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ภาคผนวก

ภาคผนวก ก

ปริมาณกากตะกอนที่ได้จากกระบวนการบำบัดน้ำเสียของโรงงานผลิตลาเท็กซ์ประจำปี 2551

เดือน	ปริมาณตะกอนที่ได้ (กิโลกรัม)
มกราคม	170
กุมภาพันธ์	150
มีนาคม	180
เมษายน	160
พฤษภาคม	150
มิถุนายน	140
กรกฎาคม	150
สิงหาคม	170
กันยายน	185
ตุลาคม	130
พฤศจิกายน	150
ธันวาคม	150
รวม	1885 กิโลกรัมต่อปี

ภาคผนวก ข

รายงานผลการวิเคราะห์ปริมาณโลหะหนักในกากตะกอนน้ำเสีย

Thai Environmental Technic Limited
บริษัท เทคนิคสิ่งแวดล้อมไทย จำกัด

Monitoring & Laboratory Services
48/69-70 Ramkhamhaeng Rd., Huamak,
Bangkapi, Bangkok 10240
48/69-70 ถนนรามคำแหง แขวงหัวหมาก
เขตบางกะปิ กรุงเทพมหานคร 10240
Tel : 0-2735-3101 (อัตโนมัติ) Fax : 0-2735-3584
E-mail address : tet1995@asiaaccess.net.th

REPORT NO. : 0210/2006/2
REPORT DATE : March 4, 2006
SAMPLING DATE : March 1, 2006
TYPE OF SAMPLE : **Sludge Sampling**

รายงานผลวิเคราะห์ (ANALYSIS REPORT)

Customer Name : บริษัท แวกซ์ กาเบ็จ รีไซเคิล เซ็นเตอร์ จำกัด
Location : บริษัท ซีลิค เคมีคอล จำกัด
Address : 6/6 หมู่ 2 ถ. เพชรเกษม แขวงหนองแขม เขตหนองแขม กทม. 10160
Contact : คุณพิมพ์พธู จินดามณี
โทรศัพท์ : (032) 228 242-4 โทรสาร : (032) 228 237, 228 033
Job No. : M/060023

Item	Description	Unit	Result	Standard[1]
			ตะกอนจากระบบบำบัด	
1.	Sampling Date	-	01/03/06	-
2.	As	mg/l	<0.0002	5
3.	Ba	mg/l	<0.10	100
4.	Cd	mg/l	<0.02	1
5.	Total Cr	mg/l	<0.02	5
6.	Total Hg	mg/l	0.0007	0.2
7.	Total Pb	mg/l	<0.10	5
8.	Se	mg/l	<0.0005	1
9.	Ag	mg/l	<0.02	5

Source : [1] Notification of the Ministry of Industry Vol. 6 (1997)
Remark : Method based on US.EPA SW846

Porntip Pethshee
Analyst No. ว-061-ค-2398

Somchai Piyavorasakul
Authorized Signature
Analyst No. ว-061-ค-871

ภาคผนวก ค

เทคนิคและวิธีการวิเคราะห์ขนาดเส้นผ่านศูนย์กลางเฉลี่ยของอนุภาค ความหนาแน่น pH การนำไฟฟ้า และความชื้นของผงตะกอนที่ใช้ในงานวิจัย

1. การวิเคราะห์หาขนาดและการกระจายตัวของอนุภาคในระดับไมโครเมตร

เครื่องมือที่ใช้วิเคราะห์ : Masterizer S, Malvern Instruments Limited

เทคนิคในการวิเคราะห์ : เทคนิคการเลี้ยวเบนของแสง (Laser diffraction Technique)

สภาวะที่ใช้ในการวิเคราะห์

: He-Ne laser source ที่ความยาวคลื่น (λ) = 633 nm

Beam Length : 2.40 mm.

Particle size range analysis : 0.05 -900 μm.

Small sample dispersion unit (MS1)

Dispersing medium : De-ionized water

Dispersant : Nonidet P40 สำหรับตัวอย่าง $CaCO_3$

: Sodium Hexametaphosphate สำหรับตัวอย่าง Glass sphere

Treatment : Ultrasonic 5 นาที & Stir medium

ค่าดัชนีหักเหของตัวอย่าง : 1.5295 สำหรับตัวอย่างผงตะกอน 1-5 และ Glass spheres

: 1.5750 สำหรับตัวอย่าง $CaCO_3$

จำนวนครั้งในการทดลอง 3 ครั้ง

Laser power : 80.6

<u>การเตรียมตัวอย่าง</u>

1. นำตัวอย่างปริมาณ 1 กรัมใส่ลงในบีกเกอร์ แล้วเติมตัวกลางที่เตรียมไว้ (De-ionized water ผสมกับ 0.1% Dispersant) ลงไป 20 มิลลิลิตร

2. ทำการกวนตัวอย่างให้กระจายตัวและนำเข้าเครื่อง Ultrasonic bath นาน 5 นาที แล้วจึงนำไปวัดหาขนาดอนุภาคด้วยเครื่อง Mastersizer S

2. การหาความหนาแน่นของผงตะกอน

เครื่องมือที่ใช้วิเคราะห์ : เครื่อง Ultrapycnometer 1000, Quantachrome

วิธีการวิเคราะห์ : ชั่งน้ำหนักตัวอย่าง โดยนำตัวอย่างอบที่สภาวะ 50 $^{\circ}$C เป็นเวลา 1 คืน

3. การหาค่า pH และค่าการนำไฟฟ้าของผงตะกอน

เครื่องมือที่ใช้วิเคราะห์ : เครื่อง pH meter รุ่น Tester 30

: เครื่องวัดค่าการนำไฟฟ้า รุ่น Ecoscan CON5

วิธีการวิเคราะห์ : นำผงตะกอนละลายใน De-ionized water 1 % (w/w) แล้ว นำไปวัดค่า pH และค่าการนำไฟฟ้า

4. การหาค่าความชื้นของผงตะกอน

เครื่องมือที่ใช้วิเคราะห์ : เตาอบ (MEMMERT UE400)

: เครื่องชั่ง (Precisa, XT220A

เทคนิคที่ใช้วิเคราะห์ : Moisture content analysis

สภาวะที่ใช้วิเคราะห์ : Temperature 25 ± 5 ^{o}C, Relative humidity 60± 10 % R.H

วิธีการวิเคราะห์ : ชั่งน้ำหนักตัวอย่างก่อนอบและหลังอบ แล้วนำค่าที่ได้ไป คำนวณหาปริมาณความชื้น (อบที่อุณหภูมิ 110 ^{o}C เป็นเวลา 24 ชั่วโมง)

ภาคผนวก ง

การวัดความหนืดของพรีพอลิเมอร์อิพ็อกซี การตรวจสอบระยะเวลาการแห้งสัมผัส และการทดสอบการทนทานต่อการกัดกร่อนจากน้ำทะเลเทียมของผลิตภัณฑ์ประกอบแต่งเรซินอิพ็อกซีตามเกณฑ์ของบริษัท ซีลิค เคมิคอล จำกัด

การวัดความหนืดของพรีพอลิเมอร์อิพ็อกซี

- ทดสอบการทำงานของจุดหมุนดังนี้

1. เปิดเครื่องวัดความหนืด รุ่น BROOKFIELD Model RVT
2. หลังจากที่ทำการปรับศูนย์อัตโนมัติแล้ว ให้ดูค่า % Torque ที่หน้าจอเครื่องว่า % Torque ที่แสดงนั้น อยู่ในตำแหน่ง 0.0 %± 0.3% หรือไม่
3. จับแกน Shaft และหมุนไปในทิศทางตามเข็มนาฬิกา จนกระทั่งหน้าจอโชว์ EEE
4. หลังจากนั้นปล่อยแกน Shaft จะเกิดการสวิงของแกน Shaft รอจนกระทั่งแกน Shaft หยุดสวิงแล้วให้ดูค่า % Torque ที่หน้าจอว่าอยู่ในตำแหน่งเดิมหรือไม่

- ทดสอบการทำงานการแกว่งของเข็มดังนี้

1. เปิดเครื่องพร้อมการใช้งาน
2. ใส่เข็มเข้ากับแกน Shaft โดยใช้เข็มเบอร์ 3
3. เลือกความเร็วรอบที่ 10, 12 rpm
4. ดูการแกว่งออกจากจุดศูนย์กลางไม่ควรเกิน ± 3 mm. ถ้าเกินกว่าต้องทำการแก้ไข

- การบำรุงรักษาเครื่องวัดความหนืด

การใช้งานเครื่องวัดความหนืดต้องมีข้อควรระวังและมีการบำรุงรักษาให้ดี เพื่อป้องกันการชำรุดเสียหายของเครื่อง ทำให้เกิดความคลาดเคลื่อนของความหนืด จนไม่สามารถนำมาใช้งานได้ ดังนั้นทุกครั้งที่ผู้ใช้ควรปฏิบัติดังนี้

1. เครื่องวัดความหนืดต้องตั้งอยู่ที่บนพื้นที่แน่นหนามั่นคงแข็งแรง และก่อนการใช้งานควรมีการตรวจสอบว่าตำแหน่งของการวางเครื่องวัดความหนืดอยู่ในแนวระนาบ
2. การใช้งานเครื่องวัดความหนืด ควรมีการใช้ร่วมกับเครื่องควบคุมแรงดันไฟฟ้า (Stabilizer) โดยค่าความเคลื่อนของแรงดันไฟฟ้าไม่มากกว่า 230 Volt ± 5%

3. การใส่และถอดเข็ม จะต้องมีการยกแกน Shaft ขึ้นและจับให้แน่น แล้วจึงหมุนเข็มใส่ประกอบกับแกน Shaft เพื่อลดการสึกหรอที่จะเกิดขึ้นกับจุดหมุน หรือใช้ชุด Quick connect coupling

4. ควรมีการใส่ Guard Leg ทุกครั้งเพื่อป้องเข็มกระแทกกับภาชนะใส่ตัวอย่าง

5. หลังจากการใช้งานเครื่องวัดความหนืด จะต้องทำความสะอาดเข็มทุกครั้ง

6. การทำความสะอาดเข็ม สามารถใช้น้ำยาทำความสะอาดหรือสารเคมีได้ แต่ไม่ควรแช่ทิ้งไว้อาจทำให้เกิดการกัดกร่อนได้

7. ควรระมัดระวังอย่าให้เข็มมีการตกหล่น อาจทำให้เกิดการเสียรูปและคดงอ

8. ในการทำความสะอาดเข็ม ห้ามใช้สก๊อตไบต์ทำความสะอาด เนื่องจากจะทำให้เข็มเกิดรอยขีดข่วนได้

9. ถ้าต้องเคลื่อนย้ายเครื่องวัดความหนืด ควรมีการล็อคแกน Shaft และใส่ Guard Leg ทุกครั้งเพื่อลดการสึกหรอที่จะเกิดขึ้นกับจุดหมุน

10. ควรมีการตรวจสอบความคลาดเคลื่อนของการวัดค่าความหนืด โดยใช้สารความหนืดมาตรฐาน หรือมีการส่งสอบเทียบภายนอก เพื่อให้เกิดความมั่นใจกับค่าที่ทำการวัด

การตรวจสอบระยะเวลาการแห้งสัมผัสของผลิตภัณฑ์ประกอบแต่งเรซินอิพ็อกซี

ระยะเวลาการแห้งตัว หมายถึง การหาระยะเวลาการแห้งตัวของสารเคลือบผิว ซึ่งวิธีที่ง่ายและใช้กันมานานคือใช้นิ้วมือแตะเบาๆ ที่ผิวของสารเคลือบผิว โดยมีวิธีทดสอบดังนี้

1. เคลือบสารเคลือบผิวลงบนชิ้นงาน แล้ววางชิ้นงานดังกล่าวในแนวนอนโดยให้ด้านที่เคลือบผิวอยู่ด้านบนโดยทำการทดสอบที่อุณหภูมิห้อง

2. จับเวลาการแห้งตัว โดยใช้นิ้วมือแตะชิ้นงานดังกล่าวเป็นระยะ

3. บันทึกระยะเวลาที่ชิ้นงานดังกล่าวแห้ง ถึงระดับ แห้งสัมผัสหรือแห้งแตะได้ (Touch dry) และแห้งแตะไม่ติด (Tack-free stage)

การทดสอบการทนทานต่อการกัดกร่อนจากน้ำทะเลเทียมของผลิตภัณฑ์ประกอบแต่งเรซินอิพ็อกซี

1. ชั่งน้ำหนักของชิ้นงานก่อนการทดสอบ

2. เตรียมน้ำทะเลเทียมจากผงเกลือสำหรับเตรียมน้ำทะเลเทียม ที่ความเข้มข้น 326 กรัมต่อลิตร

3. นำชิ้นงานแช่ในน้ำทะเลเทียม 100 ml ใส่ขวดปิดปากขวดให้สนิทใช้ระยะเวลาการติดตามผล 60 วัน

4. นำชิ้นงานมาตากให้แห้งแล้วอบในเดซิเคเตอร์ 24 ชั่วโมง และนำชิ้นงานมาชั่งน้ำหนักหลังการทดสอบ

5. วิเคราะห์ลักษณะพื้นผิวทางกายภาพด้วยเครื่อง SEM

ภาคผนวก จ

ค่ากำหนดของผลิตภัณฑ์ประกอบแต่งเรซินอิพ็อกซีสำหรับงานซ่อมแซมเรือประมงที่ใช้ในงานวิจัย

ผลิตภัณฑ์ประกอบแต่งเรซินอิพ็อกซี สำหรับงานซ่อมแซมเรือประมง

ลักษณะ	:	กาวสีขาวเข้ม เนื้อนิ่ม
ระยะเวลาการแห้งสัมผัส (นาที)	:	120 – 240
ความหนืด (cP) ที่ 30 $^{\circ}$C	:	1,400,000 – 1,600,000
ค่าการทนแรงอัด (MPa)	:	46.76 – 51.82
ค่าความแข็ง (MPa)	:	79.71 – 81.49

ภาคผนวก ฉ

ASTM D 695 Standard Test Method for Compressive Properties of Rigid Plastics และ

ASTM D 2240000 Standard Test Method for Rubber Property-Durometer Hardness

Designation: D 695 – 02a

Standard Test Method for Compressive Properties of Rigid Plastics[1]

This standard is issued under the fixed designation D 695; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers the determination of the mechanical properties of unreinforced and reinforced rigid plastics, including high-modulus composites, when loaded in compression at relatively low uniform rates of straining or loading. Test specimens of standard shape are employed.

