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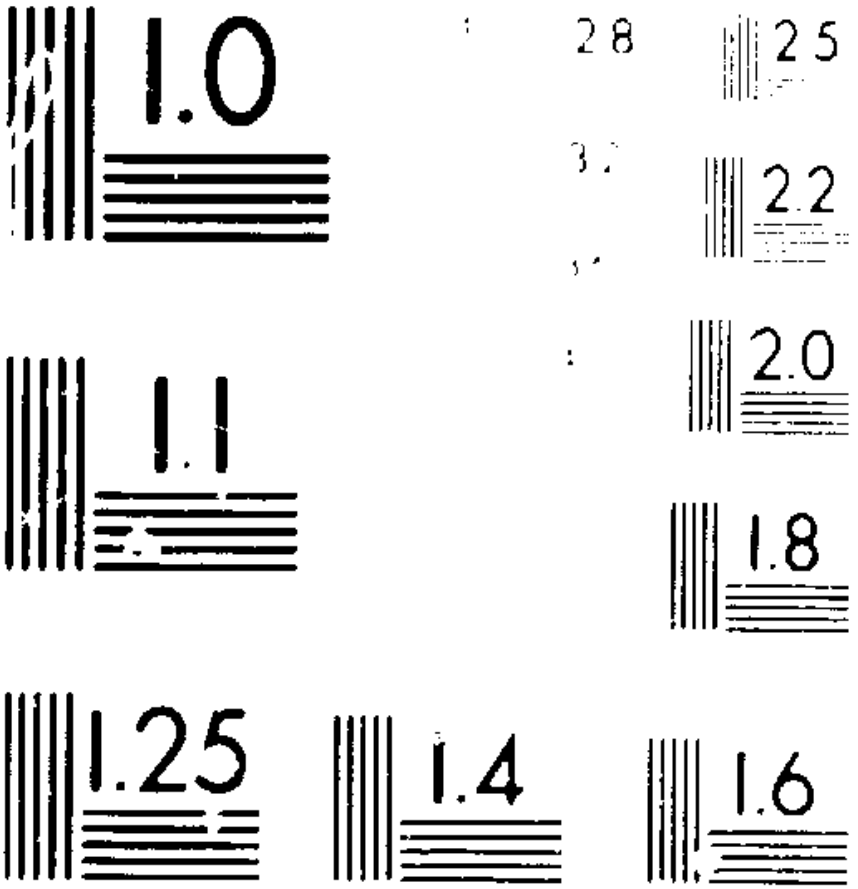

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UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

REPORT ON
THE TESTING OF PLASTICS AND RUBBER */

prepared by

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Division of Industrial Operations
Chemical Industries Branch

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C O N T E N T S

Annexures

1. Introduction

The plastics and rubber industries - the polymer industries - have been among the fastest growing sector of our economy.

Some 40 million tons of plastics are used annually in products ranging from automobile components to artificial heart valves. Some of these plastics products - in fact the great majority - are used in application that require long service.

In 1974 the rubber industry consumed 3.5 million tons of rubber in U.S.A. alone (1). The rubber industry consumption includes new rubber as well as reclaimed rubber. Major use of rubber is in the tyre industry, though a significant use is made in the manufacture of foot-wear, hose, rubber backings on textiles, wire coatings, gaskets, mattresses etc.

1.1 Need for testing

In any manufacturing industry quality control and standardization of products play a vital role. In the the field of plastics and rubber industries, with the rapid growth have come the ever increasing number and variety of raw materials which permit a wide scope of formulation changes. Dependable methods for evaluation of these products, therefore, are of particular interest not only to enable the producer to assess the possibility of new formulations but also for the protection of the consumers.

1.2 Standard methods of tests

Plastics and rubber products are usually sold on the basis of quality specifications which are dictated by the end use. These specifications are the results of agreement between the manufacturers and the purchasers. The use of quality specification for any product requires that there be an adequate body of analytical and testing procedures which can establish that the desired specification levels have been achieved.

Although plastics and rubber products are produced and sold internationally, the testing procedures used to define quality are generally nationalistic in character. Attempts to accept international standards of testing procedures by agencies like the International Standards Organization (ISO) encountered many problems arising from the diversity of test equipment and procedures in vogue in the manufacturing nations.

