. Remove the second weight from the sinker. The pointer should now read 1.50 ± 0.005

PROCEDURE:

1. Make sure that the pointer is moving freely in its pivots screw. The screw should be tightened only to the extent of free movement of pointer.
2. Fill the glass beaker with distilled water and keep it on the platform and see that the lower needle is fully immersed in water.
3. Adjust the sliding weights of long arm until the pointer reads 1.00 accurately.
4. Remove the beaker from the platform.
5. Fix the sample in the needle.
6. Adjust the sliding weight on the long arm until the pointer coincides accurately with the mark 'A' on the dial scale.
7. Raise the beam to lift the test piece and place the beaker of distilled water on the platform.
8. Raise the platform and beaker until the test piece is immersed fully in water without bubbles. Ensure that the specimen does not touch the slides or bottom of the beaker and that the sinker does not make contact with the water during test.
9. Read the scale which directly gives the specific gravity of sample being tested.

RESULT: Specific gravity of _____ rubber sample is _____

EXPERIMENT- 20

ABRASION RESISTANCE OF RUBBER

AIM: To determine abrasion resistance of vulcanized rubbers as per the standard BS 903 part A9.

APPARATUS:

Du Pont Croydon Abrasion Tester which carries a standard abrasive disc mounted on a vertical flat wheel which is rotated at a speed of 35±5 rpm about the axis of the lever arm by means of an electric motor. The torque in the lever arm is balanced by means of a weight bucket. A lever arm with specimen holders is mounted on a rod. A wire with a known weight for holding the specimens against the abrasive disc is attached to the far end of the rod.

TEST SPECIMEN: The standard dimension of test Specimen is 2 X 2 X 1 cm^3.

PROCEDURE:

1. Weigh the test specimen and record its weight as W_1. At a time 2 specimens from the same sample shall be tested.
2. Fix the specimens in its holders.
3. Press the lever arm and rod such that the specimens are in firm contact with abrasive disc. Suspend the weight to the far end of the rod which passes through a pully for holding the specimens in firm contact with the disc during test.
4. Start the machine. The abrasive surface is continuously cleaned by means of air jets.
5. After specified number of revolutions or time, stop the machine.
6. Weigh the sample and record the weight as W_2.
7. Determined the density of sample in g/cc and record it.

CALCULATION: Calculate and report the Abrasion resistance of given rubber sample in any of the following ways:

1. Abrasion loss (volume loss) in cc/hr.
2. Volume loss per horse power hour = (Volume loss in cc/hr)/(horse power)
3. Abrasion resistance index * = $\dfrac{\text{Volume loss in cc/hr of a standard compound}}{\text{Volume loss in cc/hr of test compound}}$

*Since all tests are comparative, a standard compound is included so that the result can be expressed as Abrasion Resistance Index i.e. Abrasion resistance relative to that of a standard compound.

OBSERVATION:

SL. No.	sample	Density (g/cc)	Initial weight W1 (g)	Final weight W2 (g)	Loss in weight (g)	Weight loss per hour (g)	Volume loss (cc/hr.)
1							
2							
3							
4							
5							
6							

RESULT: The Abrasion loss of _____ sample is _____ cc/hr.

EXPERIMENT- 21

FLAMMABILITY TEST

AIM: To determine Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position according to ASTMD 635

SCOPE:

1. This fire-test-response test method covers a small-scale laboratory screening procedure for comparing the relative linear rate of burning or extent and time of burning, or both, of plastics in the form of bars, molded or cut from sheets, plates, or panels, and tested in the horizontal position.
2. This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazards or fire risk assessment of materials, products, or assemblies under actual fire conditions.

SIGNIFICANCE AND USE

1. Tests made on a material under conditions here in prescribed are of value in comparing the rate of burning or extent and time of burning characteristics, or both, of different materials, in controlling manufacturing processes, or as a measure of deterioration or change in these burning characteristics prior to or during use. Correlation with flammability under actual use conditions is not implied.
2. The rate of burning and other burning phenomena will be affected by such factors as density, pigments, any anisotropy of the material and the thickness of the specimen. Test data shall be compared only for specimens of similar thickness, whether comparisons are being made with the same or different materials. The rate of burning and other burning phenomena will vary with thickness.

APPARATUS

Test Chamber, enclosed laboratory hood, or chamber free of induced or forced draft during test, having an inside volume of at least 0.5 m^3. An enclosed laboratory hood with a heat-resistant glass window for observing the test and an exhaust fan for removing the

products of combustion after the tests is recommended. The atmosphere in and around the test chamber shall be maintained between 15 to 35°C and 45 to 75 % relative humidity.

Laboratory Burner, constructed in accordance with Specification D 5025.

Gas Supply, a supply of technical-grade methane gas with suitable regulator and meter for uniform gas flow. Natural gas mixtures having an energy density of approximately 37MJ/m^3 have been found to provide similar results.

Timing Device, accurate to 0.5 s.

Scale graduated in millimeters.

Conditioning Room or Chamber

Flexible Specimen Support Fixture, used to facilitate the testing of specimens that sag and touch the wire gauze.