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

NOTE 1—For compressive properties of resin-matrix composites reinforced with oriented continuous, discontinuous, or cross-ply reinforcements, tests may be made in accordance with Test Method D 3410.

1.3 *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.* A specific precautionary statement is given in Note 11.

NOTE 2—This test method is technically equivalent to ISO 604.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics for Testing[2]

D 638 Test Method for Tensile Properties of Plastics[2]

D 883 Terminology Relating to Plastics[2]

D 3410 Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading[3]

D 4000 Classification System for Specifying Plastic Materials[4]

D 4066 Classification System for Nylon Injection and Extrusion Materials[4]

D 5947 Test Methods for Physical Dimensions of Solid Plastics Specimens[5]

E 4 Practices for Force Verification of Testing Machines[6]

E 83 Practice for Verification and Classification of Extensometers[6]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[7]

3. Terminology

3.1 General— The definitions of plastics used in this test method are in accordance with Terminology D 883 unless otherwise indicated.

3.2 *Definitions:*

3.2.1 *compressive deformation*—the decrease in length produced in the gage length of the test specimen by a compressive load. It is expressed in units of length.

3.2.2 *compressive strain*—the ratio of compressive deformation to the gage length of the test specimen, that is, the change in length per unit of original length along the longitudinal axis. It is expressed as a dimensionless ratio.

3.2.3 *compressive strength*—the maximum compressive stress (nominal) carried by a test specimen during a compression test. It may or may not be the compressive stress (nominal) carried by the specimen at the moment of rupture.

3.2.4 *compressive strength at failure (nominal)*—the compressive stress (nominal) sustained at the moment of failure of the test specimen if shattering occurs.

3.2.5 *compressive stress (nominal)*—the compressive load per unit area of minimum original cross section within the gage boundaries, carried by the test specimen at any given moment. It is expressed in force per unit area.

3.2.5.1 *Discussion*—The expression of compressive properties in terms of the minimum original cross section is almost universally used. Under some circumstances the compressive properties have been expressed per unit of prevailing cross section. These properties are called "true" compressive properties.

3.2.6 *compressive stress-strain diagram*—a diagram in which values of compressive stress are plotted as ordinates against corresponding values of compressive strain as abscissas.

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[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.10 on Mechanical Properties.

Current edition approved August 10, 2002. Published October 2002. Originally published as D 695 – 42 T. Last previous edition D 695 – 02.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 15.03.

[4] *Annual Book of ASTM Standards*, Vol 08.02.

[5] *Annual Book of ASTM Standards*, Vol 08.03.

[6] *Annual Book of ASTM Standards*, Vol 03.01.

[7] *Annual Book of ASTM Standards*, Vol 14.02.

*A Summary of Changes section appears at the end of this standard.

3.2.7 *compressive yield point*—the first point on the stress-strain diagram at which an increase in strain occurs without an increase in stress.

3.2.8 *compressive yield strength*—normally the stress at the yield point (see also section 3.2.11).

3.2.9 *crushing load*—the maximum compressive force applied to the specimen, under the conditions of testing, that produces a designated degree of failure.

3.2.10 *modulus of elasticity*—the ratio of stress (nominal) to corresponding strain below the proportional limit of a material. It is expressed in force per unit area based on the average initial cross-sectional area.

3.2.11 *offset compressive yield strength*—the stress at which the stress-strain curve departs from linearity by a specified percent of deformation (offset).

3.2.12 *percent compressive strain*—the compressive deformation of a test specimen expressed as a percent of the original gage length.

3.2.13 *proportional limit*—the greatest stress that a material is capable of sustaining without any deviation from proportionality of stress to strain (Hooke's law). It is expressed in force per unit area.

3.2.14 *slenderness ratio*—the ratio of the length of a column of uniform cross section to its least radius of gyration. For specimens of uniform rectangular cross section, the radius of gyration is 0.289 times the smaller cross-sectional dimension. For specimens of uniform circular cross section, the radius of gyration is 0.250 times the diameter.

4. Significance and Use

4.1 Compression tests provide information about the compressive properties of plastics when employed under conditions approximating those under which the tests are made.

4.2 Compressive properties include modulus of elasticity, yield stress, deformation beyond yield point, and compressive strength (unless the material merely flattens but does not fracture). Materials possessing a low order of ductility may not exhibit a yield point. In the case of a material that fails in compression by a shattering fracture, the compressive strength has a very definite value. In the case of a material that does not fail in compression by a shattering fracture, the compressive strength is an arbitrary one depending upon the degree of distortion that is regarded as indicating complete failure of the material. Many plastic materials will continue to deform in compression until a flat disk is produced, the compressive stress (nominal) rising steadily in the process, without any well-defined fracture occurring. Compressive strength can have no real meaning in such cases.

4.3 Compression tests provide a standard method of obtaining data for research and development, quality control, acceptance or rejection under specifications, and special purposes. The tests cannot be considered significant for engineering design in applications differing widely from the load-time scale of the standard test. Such applications require additional tests such as impact, creep, and fatigue.

4.4 Before proceeding with this test method, reference should be made to the ASTM specification for the material being tested. Any test specimen preparation, conditioning, dimensions, and testing parameters covered in the materials specification shall take precedence over those mentioned in this test method. If there is no material specification, then the default conditions apply. Table 1 in Classification D 4000 lists the ASTM materials standards that currently exist.

5. Apparatus

5.1 *Testing Machine*—Any suitable testing machine capable of control of constant-rate-of-crosshead movement and comprising essentially the following:

5.1.1 *Drive Mechanism*—A drive mechanism for imparting to the movable cross-head member, a uniform, controlled velocity with respect to the base (fixed member), with this velocity to be regulated as specified in Section 9.

5.1.2 *Load Indicator*—A load-indicating mechanism capable of showing the total compressive load carried by the test specimen. The mechanism shall be essentially free from inertia-lag at the specified rate of testing and shall indicate the load with an accuracy of ±1 % of the maximum indicated value of the test (load). The accuracy of the testing machine shall be verified at least once a year in accordance with Practices E 4.

5.2 *Compressometer*—A suitable instrument for determining the distance between two fixed points on the test specimen at any time during the test. It is desirable that this instrument automatically record this distance (or any change in it) as a function of the load on the test specimen. The instrument shall be essentially free of inertia-lag at the specified rate of loading and shall conform to the requirements for a Class B-2 extensometer as defined in Practice E 83.

NOTE 3—The requirements for extensometers cited herein apply to compressometers as well.

5.3 *Compression Tool*—A compression tool for applying the load to the test specimen. This tool shall be so constructed that loading is axial within 1:1000 and applied through surfaces that are flat within 0.025 mm (0.001 in.) and parallel to each other in a plane normal to the vertical loading axis. Examples of suitable compression tools are shown in Fig. 1 and Fig. 2.

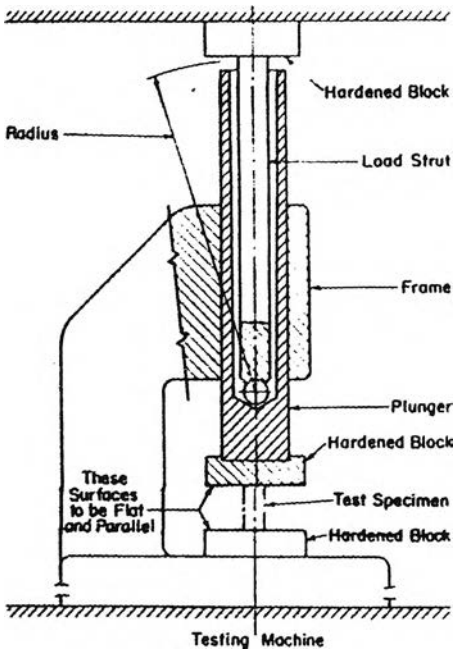
5.4 *Supporting Jig*—A supporting jig for thin specimens is shown in Fig. 3 and Fig. 4.

5.5 *Micrometers*—Suitable micrometers, reading to 0.01 mm or 0.001 in. for measuring the width, thickness, and length of the specimens.

6. Test Specimens

6.1 Unless otherwise specified in the materials specifications, the specimens described in 6.2 and 6.7 shall be used. These specimens may be prepared by machining operations from materials in sheet, plate, rod, tube, or similar form, or they may be prepared by compression or injection molding of the material to be tested. All machining operations shall be done carefully so that smooth surfaces result. Great care shall be taken in machining the ends so that smooth, flat parallel surfaces and sharp, clean edges, to within 0.025 mm (0.001 in.) perpendicular to the long axis of the specimen, result.

6.2 The standard test specimen, except as indicated in 6.3-6.7, shall be in the form of a right cylinder or prism whose length is twice its principal width or diameter. Preferred specimen sizes are 12.7 by 12.7 by 25.4 mm (0.50 by 0.50 by



NOTE 1—Devices similar to the one illustrated have been successfully used in a number of different laboratories. Details of the device developed at the National Institute for Standards and Technology are given in the paper by Aitchinson, C. S., and Miller, J. A., "A Subpress for Compressive Tests," National Advisory Committee for Aeronautics, Technical Note No. 912, 1943.

FIG. 1 Subpress for Compression Tests

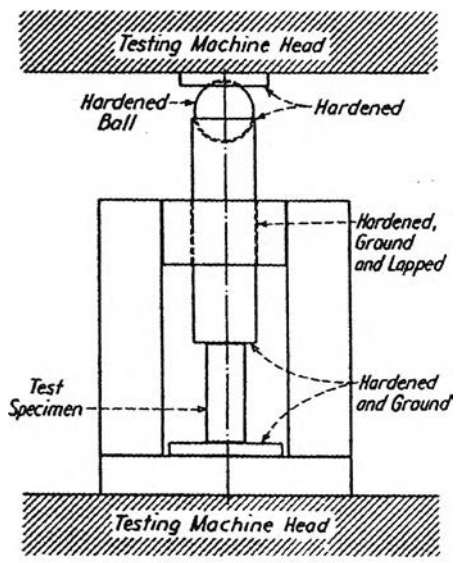


FIG. 2 Compression Tool

1 in.) (prism), or 12.7 mm in diameter by 25.4 mm (cylinder). Where elastic modulus and offset yield-stress data are desired, the test specimen shall be of such dimensions that the slenderness ratio is in the range from 11 to 16:1. In this case, preferred specimen sizes are 12.7 by 12.7 by 50.8 mm (0.50 by 0.50 by 2 in.) (prism), or 12.7 mm in diameter by 50.8 mm (cylinder).

6.3 For rod material, the test specimen shall have a diameter equal to the diameter of the rod and a sufficient length to allow a specimen slenderness ratio in the range from 11 to 16:1.

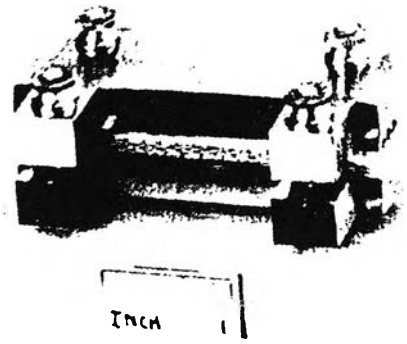


FIG. 3 Support Jig for Thin Specimen

6.4 When testing tubes, the test specimen shall have a diameter equal to the diameter of the tube and a length of 25.4 mm (1 in.) (Note 4). For crushing-load determinations (at right angles to the longitudinal axis), the specimen size shall be the same, with the diameter becoming the height.