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(1) Darnay, A. and Franklin, W.E., Midwest Research Institute, Salvage Markets for Materials in Solid Wastes, Publication 5W-29C, Washington, D.C. (1972).

Most of the English speaking countries base their standard procedure on the methods recommended by the technical section of the British Standards Institution, the American Society for Testing Materials, Indian Standards Institution and others.

ISO Technical Committees 61 and 45 deal with the Methods of Tests for plastics and rubber respectively.
A list of such ISO references together with titles are included in Annexures 1 and 1.1 respectively.

Since ASTM methods for testing of plastics which cover the entire area of plastics technology has not yet been aligned completely with ISO TC 61, these are also included due to their usefullness in Annex 1.2.

The test methods presented in these annexures give interesting facts about the common tests on plastics and rubber referred to in their properties. As a matter of interest a lack of such properties of plastics which may be classified as Processing, Mechanical, Thermal, Electrical, Optical and Resistance to Environment is enclosed in Annex 1.3.

1.3 Users of tests

It may be pointed out at this stage that tests are not ends in themselves but rather means of extracting knowledge about materials. Most production plants have laboratories for routine quality control tests and similar tests are conducted separately for research and developement purposes.

So far as the plastics processors are concerned, they are generally interested in all test values but particularly watch those that affect the handling qualities of material in production equipment (e.g., melt indexes of polyethylenes and flow characteristics of cellulosics).

The real test of a material comes with actual service and once a plastics product is taken home and used by the consumer, it is immaterial to know its exact tensile stength, for example. The product either succeeds entirely or fails.

To assure success of toys, housewares, industrial products and automotive components, the properties of likely materials are studied by design engineers who, through experience and judgement, balance material characteristics and service requirements against the amount of material needed in parts to give adequate safety margin.

In certain cases, a service requirement may be so complex that suitable material can be determined only in actual service. As an example, plastic

for pipe is tested by making pipe of it, attaching it to a pressurized water line as in actual service and watching whether it can stand it.

1.4 Standardization of tests

To meet the rigid product specifications in the manufacture of plastics and rubber, reliable testing and analytical procedures are the prerequsites. Most of the tests are performed on highly specialized laboratory equipment under carefully defined conditions. The accuracy and uniformity of testing data depends on careful standardization and maintenance of apparatus used. The high cost of handling off-specification product makes it mandatory that the change in product quality determined by testing not be the result of changes of test procedure or in the laboratory equipment.

In both quality control and specification, the most reliable check of the performance of test procedure or equipment is the routine use of a standard reference material. This material should be stable and uniform and in sufficient supply to provide reference checks over a long period. A regular testing schedule with such a material will provide an immediate indication of any change in the behaviour of the procedure or the apparatus.

In addition to the use of a reference standard material, a routine inspection schedule and maintenance programme should be carried out for the most frequently used testing equipment.

A means of evaluating procedures and equipment as well as standardizing them is proposed in ASTM D 1749. This programme can reveal discrepancies in testing and also provide a means of evaluating alternative methods of performing a test. Long term inter-laboratory sample exchange programmes are effective means of maintaining uniform test levels and observing changes in procedure that may otherwise pass undiscovered.

The routine use of reference materials, regular inspection schedules and calibration standards will assure reliable test data and improve efficiency of test programme.

In addition to the standardization of procedures and equipment, the manner in which the test results are reported must be standardized if it is to be generally understood.

2. Standard Atmospheric conditions for testing of plastics and rubber

Both relative humidity and temperature are known to have pronounced effect on the physical properties of plastics and rubber. Because of this, the conditioning and testing of these materials at a constant humidity and temperature are extremely important if the test date are to be reproducible and comparable with other test results.

2.1 ISO recommended atmospheric conditions for tests of plastics and rubber

2.1.1 ISO 291 - 1977 - Standards Atmosphere for Conditioning and Testing of Plastics specifies as follows:

Atmosphere 23/50, temperature 23°C and relative humidity 50 % - recommended atmosphere

Atmosphere 27/65, temperature 27°C and relative humidity 65 % for tropical countries.