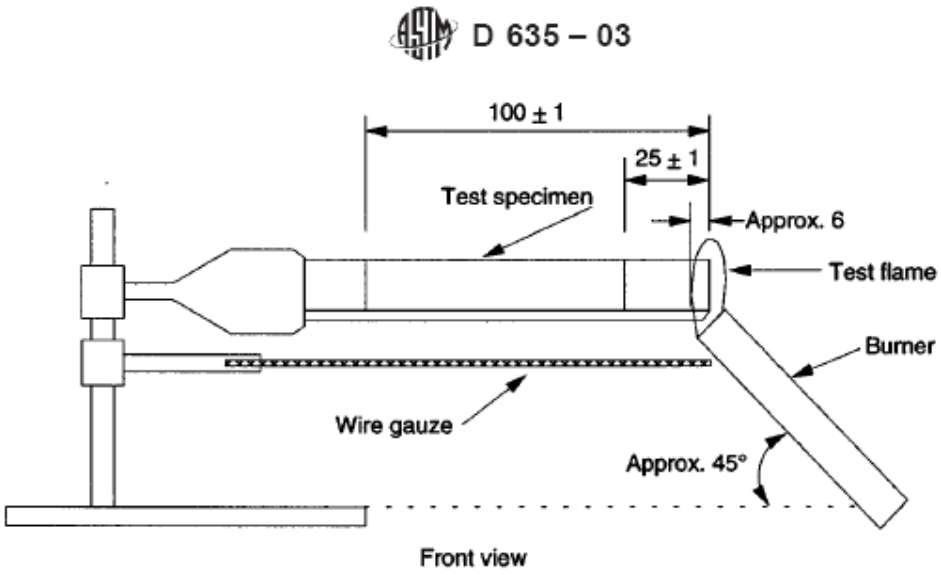


Figure : Flammability Test Setup

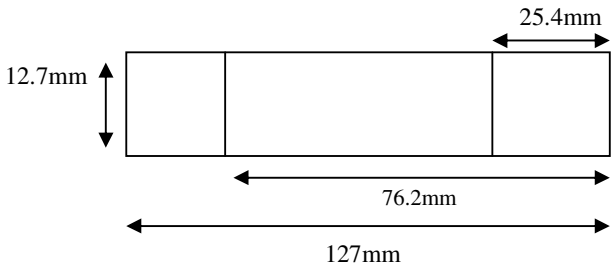
TEST SPECIMEN:

Prepare specimen of size L=127mm,W=12.75±mm.Three specimens shall be having thickness equal to minimum thickness of the lot and three with thickness of 3.18mm.The 3.18 mm thickness is not necessary, if minimum thickness of lot is more than 3.18 mm or maximum thickness is less than 3.18mm. Specimen thickness should be limited to

12.7mm. Ensure that the edges are smooth and the radii of the corners do not exceed 1.2mm.

Condition the specimens for atleast 48 hrs at temperature 23 ±2°cand relative humidity of 50±5 percent. Each specimen is marked across its width with two lines , 25.4mm and 101.6mm from one end.

SPECIMEN:



PROCEDURE:

1. First switch on the mains.
2. Check whether air pressure is there in compressor or not. If not switch on the compressor and fill the air in reservoir.
3. Allow the gas to flow through burner and ignite the burner.
4. Now slowly open the air valve and allow it until blue colour flame 2.5 cm is obtained (check with stick given)
5. Fix the specimen from one end with its longitudinal axis lying in a horizontal plane and its transverse axis inclined at 45° ,a burner to apply the flame at the tip of test specimen, arrangement to incline the burner to 45° and to move it so that its tip can be brought vertically below the free end of test specimen.
6. Now the timer starts automatically. Once 76.2mm is burnt, press the hold button of timer and record time taken for 76.2mm of sample to burn.
7. Calculate linear rate of burning using equation

Linear rate of burning (mm/min) = $\frac{60 \times 76.2}{t}$

Where t is time in seconds for the flame to travel 25.4mm mark to 101.6mm mark

QUESTION BANK

1. **Define the following**
   a) Hardness
   b) Tensile strength
   c) Flexural strength
   d) Abrasion resistance
   e) Resilience
   f) Tear strength
   g) Impact strength
   h) VSP
   i) HDT
   j) MFI
   k) Dielectric strength
   l) Specific gravity and density
   m) Conditioning
   n) Flame resistance.
2. **Write ASTM standard for the following tests**
   a) Hardness
   b) Tensile strength
   c) Flexural strength
   d) Abrasion resistance
   e) Resilience
   f) Tear strength
   g) Impact strength
   h) VSP
   i) HDT
   j) MFI
   k) Dielectric strength
   l) Specific gravity and density
   m) Flame resistance.

3. **Effect of different test variables on results of**
    a) Hardness
    b) Tensile properties
    c) Flexural properties
    d) Abrasion resistance
    e) Resilience
    f) Tear strength
    g) Impact strength
    h) VSP
    i) HDT
    j) MFI
    k) Dielectric strength
    l) Specific gravity and density
    m) Flame resistance testing.
4. Test specimen preparation methods for different tests
5. Advantages and disadvantages of the specimen preparation techniques
6. Different methods of conditioning
7. Samples dimensions and shape of the samples for different tests for ex: mechanical , thermal, electrical and other physical properties
8. Formulae used for calculations and units used for expressing test results for the properties mentioned in 3.
9. Scope and Significance of the different test methods.
10. Behavior of plastic and rubber material on tensile, flexural and compression load.
11. Different types of Flame resistance methods

Work sheet

Work sheet