NOTE 4—This specimen can be used for tubes with a wall thickness of 1 mm (0.039 in.) or over, to inside diameters of 6.4 mm (0.25 in.) or over, and to outside diameters of 50.8 mm (2.0 in.) or less.

6.5 Where it is desired to test conventional high-pressure laminates in the form of sheets, the thickness of which is less than 25.4 mm (1 in.), a pile-up of sheets 25.4 mm square, with a sufficient number of layers to produce a height of at least 25.4 mm, may be used.

6.6 When testing material that may be suspected of anisotropy, duplicate sets of test specimens shall be prepared having their long axis respectively parallel with and normal to the suspected direction of anisotropy.

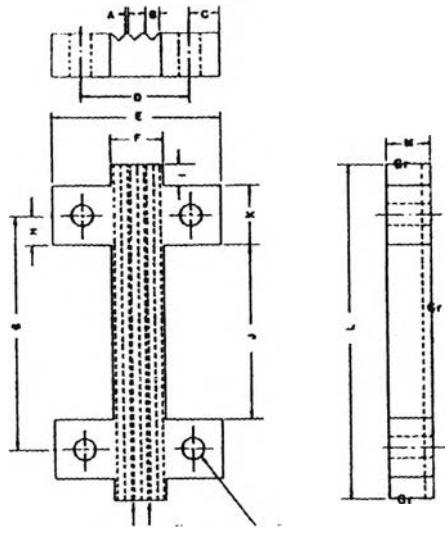
6.7 *Reinforced Plastics, Including High-Strength Composites and High-Strength Composites and Highly Orthotropic Laminates*—The following specimens shall be used for reinforced materials, or for other materials when necessary to comply with the slenderness ratio requirements or to permit attachment of a deformation-measuring device.

6.7.1 For materials 3.2 mm (⅛ in.) and over in thickness, a specimen shall consist of a prism having a cross section of 12.7 mm (½ in.) by the thickness of the material and a length such that the slenderness ratio is in the range from 11 to 16:1 (Note 5).

6.7.2 For materials under 3.2 mm (⅛ in.) thick, or where elastic modulus testing is required and the slenderness ratio does not provide for enough length for attachment of a compressometer or similar device, a specimen conforming to that shown in Fig. 5 shall be used. The supporting jig shown in Fig. 3 and Fig. 4 shall be used to support the specimen during testing (Note 6).

NOTE 5—If failure for materials in the thickness range of 3.2 mm (⅛ in.) is by delamination rather than by the desirable shear plane fracture, the material may be tested in accordance with 6.7.2.

NOTE 6—Round-robin tests have established that relatively satisfactory measurements of modulus of elasticity may be obtained by applying a compressometer to the edges of the jig-supported specimen.



LETTER	METRIC SYSTEM	BRITISH SYSTEM
A	40 mm	0.156 in.
B	3.18	.125
C	6.35	.250
D	23.8	.9375
E	36.5	1.4375
F	11.1	.4375
G	50.8	2.00
H	6.35	.250
I	4.76	.1875
J	38.1	1.500
K	12.7	.500
L	73.0	2.875
M	9.53	.375
N	3.58	.141
O	4.76 d.	.1875 d.

NOTE 1—Cold rolled steel.
NOTE 2—Furnished four steel machine screws and nuts, round head, slotted, length 31.75 mm (1¼ in.).
NOTE 3—Grind surfaces denoted "Gr."

FIG. 4 Support Jig, Details

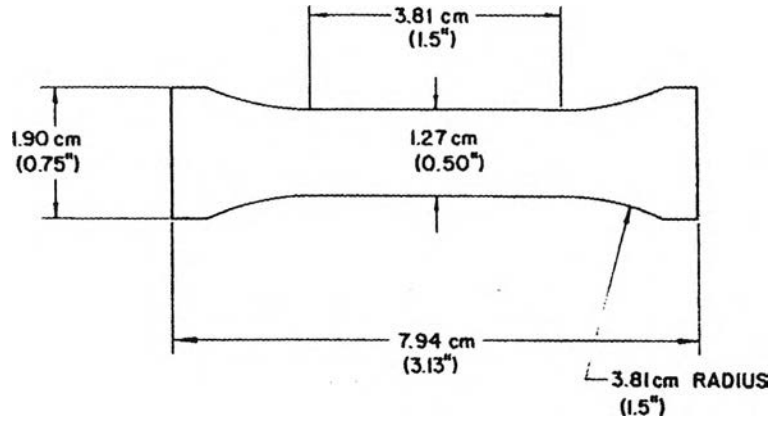


FIG. 5 Compression Test Specimen for Materials Less than 3.2 mm Thick

6.8 When testing syntactic foam, the standard test specimen shall be in the form of a right cylinder 25.4 mm (1 in.) in diameter by 50.8 mm (2 in.) in length.

7. Conditioning

7.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618 unless otherwise specified by contract or relevant ASTM material specification. Reference pre-test conditioning, to settle disagreements, shall apply tolerances of ±1°C (1.8°F) and ±2 % relative humidity.

7.1.1 Note that for some hygroscopic materials, such as nylons, the material specifications (for example, Classification System D 4066) call for testing "dry as-molded specimens." Such requirements take precedence over the above routine preconditioning to 50 % RH and require sealing the specimens in water vapor-impermeable containers as soon as molded and not removing them until ready for testing.

7.2 *Test Conditions*—Conduct the tests at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 5 % relative humidity unless otherwise specified by contract or the relevant ASTM material specification. Reference testing conditions, to settle disagreements, shall apply tolerances of ±1°C (1.8°F) and ±2 % relative humidity.

8. Number of Test Specimens

8.1 At least five specimens shall be tested for each sample in the case of isotropic materials.

8.2 Ten specimens, five normal to and five parallel with the principal axis of anisotropy, shall be tested for each sample in the case of anisotropic materials.

8.3 Specimens that break at some obvious flaw shall be discarded and retests made, unless such flaws constitute a variable, the effect of which it is desired to study.

9. Speed of Testing

9.1 Speed of testing shall be the relative rate of motion of the grips or test fixtures during the test. Rate of motion of the driven grip or fixture when the machine is running idle may be used if it can be shown that the resulting speed of testing is within the limits of variation allowed.

9.2 The standard speed of testing shall be 1.3 ± 0.3 mm (0.050 ± 0.010 in.)/min, except as noted in 10.5.4.

10. Procedure

10.1 Measure the width and thickness of the specimen to the nearest 0.01 mm (0.001 in.) at several points along its length. Calculate and record the minimum value of the cross-sectional area. Measure the length of the specimen and record the value.

10.2 Place the test specimen between the surfaces of the compression tool, taking care to align the center line of its long axis with the center line of the plunger and to ensure that the ends of the specimen are parallel with the surface of the compression tool. Adjust the crosshead of the testing machine until it just contacts the top of the compression tool plunger.

NOTE 7—The compression tool may not be necessary for testing of lower modulus (for example, 700 MPa to 3500 MPa (100 000 psi to 500 000 psi)) material if the loading surfaces are maintained smooth, flat, and parallel to the extent that buckling is not incurred.

10.3 Place thin specimens in the jig (Fig. 3 and Fig. 4) so that they are flush with the base and centered (Note 8). The nuts or screws on the jig shall be finger tight (Note 9). Place the assembly in the compression tool as described in 5.3.

NOTE 8—A round-robin test, designed to assess the influence of specimen positioning in the supporting jig (that is, flush versus centered mounting), showed no significant effect on compressive strength due to this variable. However, flush mounting of the specimen with the base of the jig is specified for convenience and ease of mounting.[8]

NOTE 9—A round-robin test on the effect of lateral pressure at the supporting jig has established that reproducible data can be obtained with the tightness of the jig controlled as indicated.

10.4 If only compressive strength or compressive yield strength, or both, are desired, proceed as follows:

10.4.1 Set the speed control at 1.3 mm/min (0.050 in./min) and start the machine.

10.4.2 Record the maximum load carried by the specimen during the test (usually this will be the load at the moment of rupture).

10.5 If stress-strain data are desired, proceed as follows:

10.5.1 Attach compressometer.

10.5.2 Set the speed control at 1.3 mm/min (0.050 in./min) and start the machine.

10.5.3 Record loads and corresponding compressive strain at appropriate intervals of strain or, if the test machine is equipped with an automatic recording device, record the complete load-deformation curve.

10.5.4 After the yield point has been reached, it may be desirable to increase the speed from 5 to 6 mm/min (0.20 to 0.25 in./min) and allow the machine to run at this speed until the specimen breaks. This may be done only with relatively ductile materials and on a machine with a weighing system with response rapid enough to produce accurate results.

11. Calculation

11.1 *Compressive Strength*—Calculate the compressive strength by dividing the maximum compressive load carried by the specimen during the test by the original minimum cross-sectional area of the specimen. Express the result in megapascals or pounds-force per square inch and report to three significant figures.

11.2 *Compressive Yield Strength*—Calculate the compressive yield strength by dividing the load carried by the specimen at the yield point by the original minimum cross-sectional area of the specimen. Express the result in megapascals or pounds-force per square inch and report to three significant figures.

11.3 *Offset Yield Strength*—Calculate the offset yield strength by the method referred to in 3.2.11.

11.4 *Modulus of Elasticity*—Calculate the modulus of elasticity by drawing a tangent to the initial linear portion of the load deformation curve, selecting any point on this straight line portion, and dividing the compressive stress represented by this point by the corresponding strain, measure from the point where the extended tangent line intersects the strain-axis. Express the result in gigapascals or pounds-force per square inch and report to three significant figures (see Annex A1).

11.5 For each series of tests, calculate to three significant figures the arithmetic mean of all values obtained and report as the "average value" for the particular property in question.

11.6 Calculate the standard deviation (estimated) as follows and report to two significant figures:

$$s = \sqrt{(\Sigma X^2 - n\bar{X}^2)/(n - 1)} \quad (1)$$

where:

s = estimated standard deviation,
X = value of single observation,
n = number of observations, and
$\bar{X}$ = arithmetic mean of the set of observations.

NOTE 10—The method for determining the offset compressive yield strength is similar to that described in the Annex of Test Method D 638.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions, previous history, etc.,

12.1.2 Method of preparing test specimens,

12.1.3 Type of test specimen and dimensions,

12.1.4 Conditioning procedure used,

12.1.5 Atmospheric conditions in test room,

12.1.6 Number of specimens tested,

12.1.7 Speed of testing,

12.1.8 Compressive strength, average value, and standard deviation,

12.1.9 Compressive yield strength and offset yield strength average value, and standard deviation, when of interest,

12.1.10 Modulus of elasticity in compression (if required), average value, standard deviation,

12.1.11 Date of test, and

12.1.12 Date of test method.

[8] Supporting data are available from ASTM Headquarters. Request RR: D20-1061.

13. Precision and Bias [9]

13.1 Table 1 and Table 2 are based on a round-robin test conducted in 1987 in accordance with Practice E 691, involving three materials tested by six laboratories for Test Method D 695M. Since the test parameters overlap within tolerances and the test values are normalized, the same data are used for both test methods. For each material, all of the samples were prepared at one source. Each test result was the average of five individual determinations. Each laboratory obtained two test results for each material.

TABLE 1 Precision, Compressive Strength
(Values in Units of Megapascals)

Material	Average	S_r[A]	S_R[B]	r[C]	R[D]
Acetal	100	1.1	2.1	3.1	5.9
Polystyrene	106	1.4	3.5	3.9	9.8
Linen-filled phenolic	158	3.7	7.5	10.4	21.0

[A] S_r is the within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories:

$$S_r = [[(S_1)^2 + (S_2)^2 + \ldots + (S_n)^2]/n]^{1/2}.$$

[B] S_R is the between-laboratories reproducibility, expressed as a standard deviation, for the indicated material.

[C] r is the within-laboratory repeatability limit, $r = 2.8 \times S_r$.

[D] R is the between-laboratory reproducibility limit, $R = 2.8 \times S_R$.

TABLE 2 Precision, Compressive Modulus
(Values in Units of Megapascals)

Material	Average	S_r[A]	S_R[B]	r[C]	R[D]
Acetal	3.28	0.14	0.25	0.39	0.70
Polystyrene	3.88	0.07	0.74	0.20	2.07
Linen-filled phenolic	6.82	0.23	0.90	0.64	2.52

[A] S_r is the within-laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories:

$$S_r = [[(S_1)^2 + (S_2)^2 + \ldots + (S_n)^2]/n]^{1/2}.$$

[B] S_R is the between-laboratories reproducibility, expressed as a standard deviation, for the indicated material.

[C] r is the within-laboratory repeatability limit, $r = 2.8 \times S_r$.