Conditioning: The period and conditioning shall be stated in the relevant specification of the material.

2.1.2 ISO 498 -1974 - Standard temperatures, humidities and time for conditioning and testing of test pieces of Rubber stipulates that the standard temperature and humidity shall be chosen from the following:

23 ± 2°C and 50 ± 5 % relative humidity
27 ± 2°C and 65 ± 5 % relative humidity

If a closer tolerance is required, the temperature should be within ± 1°C and the relative humidity ± 2 %.

Conditioning: The standard time for conditioning shall be a period not less than 16 hours immediately before testing.

3. Test equipment

A list of the test equipment necessary for the plastics and rubber testing laboratory is enclosed in Annexure 2. Names of some of the well known manufacturers are also enclosed in the same Annexure.

4. Selected bibliography on testing

A lsit of some useful publications on plastics and rebber testing is enclosed in Annexure 3.

5. Training

A list of the Institutes and laboratories where both the theoretical and practical training in the testing of plastics and rubber are possible is enclosed in the Annexure 3.

PLASTICS

UDC 678.5/ .8

Reference	Code	Title
ISO/R 62-1958	B	Plastics - Determination of water absorption
	B	Addendum 2-1965
ISO 75-1974	B	Plastics and ebonite - Determination of temperature of deflection under load
ISO 178-1975	D	Plastics - Determination of flexural properties of rigid plastics
ISO/R 179-1961	E	Plastics - Determination of Charpy impact resistance of rigid plastics (Charpy impact flexural test)
ISO/R 180-1961	E	Plastics - Determination of the Izod impact resistance of rigid plastics (Izod impact flexural tests)
ISO 291-1977	B	Plastics - Standard atmospheres for conditioning and testing
ISO 294-1975	C	Plastics injection moulding test specimens of thermo-plastics materials
ISO 295-1974	D	Plastics - Compression moulding test specimens of thermosetting materials
ISO/R 458-1965	D	Plastics - Determination of stiffness in torsion as a function of temperature
ISO/R 483-1966	E	Plastics - Methods for maintaining constant relative humidity in small enclosures by means of aqueous solutions
ISO/R 489-1966	C	Plastics - Determination of the refractive index of transparent plastics
ISO/R 527-1966	E	Plastics - Determination of tensile properties
ISO/R 537-1967	F	Plastics - Testing of plastics with the torsion pendulum
ISO 604-1973	D	Plastics - Determination of compressive properties
ISO 844-1978	C	Cellular plastics - compression test of rigid materials
ISO 845-1977	B	Cellular rubbers and plastics - Determination of apparent density
ISO 868-1978	C	Plastics - Determination of indentation hardness by means of a durometer (Shore hardness)
ISO/R 872-1968	E	Plastics - Determination of resistance to change upon exposure under glass to daylight
ISO/R 879-1968	D	Plastics - Determination of resistance of plastics to colour change upon exposure to light of a xenon lamp
ISO/R 899-1968	D	Determination of tensile creep of plastics
ISO/R 1184-1970	E	Plastics - Determination of tensile properties of films
ISO/R 1195-1970	D	Plastics - Determination of the water vapour transmission rate of plastics films and sheets - Dish method
ISO 1209-1976	B	Rigid cellular plastics - bending test
ISO 1923-1972	C	Rigid cellular plastics - Determination of tensile properties

Reference	Code	Title
ISO 2039-1973	C	Plastics and ebonite - Determination of hardness by the ball indentation method
ISO 2818-1974	E	Plastics - Preparation of test specimens by machining
ISO 2896-1974	D	Rigid cellular plastics - Determination of water absorption
ISO 3167-1975	B	Plastics - Preparation and use of multi-purpose test specimens
ISO 3268-1978	E	Plastics - Glass reinforced materials - Determination of tensile properties
ISO 3341-1977	D	Textile glass - Yarns - Determination of breaking force and breaking elongation