[D] R is the between-laboratory reproducibility limit, $R = 2.8 \times S_R$.

[9] Supporting data are available from ASTM Headquarters. Request RR: D20-1150.

NOTE 11—**Caution:** The following explanations of r and R (13.2-13.2.3) are only intended to present a meaningful way of considering the *approximate* precision of this test method. The data in Table 1 and Table 2 should not be rigorously applied to acceptance or rejection of material, as these data apply only to the materials tested in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials or between specific laboratories. The principles of 13.2-13.2.3 would then be valid for such data.

13.2 *Concept of r and R in Table 1 and Table 2*—If $S(r)$ and $S(R)$ have been calculated from a large enough body of data, and for test results that were averages from testing of five specimens for each test result, then:

13.2.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" for that the material. "r" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

13.2.2 *Reproducibility, R*—Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the "R" value for that material. "R" is the interval representing the critical difference between the two test results for the same material, obtained by different operators using different equipment in different laboratories.

13.2.3 Any judgement in accordance with 13.2.1 and 13.2.2 would have an approximate 95 % (0.95) probability of being correct.

13.3 There are no recognized standards by which to estimate the bias of this test method.

14. Keywords

14.1 compressive properties; compressive strength; modulus of elasticity; plastics

ANNEX

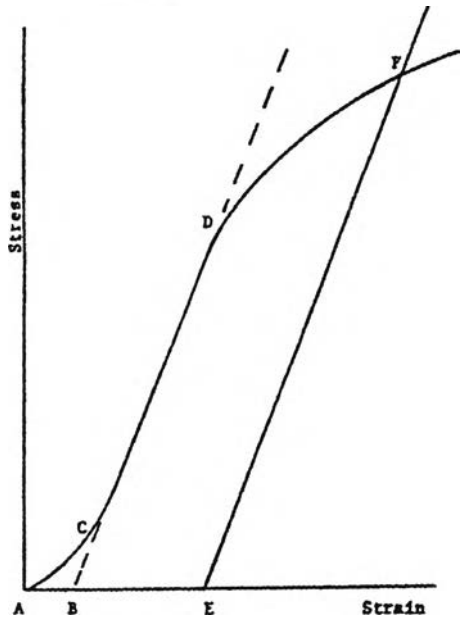
(Mandatory Information)

A1. TOE COMPENSATION

A1.1 In a typical stress-strain curve (Fig. A1.1) there is a toe region, *AC*, that does not represent a property of the material. It is an artifact caused by a takeup of slack, and alignment or seating of the specimen. In order to obtain correct values of such parameters as modulus, strain, and offset yield point, this artifact must be compensated for to give the corrected zero point on the strain or extension axis.

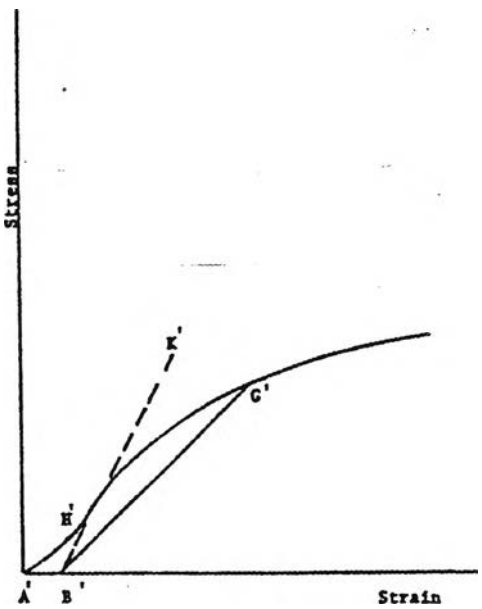
A1.2 In the case of a material exhibiting a region of Hookean (linear) behavior (Fig. A1.1), a continuation of the linear (*CD*) region of the curve is constructed through the zero-stress axis. This intersection (*B*) is the corrected zero-strain point from which all extensions or strains must be measured, including the yield offset (*BE*), if applicable. The elastic modulus can be determined by dividing the stress at any point along the line *CD* (or its extension) by the strain at the same point (measured from Point *B*, defined as zero-strain).

A1.3 In the case of a material that does not exhibit any linear region (Fig. A1.2), the same kind of toe correction of the zero-strain point can be made by constructing a tangent to the maximum slope at the inflection point (*H'*). This is extended to intersect the strain axis at Point *B'*, the corrected zero-strain point. Using Point *B'* as zero strain, the stress at any point (*G'*) on the curve can be divided by the strain at that point to obtain a secant modulus (slope of line *B' G'*). For those materials with



NOTE 1—Some chart recorders plot the mirror image of this graph.

FIG. A1.1 Material with Hookean Region



NOTE 1—Some chart recorders plot the mirror image of this graph.

FIG. A1.2 Material with No Hookean Region

no linear region, any attempt to use the tangent through the inflection point as a basis for determination of an offset yield point may result in unacceptable error.

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

D695–02a:
(*1*) Added Terminology D 883.
(*2*) Added Test Methods D 5947.
(*3*) Added 3.1, adjusted numbering throughout Section 3.
(*4*) Changed reference in 3.2.8 from 3.11 to 3.2.11.
(*5*) Deleted last sentence of 4.1.
(*6*) Added last sentence to 4.4.
(*7*) Reworded 5.1.1 to improve readability
(*8*) Changed "fortuitous flow" to "flaw" in 8.3.
(*9*) Reworded Note 11, 13.2, 13.2.1, and 13.2.2 to be in accordance with Guide D 4968.
(*10*) Corrected the title of Fig. 3.
D695–02:
(*1*) Revised 7.1 and 7.2.

Designation: D 2240 – 05

Standard Test Method for Rubber Property—Durometer Hardness[1]

This standard is issued under the fixed designation D 2240; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers twelve types of rubber hardness measurement devices known as durometers: Types A, B, C, D, DO, E, M, O, OO, OOO, OOO-S, and R. The procedure for determining indentation hardness of substances classified as thermoplastic elastomers, vulcanized (thermoset) rubber, elastomeric materials, cellular materials, gel-like materials, and some plastics is also described.

1.2 This test method is not equivalent to other indentation hardness methods and instrument types, specifically those described in Test Method D 1415.

1.3 This test method is not applicable to the testing of coated fabrics.

1.4 All materials, instruments, or equipment used for the determination of mass, force, or dimension shall have traceability to the National Institute for Standards and Technology, or other internationally recognized organizations parallel in nature.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only. Many of the stated dimensions in SI are direct conversions from the U. S. Customary System to accommodate the instrumentation, practices, and procedures that existed prior to the Metric Conversion Act of 1975.

1.6 *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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 374 Test Methods for Thickness of Solid Electrical Insulation

D 618 Practice for Conditioning Plastics for Testing

D 785 Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials

D 1349 Practice for Rubber—Standard Temperatures for Testing

D 1415 Test Method for Rubber Property—International Hardness

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries

F 1957 Test Method for Composite Foam Hardness-Durometer Hardness

2.2 *ISO Standard:*[3]

ISO/IEC 17025: 1999 General Requirements for the Competence of Testing and Calibration Laboratories

3. Summary of Test Method

3.1 This test method permits hardness measurements based on either initial indentation or indentation after a specified period of time, or both. Durometers with maximum reading indicators used to determine maximum hardness values of a material may yield lower hardness when the maximum indicator is used.

3.2 The procedures for Type M, or micro hardness durometers, accommodate specimens that are, by their dimensions or configuration, ordinarily unable to have their durometer hardness determined by the other durometer types described. Type M durometers are intended for the testing of specimens having a thickness or cross-sectional diameter of 1.25 mm (0.050 in.) or greater, although specimens of lesser dimensions may be successfully accommodated under the conditions specified in Section 6, and have a Type M durometer hardness range between 20 and 90. Those specimens which have a durometer hardness range other than specified shall use another suitable procedure for determining durometer hardness.

4. Significance and Use

4.1 This test method is based on the penetration of a specific type of indentor when forced into the material under specified conditions. The indentation hardness is inversely related to the penetration and is dependent on the elastic modulus and viscoelastic behavior of the material. *The geometry of the*

[1] This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.10 on Physical Testing.

Current edition approved Aug. 15, 2005. Published September 2005. Originally approved in 1964. Last previous edition approved in 2004 as D 2240–04[ε1].

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland.

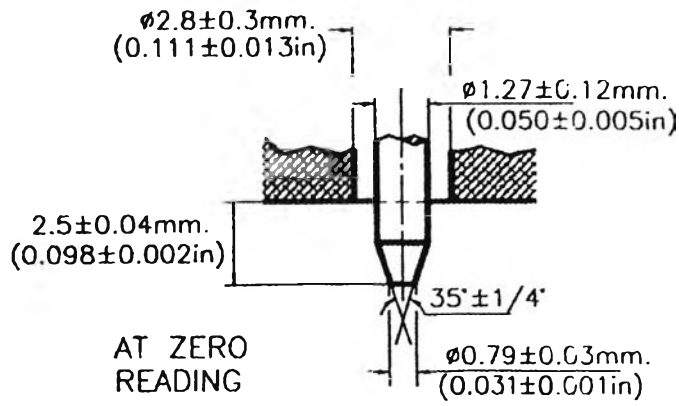


FIG. 1 (a) Type A and C Indentor

indentor and the applied force influence the measurements such that no simple relationship exists between the measurements obtained with one type of durometer and those obtained with another type of durometer or other instruments used for measuring hardness. This test method is an empirical test intended primarily for control purposes. No simple relationship exists between indentation hardness determined by this test method and any fundamental property of the material tested. For specification purposes, it is recommended that Test Method D 785 be used for materials other than those described in 1.1.

5. Apparatus

5.1 *Hardness Measuring Apparatus, or Durometer, and an Operating Stand*, Type 1, Type 2, or Type 3 (see 5.1.2) consisting of the following components:

5.1.1 *Durometer*:

5.1.1.1 *Presser Foot*, the configuration and the total area of a durometer presser foot may produce varying results when there are significant differences between them. It is recommended that when comparing durometer hardness determinations of the same type (see 4.1), that the comparisons be between durometers of similar presser foot configurations and total area, and that the presser foot configuration and size be noted in the Hardness Measurement Report (see 10.2.4 and 5.1.1.3).

5.1.1.2 *Presser Foot*, Types A, B, C, D, DO, E, O, OO, OOO, and OOO-S, with an orifice (to allow for the protrusion of the indentor) having a diameter as specified in Fig. 1 (a, b, c, d, e, f, and g), with the center a minimum of 6.0 mm (0.24 in.) from any edge of the foot. When the presser foot is not of a flat circular design, the area shall not be less than 500 mm^2 (19.7 $in.^2$).

NOTE 1—The Type OOO and the Type OOO-S, designated herein, differ in their indentor configuration, spring force, and the results obtained. See Table 1 and Fig. 1 (e and g).

5.1.1.3 *Presser Foot*—flat circular designs designated as Type *xR*, where *x* is the standard durometer designation and *R* indicates the flat circular press foot described herein, for example, Type *aR*, *dR*, and the like. The presser foot, having a centrally located orifice (to allow for the protrusion of the indentor) of a diameter as specified in Fig. 1 (a through g). The flat circular presser foot shall be 18 ± 0.5 mm (0.71 ± 0.02 in.) in diameter. These durometer types shall be used in an operating stand (see 5.1.2).

(a) Durometers having a presser foot configuration other than that indicated in 5.1.1.3 shall not use the Type *xR* designation, and it is recommended that their presser foot configuration and size be stated in the Hardness Measurement Report (see 10.2.4).

5.1.1.4 *Presser Foot, Type M*, with a centrally located orifice (to allow for the protrusion of the indentor), having a diameter as specified in Fig. 1 (d), with the center a minimum of 1.60 mm (0.063 in.) from any edge of the flat circular presser foot. The Type M durometer shall be used in a Type 3 operating stand (see 5.1.2.4).

5.1.1.5 *Indentor*, formed from steel rod and hardened to 500 HV10 and shaped in accordance with Fig. 1 (a, b, c, d, e, or g), polished over the contact area so that no flaws are visible under 20× magnification, with an indentor extension of 2.50 ± 0.04 mm (0.098 ± 0.002 in.).

5.1.1.6 *Indentor, Type OOO-S*, formed from steel rod and hardened to 500 HV10, shaped in accordance with Fig. 1 (f), polished over the contact area so that no flaws are visible under 20× magnification, with an indentor extension of 5.00 ± 0.04 mm (0.198 ± 0.002 in.).

5.1.1.7 *Indentor, Type M*, formed from steel rod and hardened to 500 HV10 and shaped in accordance with Fig. 1 (d), polished over the contact area so that no flaws are visible under 50× magnification, with an indentor extension of 1.25 ± 0.02 mm (0.049 ± 0.001 in.).

5.1.1.8 *Indentor Extension Indicator*, analog or digital electronic, having a display that is an inverse function of the indentor extension so that:

(1) The display shall indicate from 0 to 100 with no less than 100 equal divisions throughout the range at a rate of one hardness point for each 0.025 mm (0.001 in.) of indentor movement.

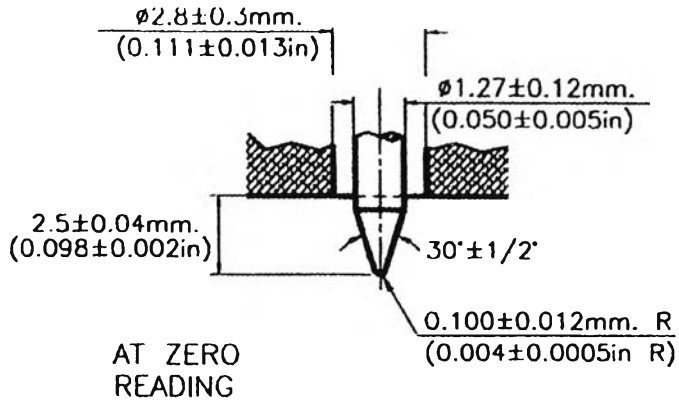


FIG. 1 (b) Type B and D Indentor *(continued)*

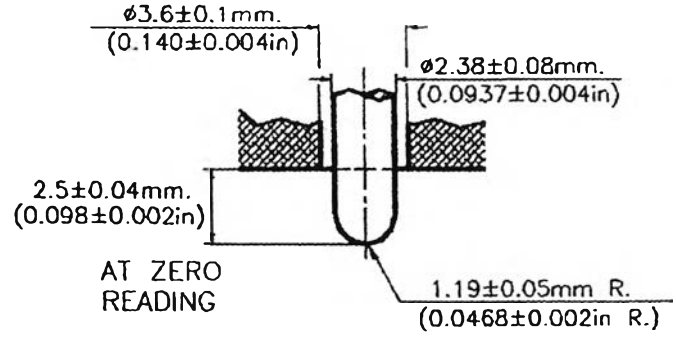


FIG. 1 (c) Type O, DO, and OO Indentor *(continued)*

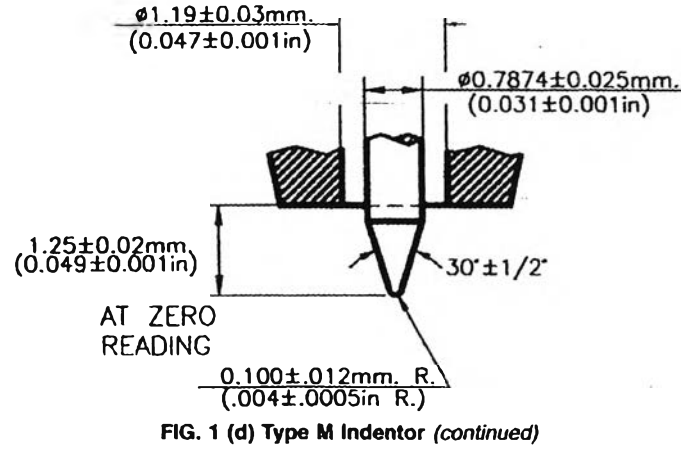


FIG. 1 (d) Type M Indentor *(continued)*

(2) The display for Type OOO-S durometers shall indicate from 0 to 100 with no less than 100 equal divisions throughout the range at a rate of one hardness point for each 0.050 mm (0.002 in.) of indentor movement,

(3) The display for Type M durometers shall indicate from 0 to 100 with no less than 100 equal divisions at a rate of one hardness point for each 0.0125 mm (0.0005 in.) of indentor movement, and

(4) In the case of analog dial indicators having a display of 360°, the points indicating 0 and 100 may be at the same point on the dial and indicate 0, 100, or both.

5.1.1.9 *Timing Device (optional)*, capable of being set to a desired elapsed time, signaling the operator or holding the hardness reading when the desired elapsed time has been reached. The timer shall be automatically activated when the presser foot is in contact with the specimen being tested, for example, the initial indentor travel has ceased. Digital electronic durometers may be equipped with electronic timing devices that shall not affect the indicated reading or determinations attained by more than one-half of the calibration tolerance stated in Table 1.

5.1.1.10 *Maximum Indicators (optional)*, maximum indicating pointers are auxiliary analog indicating hands designed to remain at the maximum hardness value attained until reset by

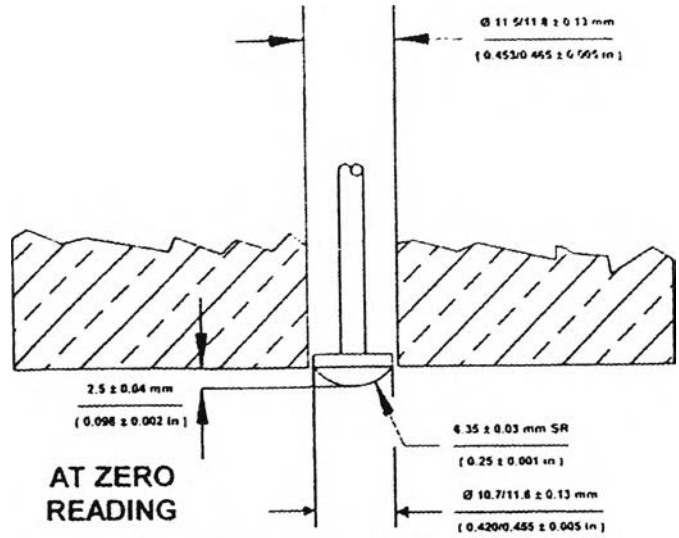


FIG. 1 (e) Type OOO Indentor *(continued)*

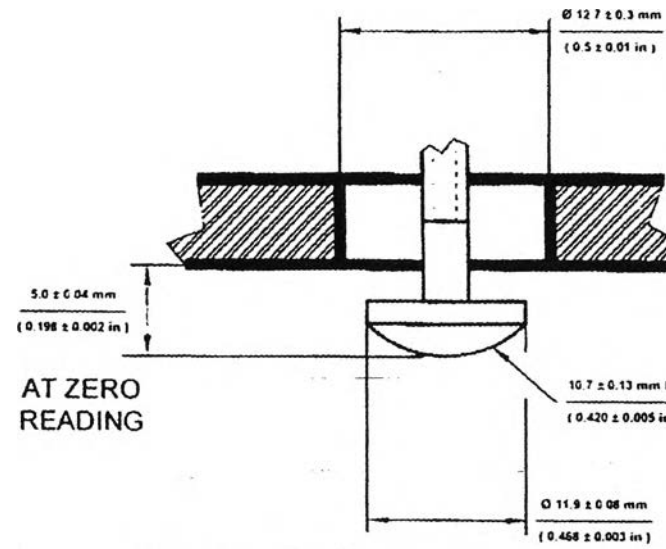


FIG. 1 (f) Type OOO-S Indentor *(continued)*

the operator. Electronic maximum indicators are digital displays electronically indicating and maintaining the maximum value hardness valued achieved until reset by the operator.

5.1.1.11 Analog maximum indicating pointers have been shown to have a nominal effect on the values attained, however, this effect is greater on durometers of lesser total mainspring loads; for example, the effect of a maximum indicating pointer on Type D durometer determinations will be less than those determinations achieved using a Type A durometer. Analog style durometers may be equipped with maximum indicating pointers. The effect of a maximum indicating pointer shall be noted at the time of calibration in the calibration report (see 10.1.5), and when reporting hardness determinations (see 10.2.4). Analog Type M, OO, OOO, and Type OOO-S durometers shall not be equipped with maximum indicating pointers.

5.1.1.12 Digital electronic durometers may be equipped with electronic maximum indicators that shall not affect the indicated reading or determinations attained by more than one half of the spring calibration tolerance stated in Table 1.

5.1.1.13 *Calibrated Spring*, for applying force to the indentor, in accordance with Fig. 1 (a through g) and capable of applying the forces as specified in Table 1.

5.1.2 *Operating Stand* (Fig. 2):

5.1.2.1 Type 1, Type 2, and Type 3 shall be capable of supporting the durometer presser foot surface parallel to the specimen support table (Fig. 3) throughout the travel of each. The durometer presser foot to specimen support table parallelism shall be verified each time the test specimen support table is adjusted to accommodate specimens of varying dimensions. This may be accomplished by applying the durometer presser foot to the point of contact with the specimen support table and making adjustments by way of the durometer mounting assembly or as specified by the manufacturer.

5.1.2.2 *Operating Stand, Type 1* (specimen to indentor type), shall be capable of applying the specimen to the indentor in a manner that minimizes shock.

5.1.2.3 *Operating Stand, Type 2* (indentor to specimen type), shall be capable of controlling the rate of descent of the indentor to the specimen at a maximum of 3.20 mm/s (0.125

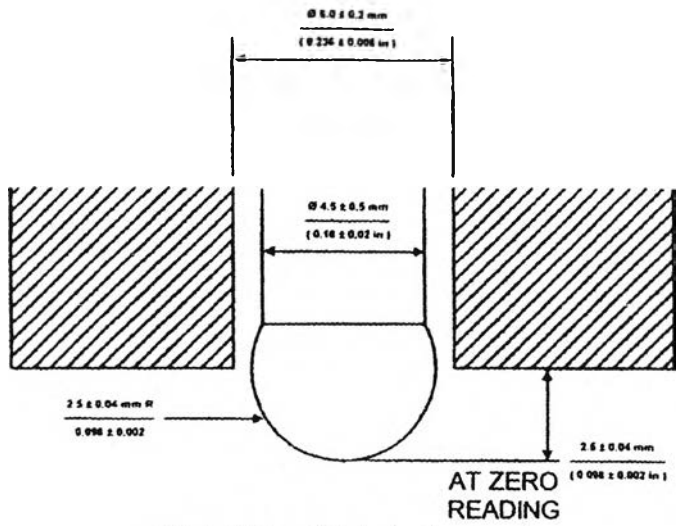


FIG. 1 (g) Type E Indentor *(continued)*

TABLE 1 Durometer Spring Force Calibration[A]
All Values are in N

Indicated Value	Type A, B, E, O	Type C, D, DO	Type M	Type OO, OOO	Type OOO-S
0	0.55	0	0.324	0.203	0.167
10	1.3	4.445	0.368	0.294	0.343
20	2.05	8.89	0.412	0.385	0.520
30	2.8	13.335	0.456	0.476	0.696
40	3.55	17.78	0.5	0.566	0.873
50	4.3	22.225	0.544	0.657	1.049
60	5.05	26.67	0.589	0.748	1.226
70	5.8	31.115	0.633	0.839	1.402
80	6.55	35.56	0.677	0.93	1.579
90	7.3	40.005	0.721	1.02	1.755
100	8.05	44.45	0.765	1.111	1.932
N/durometer unit	0.075	0.4445	0.0044	0.00908	0.01765
Spring Calibration Tolerance	± 0.075 N	± 0.4445 N	± 0.0176 N	± 0.0182 N	± 0.0353 N

[A] Refer to 5.1.1.3 for the Type *xR* designation.

in./s) and applying a force sufficient to overcome the calibrated spring force as shown in Table 1.

5.1.2.4 *Operating Stand, Type 3* (indentor to specimen type), hydraulic dampening, pneumatic dampening, or electromechanical (required for the operation of Type M durometers) shall be capable of controlling the rate of descent of the indentor to the specimen at a maximum of 3.2 mm/s (0.125 in./s) and applying a force sufficient to overcome the calibrated spring force as shown in Table 1. Manual application, Type 1 or Type 2 operating stands are not acceptable for Type M durometer operation.

5.1.2.5 The entire instrument should be plumb and level, and resting on a surface that will minimize vibration. Operating the instrument under adverse conditions will negatively affect the determinations attained.

5.1.2.6 *Specimen Support Table*, (Fig. 3) integral to the operating stand, and having a solid flat surface. The specimen support platform may have orifices designed to accept various inserts or support fixtures (Fig. 3) to provide for the support of irregularly configured specimens. When inserts are used to support test specimens, care must be taken to align the indentor to the center of the insert, or the point at which the indentor is to contact the specimen. Care should be exercised to assure that the indentor does not abruptly contact the specimen support table as damage to the indentor may result.

6. Test Specimen

6.1 The test specimen, herein referred to as "specimen" or "test specimen" interchangeably, shall be at least 6.0 mm (0.24 in.) in thickness unless it is known that results equivalent to the 6.0-mm (0.24-in.) values are obtained with a thinner specimen.

6.1.1 A specimen may be composed of plied pieces to obtain the necessary thickness, but determinations made on such specimens may not agree with those made on solid specimens, as the surfaces of the plied specimens may not be in complete contact. The lateral dimensions of the specimen shall be sufficient to permit measurements at least 12.0 mm (0.48 in.) from any edge, unless it is known that identical results are obtained when measurements are made at a lesser distance from an edge.