Rubber and rubber products

UDC 678.4 + 678.7

Reference	Code	Title
ISO/R 34-1957	C	Determination of tear strength of vulcanized natural and synthetic rubbers (crescent test piece)
ISO 37-1977	D	Rubber, vulcanized - Determination of tensile stress - strain properties.
ISO 48-1975	D	Vulcanized rubbers - Determination of hardness (Hardness between 30 and 85 IRHD)
ISO 132-1975	C	Vulcanized rubbers - Determination of resistance to flex cracking (De Mattia - type machine)
ISO 133-1975	C	Vulcanized rubbers - Determination of resistance to cut growth (De Mattia - type machine)
ISO 188-1976	C	Rubber, vulcanized - Accelerated ageing or heat-resistance tests
ISO 498-1974	B	Rubber - Standard temperatures, humidity and times for the conditioning and testing of test pieces
ISO 1307-1975	B	Rubber hose - bore sizes, tolernaces on length and test pressures
ISO 1400-1975	C	Vulcanized rubbers of high hardness(85 to 100 IRHD) - Determination of hardness
ISO 1402-1974	C	Rubber hose - Hydrostatic testing
ISO 1419-1977	B	Fabrics coated with rubber or plastics - Accelerated ageing and simulated service tests
ISO 1420-1978	B	Rubber or plastics coated fabrics - determination of resistance to penetration by water
ISO 1421-1977	B	Fabrics coated with rubber or plastics - Determination of breaking strength and elongation at break
ISO 1431-1972	D	Vulcanized rubbers - Determination of resistance to ozone cracking under static conditions
ISO 1432-1976	D	Rubber, vulcanized - Determination of stiffness at low temperature (Gehman test)
ISO 1653-1975	C	Vulcanized rubbers - Determination of compression set under constant deflection at low temperatures
ISO 1658-1973	C	Natural rubber (NR) - Test recipes and evaluation of vulcanization characteristics
		Addendum 2-1976
ISO 1746-1976	B	Rubber hose - bending test
ISO 1747-1976	C	Rubber, vulcanized - Determination of adhesion to rigid plates in shear - Quadruple shear method

Reference	Code	Title
ISO 1796-1972	B	Raw rubber - sample preparation
ISO 1798-1976	B	Flexible cellular materials - Determination of tensile strength and elongation at break
ISO 1818-1975	D	Vulcanized rubbers of low hardness (10 to 35 IRHD) - Determination of hardness
ISO 1826-1974	B	Rubbers - Time-lapse between vulcanization and testing
ISO 1827-1976	C	Rubber, vulcanized - Determination of modulus in shear - Quadruple shear method
ISO 1853-1975	C	Conducting and antistatic rubbers - Measurement of resistivity
ISO 1856-1972	B	Flexible cellular materials - Determination of compression set
ISO 2007-1975	B	Raw rubber and unvulcanized compounded rubber - Rapid plasticity test
ISOISO 2285-1975	C	Vulcanized rubbers - Determination of tension set under constant elongation at normal and high temperature
ISO 2302-1978	C	Rubber, isobutene-isoprene (ISR) Evaluation procedures
ISO 2303-1975	B	Rubber, isoprene (IR) - Non oil-extended, solution polymerized types - Test recipe and evaluation of vulcanization characteristics
ISO 2322-1975	B	Rubber, styrene-butadiene (SBR) - Emulsion-polymerized general purpose types - Test recipe and evaluation of vulcanization characteristics
IS:		Addendum 1-1976
ISO 2393-1973	D	Rubber test mixes - Preparation, mixing and vulcanization - Equipment and procedures
ISO 2439-1972	B	Flexible cellular materials - Hardness testing by indentation techniques
ISO 2440-1972	B	Flexible cellular materials - Accelerated ageing tests
ISO 2472-1975	B	Ebonite - Determination of tensile strength and elongation at break
ISO 2473-1972	B	Ebonite - Determination of cross-breaking strength
ISO 2474-1972	B	Ebonite - Determination of crushing strength
ISO 2475-1975	C	Rubber, chloroprene (CR) - General purpose types - Evaluation procedures
ISO 2476-1975	C	Rubber, butadiene (BR) - Non oil-extended, solution-polymerized types - Test recipe and evaluation of vulcanization characteristics
		Addendum 1-1976
ISO 2781-1975	C	Vulcanized rubbers - Determination of density
ISO 2782-1977	D	Rubber, vulcanized - Determination of permeability to gases - Constant pressure method
ISO 2783-1975	B	Ebonite - Determination of hardness by means of a durometer