6.1.2 The surfaces of the specimen shall be flat and parallel over an area to permit the presser foot to contact the specimen over an area having a radius of at least 6.0 mm (0.24 in.) from the indentor point. The specimen shall be suitably supported to provide for positioning and stability. *A suitable hardness*

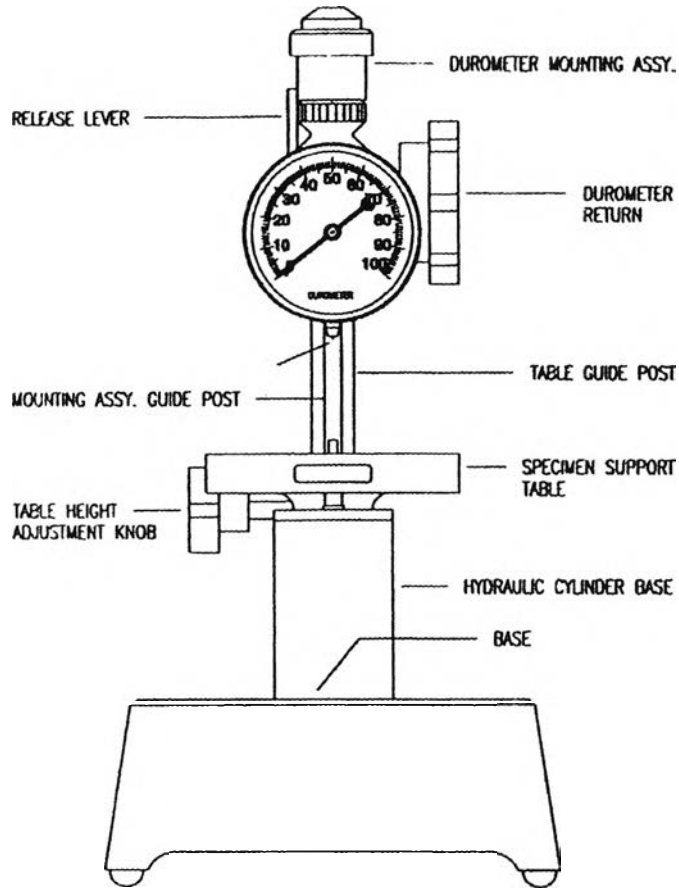
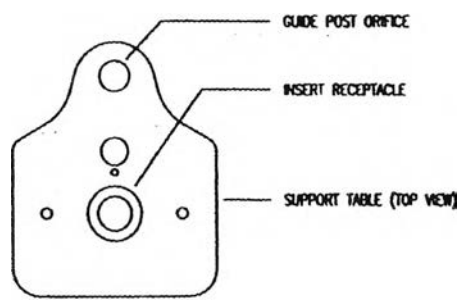


FIG. 2 Durometer Operating Stand



TYPICAL TABLE INSERTS USED FOR POSITIONING TUBING, O-RINGS AND SMALL SPECIMENS

FIG. 3 Small Specimen Support Table

determination cannot be made on an uneven or rough point of contact with the indentor.

6.2 Type OOO, OOO-S, and M test specimens should be at least 1.25 mm (0.05 in.) in thickness, unless it is known that results equivalent to the 1.25-mm (0.05-in.) values are obtained with a thinner specimen.

6.2.1 A Type M specimen that is not of a configuration described in 6.2.2 may be composed of plied pieces to obtain

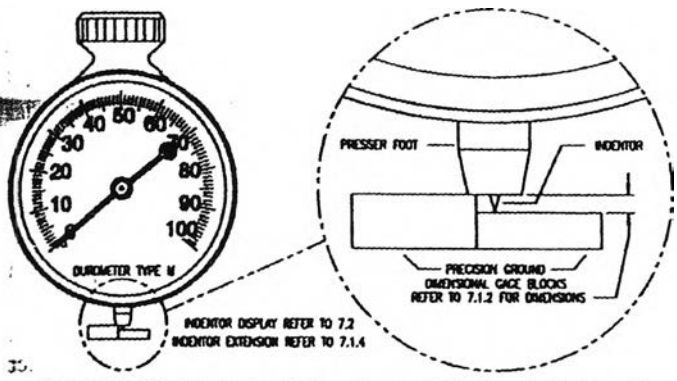


FIG. 4 Detail of Indentor Extension and Display Adjustment

the necessary thickness, but determinations made on such specimens may not agree with those made on solid specimens because the surfaces of the plied specimens may not be in complete contact. The lateral dimensions of the specimen should be sufficient to permit measurements at least 2.50 mm (0.10 in.) from any edge unless it is known that identical results are obtained when measurements are made at lesser distance from an edge. *A suitable hardness determination cannot be made on an uneven or rough point of contact with the indentor.*

6.2.2 The Type M specimen, when configured as an o-ring, circular band, or other irregular shape shall be at least 1.25 mm (0.05 in.) in cross-sectional diameter, unless it is known that results equivalent to the 1.25-mm (0.05-in.) values are obtained with a thinner specimen. The specimen shall be suitably supported in a fixture (Fig. 3) to provide for positioning and stability.

6.3 The minimum requirement for the thickness of the specimen is dependent on the extent of penetration of the indentor into the specimen; for example, thinner specimens may be used for materials having higher hardness values. The minimum distance from the edge at which measurements may be made likewise decreases as the hardness increases.

7. Calibration

7.1 *Indentor Extension Adjustment Procedure:*

7.1.1 Place precision ground dimensional blocks (Grade B or better) on the support table and beneath the durometer presser foot and indentor. Arrange the blocks so that the durometer presser foot contacts the larger block(s) and the indentor tip just contacts the smaller block (Fig. 4). It is necessary to observe the arrangement of the blocks and the presser foot/indentor under a minimum of 20× magnification to assure proper alignment.

7.1.2 Indentor extension and shape shall be in accordance with 5.1.1.5, 5.1.1.6, or 5.1.1.7, respective to durometer type. See Fig. 1 (a through g). Examination of the indentor under 20× magnification, 50× for Type M indentors, is required to examine the indentor condition. Misshapen or damaged indentors shall be replaced.

7.1.3 A combination of dimensional gage blocks shall be used to achieve a difference of 2.54 + 0.00/–0.0254 mm (0.100 +0.00/–0.001 in.) between them. For Type OOO-S durometers, the gage block dimensions are 5.08 + 0.00/–0.0508 mm (0.200 +0.00/–0.002 in.). For Type M durometers, the gage block dimensions are 1.27 + 0.0/–0.0127 mm (0.050 + 0.00/–0.0005 in.) between them (Fig. 4).

7.1.4 Carefully lower the durometer presser foot until it contacts the largest dimensional block(s), the indentor tip should just contact the smaller block, verifying full indentor extension.

7.1.5 Adjust the indentor extension to 2.50 ± 0.04 mm (0.098 ± 0.002 in.). For Type OOO-S durometers, adjust the indentor extension to 5.0 ± 0.04 mm (0.198 ± 0.002 in.). For Type M durometers, adjust the indentor extension to 1.25 ± 0.02 mm (0.049 ± 0.001 in.), following the manufacturer's recommended procedure.

7.1.5.1 When performing the procedures in 7.1, care should be used so as not to cause damage to the indentor tip. Fig. 4 depicts a suitable arrangement for gaging indentor extension.

7.1.6 Parallelism of the durometer presser foot to the support surface, and hence the dimensional gage blocks, at the time of instrument calibration, may be in accordance with Test Methods D 374, Machinist's Micrometers, or otherwise accomplished in accordance with the procedures specified by the manufacturer.

7.2 *Indentor Display Adjustment:*

7.2.1 After adjusting the indentor extension as indicated in 7.1, use a similar arrangement of dimensional gage blocks to verify the linear relationship between indentor travel and indicated display at two points: 0 and 100. Following the manufacturer's recommendations, make adjustments so that:

7.2.2 The indicator displays a value equal to the indentor travel measured to within:

–0.0 +1.0 durometer units measured at 0;

±0.50 durometer units measured at 100;

±1 durometer units at all other points delineated in 7.4.

7.2.3 Each durometer point indicated is equal to 0.025 mm (0.001 in.) of indentor travel, except for:

7.2.3.1 Type M Durometers, each indicated point is equal to 0.0125 mm (0.0005 in.) of indentor travel;

7.2.3.2 Type OOO-S Durometers, each indicated point is equal to 0.050 mm (0.002 in.) of indentor travel.

7.2.4 The indicator shall not display a value greater than 100 or less than 0 at the time of calibration.

7.2.5 Other means of determining indentor extension or indentor travel, such as optical or laser measurement methods, are acceptable. The instrumentation used shall have traceability as described in 1.4.

7.2.6 The durometer shall be supported in a suitable fashion when performing the procedures described in 7.1 and 7.2.

7.3 *Calibration Device:*

7.3.1 The durometer spring shall be calibrated by supporting the durometer in a calibrating device, see Fig. 5, in a vertical position and applying a measurable force to the indentor tip. The force may be measured by means of a balance as depicted in Fig. 5, or an electronic force cell. The calibrating device shall be capable of measuring applied force to within 0.5 % of the maximum spring force necessary to achieve 100 durometer units.

7.3.2 Care should be taken to ensure that the force is applied vertically to the indentor tip, as lateral force will cause errors in calibration. See 7.1.5.1 and 7.1.6.

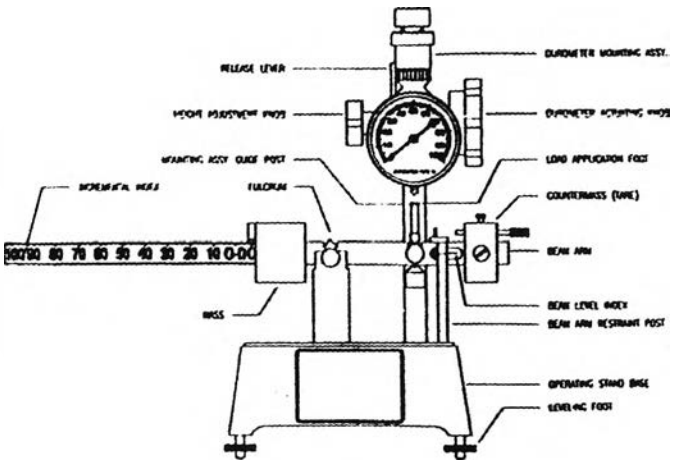


FIG. 5 Example of Durometer Calibration Apparatus

7.4 *Spring Calibration*—The durometer spring shall be calibrated at displayed readings of 10, 20, 30, 40, 50, 60, 70, 80, and 90. The measured force (9.8× mass in kilograms) shall be within the spring calibration tolerance specified in Table 1. Table 1 identifies the measured force applied to the indentor for the entire range of the instrument, although it is necessary only to verify the spring calibration at points listed herein.

7.5 *Spring Calibration Procedure*:

7.5.1 Ensure that the indentor extension has been adjusted in accordance with 7.1, and the linear relationship between indentor travel and display is as specified in 7.2.

7.5.2 Place the durometer in the calibration device as depicted in Fig. 5. Apply the forces indicated in Table 1 so that forces applied are aligned with the centerline of the indentor in a fashion that eliminates shock or vibration and adjust the durometer according to manufacturers' recommendations so that:

7.5.3 At the points enumerated in 7.4, the display shall indicate a value equal to 0.025 mm (0.001 in.) of indentor travel. For Type OOO-S durometers, the display shall indicate a value equal to 0.05 mm (0.002 in.) of indentor travel. For Type M durometers, the display shall indicate a value equal to 0.0125 mm (0.0005 in.) of indentor travel within the spring calibration tolerances specified in 7.6.

7.6 Spring calibration tolerances are ±1.0 durometer units for Types A, B, C, D, E, O, and DO, ±2.0 durometer units for Types OO, OOO, and OOO-S, and ±4.0 durometer units for Type M, while not indicating below 0 or above 100 at the time of calibration (see Table 1).

7.7 *Spring Force Combinations*:

7.7.1 For Type A, B, E, and O durometers:

Force, N = 0.55 + 0.075 HA

Where HA = hardness reading on Type A, B, E, and O durometers.

7.7.2 For Type C, D, and DO durometers:

Force, N = 0.4445 HD

Where HD = hardness reading on Type C, D, and DO durometers.

7.7.3 For Type M durometers:

Force, N = 0.324 + 0.0044 HM

Where HM = hardness reading on Type M durometers.

7.7.4 For Type OO and OOO durometers:

Force, N = 0.203 + 0.00908 HOO

Where HOO = hardness reading on Type OO durometers.

7.7.5 For Type OOO-S durometers:

Force, N = 0.167 + 0.01765 HOOO-S

Where HOOO-S = hardness reading on Type OOO-S durometers.

7.8 The rubber reference block(s) provided for verifying durometer operation and state of calibration are not to be relied upon as calibration standards. The calibration procedures outlined in Section 7 are the only valid calibration procedures.