Reference	Code	Title
ISO 2856-1975	E	Elastomers - General requirements for dynamic testing
ISO 2878-1978	C	Rubber, vulcanized - Antistatic and conductive products - Determination of electrical resistance
ISO 2921-1975	C	Vulcanized rubber - Determination of low temperature characteristics - Temperature retraction procedure (TR test)
ISO 2928-1975	C	Rubber hose for liquefied petroleum gases (LPG)
ISO 2929-1975	C	Rubber hose for fuel truck delivery
ISO 2951-1974	D	Vulcanized rubber - Determination of insulation resistance
ISO 3011-1975	B	Fabrics coated with rubber or plastics - Determination of resistance to ozone cracking under static conditions
ISO 3417-1977	E	Rubber - Measurement of vulcanization characteristics with the oscillating disc curemeter
ISO 4080-1978	B	Rubber products - Hoses - Determination of gas permeance
ISO 4646-1979	D	Rubber or plastics coated fabrics - low temperature impact test
ISO 4648-1978	C	Rubber, vulcanized - Determination of dimensions of test pieces and products for test purposes
ISO 4659-1977	B	Rubber, styrene-butadiene (SBR) - Masterbatches with carbon black or carbon black and oil - Test recipe and evaluation of vulcanization characteristics
ISO 4661-1977	C	Rubber - Determination of rebound resilence of vulcanizates
ISO 4663-1977	E	Rubber - Determination of dynamic behaviour of vulcanizates at low frequencies - Torsion pendulum method
ISO 4664-1978	C	Rubber determination of dynamic properties of vulcanizates for classification purposes (by forced sinuoidal shear strain)
ISO 4672-1978	C	Rubber products - Hoses - Low-temperature flexibility tests
ISO 4674-1977	C	Fabrics coated with rubber or plastics - Determination of tear resistance

Annexure 1.2

ASTM TEST METHODS ON PLASTICS

- Permanence tests -

Reference	Title
ASTM D 1693-70	Environmental stress cracking
ASTM G23-69	Accelerated weathering
ASTM D794-68 (1972)	Permanent effect of heat
ASTM D 1435-69	Outdoor weathering
ASTM D 706-63	Weight loss on heating
ASTM D 570-63 (1972)	Water absorption

- Chemical tests -

ASTM C 619-71	Chemical resistance of asbestos fiber-reinforced thermosetting resins
ASTM C 581-68	Chemical resistance of thermosetting resins

- Mechanical tests -

ASTM D 790-71	Flexural properties
ASTM D 1822-68	Tensile impact
ASTM D 747-70	Stiffness in flexure
ASTM D 256-72a	Izod impact
ASTM D 638-72	Tensile properties
ASTM D 785-65 (1970)	Rockwell hardness
ASTM D 621-64	Deformation under load
ASTM D 695-69	Compressive properties of rigid plastics
ASTM D 732-46 (1969)	Shear strength

- Thermal tests -

ASTM D 648-72	Deflection temperature
ASTM D 696-70	Coefficient of linear thermal expansion
ASTM D 635-72	Flammability (for self supporting materials)
ASTM D 1238-70	Flow rate (melt index) by extrusion plastometer
ASTM D 569-59 (1971)	Flow properties
ASTM D 864-52 (1971)	Coefficient of cubical thermal expansion
ASTM D 1525-70	Vicat softening point
ASTM D 746-72	Brittleness temperature

Reference	Title
	- Analytical tests -
ASTM D 792-66 (1970)	Specific gravity and density
ASTM D 1505-68	Density by density gradient technique
	- Optical tests -
ASTM E 308-66	Spectrophotometry and description of color in CIE 1931 system
ASTM D 1003-61 (1970)	Haze and luminous transmittance of transparent plastics
	- Electrical tests
ASTM D 618-61 (1971)	Conditioning procedures
ASTM D 495-71	Arc resistance
ASTM D 149-64 (1970)	Dielectric strength
ASTM D 150-70	Dielectric constant and dissipation factor
ASTM D 257-66 (1972)	Tests for electrical resistance

Annexure 1.3

Plastic Properties Chart

Processing

1. Moulding qualities
2. Compression moulding temperature, ^{o}C
3. Comp. moulding pressure, kgf/cm^2
4. Injection moulding temperature, ^{o}C
5. Injection moulding pressure, kgf/cm^2
6. Compression ratio
7. Mould (linear) shrinkage, cm/cm
8. Specific gravity
9. Specific volume, cc/kg
10. Machining qualities

Mechanical

11. Tensile strength, kgf/cm^2
12. Elongation, %
13. Tensile elastic modulus, kgf/cm^2
14. Compressive strength, kgf/cm^2
15. Flexural yield strength, kgf/cm^2
16. Impact strength, cm-kg/cm of notch
17. Hardness, Rockwell
18. Flexural elastic modulus, kgf/cm^2
19. Compressive modulus, kgf/cm^2

Thermal

20. Thermal conductivity, $cal/sec/cm^2/(^{o}C/cm)$
21. Specific heat, $cal/^{o}C/gm$
22. Thermal expansion, $cm/cm/^{o}C$
23. Resistance to heat, ^{o}C (continuous)
24. Deflection temperature, ^{o}C

Electrical

25. Volume resistivity, ohm-cm (50% RH and $23^{o}C$)
26. Dielectric strength, short time, volts/mil
27. Dielectric strength, step-by-step, volts/mil
28. Dielectric constant, 60 cyc

29. Dielectric constant, 10^3 cyc
30. Dielectric constant, 10^6 cyc
31. Dissipation (power) factor, 60 cyc
32. Dissipation (power) factor, 10^3 cyc
33. Dissipation (power) factor, 10^6 cyc
34. Arc resistance, sec

Optical

35. Clarity
36. Haze, %
37. Transmittance, %
38. Refractive index

Resistance to environment

39. Water absorp., 24 hr., 3.5 mm thick, %
40. Burning rate (flammability), mm/min
41. Effect of sunlight
42. Effect of weak acids
43. Effect of strong acids
44. Effect of weak alkalis
45. Effect of strong alkalis
46. Effect of organic solvents

Annexure 2

1. . Plastics and rubber testing equipment

1. Universal Testing Machine (capacity 50 KN) for testing tensile, compression and flexural properties of plastics and rubber.
   Test Methods: ISO/R 572-1966, ISO 37-1976, ISO/R 1184-1970, ISO 1798-1976, ISO 2285-1975, ISO 2472-1975

2. Universal Impact Tester for testing charpy impact resistance, Izod Impact resistance and Tensile Impact properties of plastics.
   Test Methods: ISO/R 179-1961, ISO/R 180-1961

3. Vicat softening temperature and temperature of deflection under load tester for plastics and dimensional stability tester.
   Test Method : ISO 75-1974

4. Shore Hardness tester (Durometer) for plastics.
   Test Method : ISO/R 868-1968

5. Indentation Hardness tester for soft-elastic foam materials.

6. International Hardness tester for vulcanized rubber.
   Test Methods: ISO 48-1975, ISO 1400-1975, ISO 1818-1975

7. Rubber Micro Hardness tester.
   Test Method : ISO 48-1975

8. Gel permeation chromatography for determination of molecular weight distribution of polymers, petroleum products etc.

9. Differential Thermal analysis (DTA) and Graphemetric Thermel analysis(GTA). for plastics and organic material.

10. Gel tester for polymers.

11. Instron Capillary Rheometer.

12. Dust and Fog tracking of electrical insulation materials
    Test Method : ASTM D 2132-62

14. Dart Drop tester for films.

15. Water vapour permeability equipment for plastics.
    Test Method : ISO/R 1195-1970

16. Grinding machine

17. Compression moulding press and compression moulds for preparation of compression moulding test specimens for thermosetting and thermoplastic materials.