7.8.1 The use of metal reference blocks is no longer recommended (see Note 2).

7.9 Verifying the state of durometer calibration, *during routine use*, may be accomplished by:

7.9.1 Verifying that the zero reading is no more than 1 indicated point above zero, and not below zero (on durometers so equipped), when the durometer is positioned so that no external force is placed upon the indentor.

7.9.2 Verifying that the 100 reading is no more than 100 and no less than 99 when the durometer is positioned on a flat surface of a non-metallic material so that the presser foot is in complete contact, causing the indentor to be fully retracted.

7.9.2.1 It is important that when performing the verification of 100, as described in 7.9.2, that extreme care be taken so as to not cause damage to the indentor. Verification of the 100 value is not recommended for durometers having a spring force greater than 10 N (Types C, D, and DO).

7.9.2.2 When performing the verification of 100, as described in 7.9.2, the non-metallic material shall be of a hardness value greater than 100 of the type (scale) of the durometer being employed. Tempered glass of a thickness greater than 6.35 mm (0.25 in.) has been found satisfactory for this application.

7.9.3 Verifying the displayed reading at any other point using commercially available rubber reference blocks which are certified to a stated value of the type (scale) of the durometer being employed. The displayed value of the durometer should be within ±2 durometer points of the reference block's stated value.

7.9.4 Verification of the zero and 100 readings of a durometer provide reasonable assurance that the linear relationship between the indicated display and the durometer mechanism remain valid.

7.9.5 Verification of points between zero and 100 provide reasonable assurance that the curvilinear relationship between the indicated display and the durometer mechanism remain valid.

7.9.6 *This is not a calibration procedure, it is a means by which a user may routinely verify that the durometer may be functioning correctly.* (See Note 2.)

8. Laboratory Atmosphere and Test Specimen Conditioning

8.1 Tests shall be conducted in the standard laboratory atmosphere, as defined in Practice D 618, Section 4.2.

8.2 The instrument shall be maintained in the standard laboratory atmosphere, as defined in Practice D 618, Section 4.1, for 12 h prior to performing a test.

8.3 The specimen shall be conditioned in accordance with condition 40/23 exclusive of humidity control, as described in Practice D 618, Section 8.1, Procedure A and tested under the same conditions, exclusive of humidity control.

8.4 These procedures may be modified if agreed upon between laboratories or between supplier and user and are in accordance with alternative procedures identified in Practice D 618.

8.5 No conclusive evaluation has been made on durometers at temperatures other than 23.0 ± 2.0°C (73.4 ± 3.6°F). Conditioning at temperatures other than the above may show changes in calibration. Durometer use at temperatures other than the above should be decided locally (see Practice D 1349).

9. Procedure

9.1 *Operating Stand Operation (Type 3 Operating Stand Required for Type M)*:

9.1.1 Care shall be exercised to minimize the exposure of the instrument to environmental conditions that are adverse to the performance of the instrument, or adversely affect test results.

9.1.2 Adjust the presser foot to support table parallelism as described in 5.1.2.1. It is necessary to make this adjustment each time the support table is moved to accommodate specimens of varying dimensions.

9.1.3 Prior to conducting a test, adjust the vertical distance from the presser foot to the contact surface of the test specimen to 25.4 ± 2.5 mm (1.00 ± 0.100 in.), unless it is known that identical results are obtained with presser foot at a greater or lesser vertical distance from the test specimen contact surface, or if otherwise stipulated by the manufacturer.

9.1.4 Place the specimen on the specimen support table, in a manner that the contact point of the indentor is in accordance with Section 6, unless it is known that identical results are obtained when measurements are made with the indentor at a lesser distance from the edge of the test specimen.

9.1.5 Actuate the release lever (Fig. 2) of the operating stand or activate the electromechanical device, allowing the durometer to descend at a controlled rate and apply the presser foot to the specimen in accordance with 5.1.2. In the case of "specimen to indentor" type operating stands, operate the lever or other mechanism to apply the specimen to the indentor in a manner that assures parallel contact of the specimen to the durometer presser foot without shock and with just sufficient force to overcome the calibrated spring force as shown in Table 1.

9.1.6 An operating stand that applies the mass at a controlled rate of descent, without shock is mandatory for Type M durometers. Hand-held application or the use of a Type 1 or Type 2 operating stand for the Type M durometer is not an acceptable practice, see 5.1.2.4.

9.1.7 For any material covered in 1.1, once the presser foot is in contact with the specimen, for example, when the initial indentor travel has ceased, the maximum indicated reading shall be recorded. The time interval of 1 s, between initial indentor travel cessation and the recording of the indicated reading, shall be considered standard. Other time intervals, when agreed upon among laboratories or between supplier and user, may be used and reported accordingly. The indicated hardness reading may change with time.

9.1.7.1 If the durometer is equipped with an electronic maximum indicator or timing device (refer to 5.1.1.9) the indicated reading shall be recorded within 1 ± 0.3 s of the cessation of indentor travel and reported (refer to 10.2.9 for reporting protocols), unless otherwise noted.

9.1.7.2 If the durometer is equipped with an analog type maximum indicator (refer to 5.1.1.10), the maximum indicated reading may be recorded and shall be reported (refer to 10.2.9), unless otherwise noted.

9.1.7.3 If the durometer is not equipped with the devices described in 5.1.1.9 or 5.1.1.10, the indicated reading shall be recorded within 1 s as is possible and reported (refer to 10.2.9), unless otherwise noted.

9.1.8 Make five determinations of hardness at different positions on the specimen at least 6.0 mm (0.24 in.) apart, 0.80 mm (0.030 in.) apart for Type M; and calculate the arithmetic mean, or alternatively calculate the median. The means of calculating the determinations shall be reported according to 10.2.8

9.2 *Manual (Hand Held) Operation of Durometer*:

9.2.1 Care shall be exercised to minimize the exposure of the instrument to environmental conditions that are adverse to the performance of the instrument, or adversely affect test results.

9.2.2 Place the specimen on a flat, hard, horizontal surface. Hold the durometer in a vertical position with the indentor tip at a distance from any edge of the specimen as described in Section 6, unless it is known that identical results are obtained when measurements are made with the indentor at a lesser distance.

9.2.3 Apply the presser foot to the specimen, maintaining it in a vertical position keeping the presser foot parallel to the specimen, with a firm smooth downward action that will avoid shock, rolling of the presser foot over the specimen, or the application of lateral force. Apply sufficient pressure to assure firm contact between the presser foot and the specimen.

9.2.4 For any material covered in 1.1, after the presser foot is in contact with the specimen, the indicated reading shall be recorded within 1 ± 0.1 s, or after any period of time agreed upon among laboratories or between supplier and user. If the durometer is equipped with a maximum indicator, the maximum indicated reading shall be recorded within 1 ± 0.1 s of the cessation of initial indentor travel. The indicated hardness reading may change with time.

9.2.5 Make five determinations of hardness at different positions on the specimen at least 6.0 mm (0.24 in.) apart and calculate the arithmetic mean, or alternatively calculate the median. The means of calculating the determinations shall be reported according to 10.2.8.

9.3 It is acknowledged that durometer readings below 20 or above 90 are not considered reliable. It is suggested that readings in these ranges not be recorded.

9.4 Manual operation (handheld) of a durometer will cause variations in the results attained. Improved repeatability may be obtained by using a mass, securely affixed to the durometer and centered on the axis of the indentor. Recommended masses

TABLE 2 Type 1 Precision—Type M Durometer Method

Material		Within Laboratories			Between Laboratories		
	MEAN	Sr^A	r^B	$(r)^C$	SR^D	R^E	$(R)^F$
1	31.8	1.26	3.58	11.24	3.76	10.63	33.41
2	40.8	1.14	3.23	7.90	2.47	7.00	17.13
3	54.0	0.975	2.76	5.11	2.38	6.73	12.46
4	62.8	0.782	2.21	3.52	2.24	6.34	10.10
5	70.9	0.709	2.01	2.83	0.974	2.76	3.89
6	80.6	1.686	4.77	5.92	1.61	4.56	5.65
7	87.7	1.15	3.25	3.71	2.63	7.45	8.50
8	32.4	0.947	2.68	8.26	3.64	10.29	31.73
9	41.8	0.797	2.26	5.40	2.23	6.31	15.11
10	53.3	0.669	1.89	3.55	2.29	6.49	12.17
11	63.2	0.485	1.37	2.17	2.19	6.20	9.80
12	69.6	0.737	2.09	3.00	0.99	2.80	4.02
13	78.3	0.784	2.22	2.84	1.04	2.94	3.75
14	87.6	1.121	3.17	3.62	2.65	7.49	8.55
15	34.1	0.85	2.40	7.05	1.84	5.20	15.25
16	42.3	0.635	1.80	4.25	1.20	3.39	8.01
17	54.6	0.56	1.59	2.90	2.15	6.09	11.15
18	62.9	1.12	3.17	5.04	1.47	4.16	6.61
19	70.3	0.689	1.95	2.77	0.944	2.67	3.80
20	81.7	0.483	1.37	1.67	1.10	3.10	3.80
21	87.9	0.879	2.49	2.83	2.07	5.86	6.67
AVERAGE	61.4						
POOLED VALUES		0.924	2.62	4.26	2.146	6.07	9.89

[A] Sr = repeatability standard deviation, measurement units.
[B] r = repeatability = 2.83 × Sr, measurement units.
[C] (r) = repeatability, relative, (that is, in percent).
[D] SR = reproducibility standard deviation, measurement units.
[E] R = reproducibility = 2.83 × SR, measurement units.
[F] (R) = reproducibility, relative, (that is, in percent).

TABLE 3 Type 1 Precision—Type A Durometer Method

Material	Average Level	Within Laboratories			Between Laboratories		
		Sr^A	r^B	$(r)^C$	SR^D	R^E	$(R)^F$
1	51.4	0.646	1.83	3.56	1.56	4.41	8.59
2	65.3	0.878	2.48	3.81	2.21	6.06	9.27
3	68.0	0.433	1.23	1.80	2.28	6.45	9.49
Pooled	61.6	0.677	1.92	3.11	2.018	5.72	9.28

[A] Sr = repeatability standard deviation, measurement units.
[B] r = repeatability = 2.83 × Sr, measurement units.
[C] (r) = repeatability, relative, (that is, in percent).
[D] SR = reproducibility standard deviation, measurement units.
[E] R = reproducibility = 2.83 × SR, measurement units.
[F] (R) = reproducibility, relative, (that is, in percent).

TABLE 4 Type 1 Precision—Type D Durometer Method

Material	Average Level	Within Laboratories			Between Laboratories		
		Sr^A	r^B	$(r)^C$	SR^D	R^E	$(R)^F$
1	42.6	0.316	0.894	2.10	2.82	7.98	18.7
2	54.5	0.791	2.24	4.11	3.54	10.0	18.4
3	82.3	1.01	2.86	3.47	3.54	10.0	12.2
Pooled	59.8	0.762	2.16	3.61	3.32	9.40	15.7

[A] Sr = repeatability standard deviation, measurement units.
[B] r = repeatability = 2.83 × Sr, measurement units.
[C] (r) = repeatability, relative, (that is, in percent).
[D] SR = reproducibility standard deviation, measurement units.
[E] R = reproducibility = 2.83 × SR, measurement units.
[F] (R) = reproducibility, relative, (that is, in percent).

are 1 kg for Type A, B, E, and O durometers, 5 kg for Type C, D, and DO durometers, and 400 g for Type OO, OOO, and OOO-S durometers. The introduction of an additional mass on Type M durometers is not permitted. Further improvement may be achieved by the use of a durometer operating stand that controls the rate of descent of the durometer presser foot to the test specimen and incorporates the masses described above.

10. Report

10.1 *Instrument Calibration Report (Durometer or Operating Stand):*

10.1.1 Date of calibration.

10.1.2 Date of last calibration.

10.1.3 Calibration due date (see Note 2).

10.1.4 Manufacturer, type, model, and serial number of the instrument, and a notation when a maximum indicator or timing device is present.

10.1.5 Values obtained (pre- and post-calibration results), including a notation of the effect of a maximum indicator, if present. The method of reporting the calibrated value shall be by attaining the arithmetic mean of the determinations.

10.1.6 Ambient temperature.

10.1.7 Relative humidity.

10.1.8 Technician identification.

10.1.9 Applicable standards to which the instrument is calibrated.

10.1.10 Calibrating instrument information to include type, serial number, manufacturer, date of last calibration, calibration due date (see Note 2), and a statement of traceability of standards used to NIST or other acceptable organization. See 1.4.

10.2 *Hardness Measurement Report*:

10.2.1 Date of test.

10.2.2 Relative humidity.

10.2.3 Ambient temperature.

10.2.4 Manufacturer, type, and serial number of the durometer or operating stand, or both, including a notation when a maximum indicator or timing device is present, date of last calibration, and calibration due date (see Note 2).