18. Injection moulding machine and moulds for preparation of injection moulding test specimens for thermoplastics.
Test Method : ISO 294-1975

19. Accelerated weathering apparatus for plastics provided with heat, moisture, UV, O_3, CO_2 and other gas sources.

20. Xenon Arc tester.
Test Method : ISO/R 879- 1968

21 Apparatus for determination of colour change upon exposure to day-light for plastics.
Test Method : ISO 872-1976

22. Elmendorf tear resistance test for plastics films.

23. Hydrostatic testing apparatus for rubber and plastics.
Test Method : ISO 1402-1974

24. Mooney viscosity and rate of cure of rubber by shearing disc viscometer.

25. Oscilliating disc curemeter for measurement of vulcanization characteristics of rubber.

26. Flex cracking testing machine (DeMatia) for vulcanized rubber.
Test Methods: ISO 133-1975, ISO 132-1975

27. Rebound resilence tester for vulcanized rubber (Lupke Pendulum).
Test Method: ISO/R 1767-1971

28. Abrasion resistance tester for vulcanized rubber.

29. Accelerated ageing or heat resistance test for vulcanized rubber.
Test Method : ISO 188-1971

30. Brookfield synchro-lectric viscometer.

31. Dial guages for measuring thickness of:
Flexible cellular materials - ISO/R 1794-1971
Rigid cellular plastics - ISO 1923-1972
Plastics pipes - ISO 3126-1974

32. Drop testing machine to determine the drop impact resistance of blow-moulded thermoplastic containers.
Test Method : ASTM D 2463-74

33. Compression device for determination of the compression deformation.

34. Abrasion tester (Taber).
Test Method : BS . 3794-1964

35. Micrometer.
Test Methods: ISO 2589-1972, BS 3144-1968

36. Densimeter for determination of specific gravity of rubber.

37. Punch press to punch out test specimens of rubber, soft plastics and similar materials.
Test Method : BS 3144-1968

32. Hydraulic test press for preparation of test specimens by heating and applying pressure. (Maximum load:30 tonnes; Maximum pressure: 200 kg/cm^2; Maximum temperature:200°C with control device)

2. Some well known Manufacturers of plastics and rubber test equipment

1. Zwick GMBH, Ulm, West Germany.
2. CEAST, Italy.
3. Adamel-Lhomargy, France.
4. Bally, West Germany.
5. INSTRON, U.S.A.
6. Testing Equipment Mfg. Co. Ltd., Tokyo, Japan.
7. Kondo Scientific Instruments Mfg. Co. Ltd., Tokyo, Japan.

Annexure 3

Selected Bibliography on testing of plastics and rubber

Text Books

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ii) Ward, L. M.,
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A. I. R. I., Bombay.

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Part 34 Plastic Pipe
Part 35 Plastics - General Test Methods, Nomenclature.
Part 37 Rubber - Test Methods.

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in: Progree in Rubber Technology Vol 36 (1972),
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Composites - Standards, Testing and Design,
Conference Proceedings (1974),
IPC Science and Technology Press, Guildford, Surrey.

xiv) Turner, S.,
Mechanical Testing of Plastics (1973)
Butterworth, London.

xv) Vircent, P. I.,
Impact Tests and Service Performance of Thermoplastics (1977),
Plastic Institute, London.

xvi) RAPRA Guide to Rubber and Plastics test equipment (1973),
RAPRA, Shawbury, Shrewsbury.

xvii) RAPRA Developements in Testing (1973)

Annexure 4

Some Training Institutes and Laboratories

1. National College of Rubber Technology, London
2. I. C. I. Plastics Division, Welwyn Garden City, Hertfordshire, U.K.
3. The Plastic Institute, 11 Hobart Place, London SW 1.
4. Polytechnic Institute of New York, Brooklyn, New York.
5. Chemistry and Polymer Technology Department, Polytechnic of South Bank, London.
6. Institute of Polymer Science, University of Akron, Akron, Chio.
7. Malaysian Rubber Research and Developement Board, Kuala Lumpur.
8. ESCON Consultants (P) Ltd., 7-A, Elgin Road, Calcutta - 700025, India. (They can suggest training facilities in India, viz., one in Madras developed through UNIDO assistance).
9. Institute of Technology, Matunga, Bombay University, Bombay, India