NOTE 2—The calibration interval (calibration due date) for a durometer is to be determined by the user, based upon frequency of use, severity of conditions, environmental factors, and other variables.

Periodic checking of the operation and state of durometer calibration using commercially available rubber test blocks (refer to 7.8), specifically designed for this purpose, is recommended.

An instrument that has been exposed to severe shock, is visibly damaged, produces test determinations more than 2 points different from calibrated rubber test blocks or other reference standard, or is otherwise suspected of unreliability, should be removed from service and returned to a qualified calibration facility.

A calibration interval of one year is recommended for durometer test blocks and durometer instruments that are infrequently used, more often for others.

The calibration interval for instruments and peripheral devices employed in the calibration of durometers is to be determined by the calibration service provider. It is recommended that the protocols outlined in ISO/IEC 17025, as required by the manufacturer, and those to which the service is provided, be followed.

10.2.5 Means of testing, whether manual (hand held), Type 1 operating stand (specimen to indentor), Type 2 operating stand (indentor to specimen type), or Type 3 operating stand (electromechanical or hydraulically dampened).

10.2.6 Description of test specimen, including thickness, number of pieces plied if less than the thickness indicated in Section 6, including the vulcanization date.

10.2.7 Complete identification of material tested.

10.2.8 Hardness value obtained and method of calculation, either arithmetic mean or alternatively, the median.

10.2.9 Indentation hardness time interval at which determination was made. Readings may be reported in the form: M/60/1 where M is the type of durometer, 60 the reading, and 1 the time in seconds that the presser foot is in contact with the specimen or from an electronic timing device.

11. Precision and Bias

11.1 These precision and bias statements have been prepared in accordance with Practice D 4483. Refer to this Practice for terminology and other testing and statistical concepts.

11.2 The Type 1 precision for the Type M method was determined from an interlaboratory program with 21 materials of varying hardness, with six participating laboratories. Tests were conducted on two separate days in each laboratory for the Type M testing program. All materials were supplied from a single source, being those commonly supplied as reference materials with the instruments from the manufacturer.

11.3 The precision results in this precision and bias section give an estimate of the precision of this test method with the materials (rubbers) used in the particular interlaboratory program as described above. The precision parameters should not be used for acceptance or rejection testing, or both, of any group of materials without documentation that they are applicable to those particular materials and the specific testing protocols that include this test method.

11.4 The Type 1 precision for both Type A and D methods was determined from an interlaboratory program with 3 materials of varying hardness, with six participating laboratories. Tests were conducted on two separate days in each laboratory for both A and D testing programs. All materials were supplied from a single source.

11.5 A test result for hardness, for Types A, D, and M, was the median of five individual hardness readings on each day in each laboratory.

11.6 Table 2 shows the precision results for Type M method,[4] Table 3 shows the precision results for Type A method,[5] and Table 4 gives the precision results for Type D method.[5]

11.7 *Precision*—The precision of this test method may be expressed in the format of the following statements which use as appropriate value r, R, (r), or (R), that is, that value to be used in decisions about test results (obtained with the test method). The appropriate value is that value of r or R associated with a mean level in Table 1 closest to the mean level under consideration (at any given time, for any given material) in routine testing operations.

NOTE 3—A Type 1 precision statement for Types E, OOO, OOO-S, and R have not yet been made available.

11.7.1 *Repeatability*—The repeatability, r, of these test methods has been established as the appropriate value tabulated in Tables 2-4. Two single test results, obtained under normal test method procedures, that differ by more than this tabulated r (for any given level) must be considered as derived from different or non-identical sample populations.

11.7.2 *Reproducibility*—The reproducibility, R, of these test methods has been established as the appropriate value tabulated in Tables 2-4. Two single test results obtained in two different laboratories, under normal test method procedures, that differ by more than the tabulated R (for any given level) must be considered to have come from different or non-identical sample populations.

11.7.3 Repeatability and reproducibility are expressed as a percentage of the mean level, (r) and (R), and have equivalent application statements as above for r and R. For the (r) and (R) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

11.8 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true) test property value. Reference values do not exist for this test method since the value (of the test property) is exclusively defined by this test method. Bias, therefore cannot be determined.

12. Keywords

12.1 durometer; durometer hardness; hardness; indentation hardness; micro durometer hardness

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D11-1091.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D11-1029.

APPENDIXES

(Nonmandatory Information)

X1. DUROMETER SELECTION GUIDE

X1.1 The durometer selection guide is designed to assist in the selection of the proper durometer type for various applications.

X1.2 It is generally recognized that durometer hardness determination below 20 and above 90 are unreliable. It is recommended that the next lower or higher type (scale) be used in these situations.

X1.3 It is also recommended that, whenever possible, an operating stand be employed in performing durometer hardness tests.

TABLE X1.1 Durometer Selection: Typical Uses

Type (Scale)	Typical Examples of Materials Tested	Durometer Hardness (Typical Uses)
A	Soft vulcanized rubber, natural rubber, nitriles, thermoplastic elastomers, flexible polyacrylics and thermosets, wax, felt, and leathers	20–90 A
B	Moderately hard rubber, thermoplastic elastomers, paper products, and fibrous materials	Above 90 A Below 20 D
C	Medium-hard rubber, thermoplastic elastomers, medium-hard plastics, and thermoplastics	Above 90 B Below 20 D
D	Hard rubber, thermoplastic elastomers, harder plastics, and rigid thermoplastics	Above 90 A
DO	Moderately hard rubber, thermoplastic elastomers, and very dense textile windings	Above 90 C Below 20 D
M	Thin, irregularly shaped rubber, thermoplastic elastomer, and plastic specimens	20–85 A
O	Soft rubber, thermoplastic elastomers, very soft plastics and thermoplastics, medium-density textile windings	Below 20 DO
OO	Extremely soft rubber, thermoplastic elastomers, sponge, extremely soft plastics and thermoplastics, foams, low-density textile windings, human and animal tissue	Below 20 O
CF	Composite foam materials, such as amusement ride safety cushions, vehicle seats, dashboards, headrests, armrests, and door panels	See Test Method F 1957

X2. RELATED TEST METHODS[2]

C 367 Test Methods for Strength Properties of Prefabricated Architectural Acoustical Tile or Lay-In Ceiling Panels

C 473 Test Methods for Physical Testing of Gypsum Panel Products

C 581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service

C 661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer

C 836 Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course

D 461 Test Methods for Felt

D 531 Test Method for Rubber Property—Pusey and Jones Indentation

D 619 Test Methods for Vulcanized Fibre Used for Electrical Insulation

D 1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

D 1054 Test Method for Rubber Property—Resilience Using a Goodyear-Healey Rebound Pendulum

D 1414 Test Methods for Rubber O-Rings

D 1474 Test Methods for Indentation Hardness of Organic Coatings

D 2134 Test Method for Determining the Hardness of Organic Coatings with a Sward-Type Hardness Rocker

D 2287 Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds

D 2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

D 2632 Test Method for Rubber Property—Resilience by Vertical Rebound

D 4289 Test Method for Elastomer Compatibility of Lubricating Greases and Fluids

D 5672 Test Method for Flexible Cellular Materials—Measurement of Indentation Force Deflection Using a 25-mm (1-in.) Deflection Technique

D 6546 Test Methods for and Suggested Limits for Determining Compatibility of Elastomer Seals for Industrial Hydraulic Fluid Applications

F 1151 Test Method for Determining Variations in Hardness of Film Ribbon Pancakes

NOTE X2.1—The hardness testing of other nonmetallic materials may be under the jurisdiction of one or more ASTM committees; the respective committee should be contacted for specific information.

ภาคผนวก ช

คู่มือการใช้เครื่องวัด pH รุ่น Tester 30 และเครื่องวัดการนำไฟฟ้า รุ่น Ecoscan CON5

คู่มือการใช้งานของเครื่องวัดค่า pH รุ่น Tester 30

pHTestr 30 Waterproof pH Tester with Simultaneous Temperature Display

Applications

General : Idea for quick and accurate pH checks in pools and spas, aquariums and hydroponics operations, or anywhere frequent pH testing is required. pHTestr 30 meets requirements for many standard environmental and ASTM test methods

Industrial : Use for cooling towers, food processing water testing and process/ wastewater testing in metal finishing, photo development, printing and chemical industries.

Educational : Useful in schools, many laboratory applications and ecology studies.

Specifications of pHTestr 30 Waterproof Tester

Product Code	**pHTest 30**
pH Range	-1.00 to 15.00 pH
Resolution	0.01 pH
Accuracy	± 0.01 pH
Temperature Display	0 to 50 ^{o}C or 32 to 122 F
Resolution	0.1 ^{o}C /F
Accuracy	0.5 ^{o}C / 0.9 F
No. of Calibration Points	3 points
pH Buffer Options	USA- pH 4.01, 7.00, 10.01 ; NIST-pH 4.01,6.86,9.18
LCD Display	Dual display with battery indicator, error messages/codes
ATC	Yes
Special Funtions	Large Dual Custom Display, Self-diagnostic; Hold functions; Auto-Power Off after 8.5 minutes
Power	4 'AAA' x 1.4 V alkaline button cell batteries; > 500hrs

คู่มือการใช้งานของเครื่องวัดค่า Conductivityรุ่น Ecoscan CON 5

Economy Palm-top Meters : EcoScan CON 5/TDS 5 Conductivity/TDS Meters

Applications

Routine testing : For quick conductivity or TDS checks in laboratories, field and schools. Useful in hydroponics and agricultural industries.

Industrial : For checking metal finishing, cooling tower water, printing fountain solutions, boiler water, brines, drilling mud, rise tanks, ponds, pollution control, recirculating systems, waste water and industrial process systems.

Water Quality Testing : For analyzing water hard water, untreated water, drinking water, effluent water, pool water and incoming process water. Ideal for all types of quality assurance and water quality testing.

Specifications of EcoScan CON 5/TDS 5 Meters

Product Code	**EC-CON 5**	**EC-TDS 5**
Conductivity Range	0 to 199.9, 1999 µS/cm 19.99 mS/cm	Not Available
Resolution & Accuracy	0.1, 1 µS/cm & 0.01 mS/cm	-
TDS Range	Not Available	0 to 99.9 , 999 ppm; 9.99 ppt
Resolution & Accuracy	-	0.1, 1 ppm & 0.01 ppt; ±1 %Full Scle
TDS Factor	-	0.50 to 0.85 (default 0.67)
Temperature Range	0 to 100.0 ^{o}C	
Resolution & Accuracy	0.1 ^{o}C & ± 0.5 ^{o}C	
Temperature Compensation	Automatic / Manual (0 to 80 ^{o}C)	
Temperature Coefficitent	2 % / ^{o}C	
No. of Calibration Points	1 per range (Up to 3 max)	
Special Funtions	Auto Power-Off after 17 minutes; Hold & Self-diagnostic messages	
Power	4 'AAA' x 1.4 V batteries	

ภาคผนวก ช

เอกสารกำกับความปลอดภัยของสารเคมี (Material safety data sheet)ของพรีพอลิเมอร์อิพ็อกซีและสารทำแข็ง

HEXION™ Specialty Chemicals

Safety Data Sheet

1 Identification of substance:

- **Product details:**
- **Trade name:**
- **Article number:**
- **Application of the substance / the preparation** Epoxy resin systems
- **Manufacturer/Supplier:**

Hexion Specialty Chemicals Korea Co., Ltd.
580-3. Whasan-ri. Onsan-eup. Ulju-gun.
Ulsan Metropolis City, 689-896, Korea
Tel : 82-52-231-5173
Fax : 82-52-231-5163

- **Information:** See : Chapter 16 (Contact)
- **Emergency information:** See : Manufacturer/Supplier

2 Composition/Data on components:

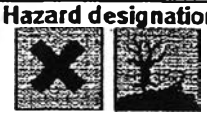
- **Chemical characterization:**
- **CAS No Designation:**

25068-38-6 Bisphenol A-epichlorohydin resin, mw≤700

- **Identification number(s):** No-Longer Polymer(LNP)
- **EINCES Number:** 500-033-5
- **EU Number:** 603-074-00-8
- **Chemical characterization**
- **Description :** Epoxy resin

3 Hazards identification :

- **Hazard designation**



Xi Irritant
N Dangerous for the environment

- **Information pertaining to particular dangers for man and environment**

R 36/38 Irritating to eyes and skin.
R 43 May cause sensitization by skin contact.
R 51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Contain epoxy constituents. See information supplied by the manufacture.

4 First aid measures

- **General information** Instantly remove any clothing soiled by the product.
- **After inhalation**

Supply fresh air and call for doctor for safety reasons.
In case of unconsciousness bring patient into stable side position for transport.

- **After skin contact**

Clean affected area with soap and plenty of water.

- **After eye contact**

Rinse opened eye for several minutes under running water. If symptoms persist, consult doctor.

- **After swallowing**

Resin out mouth and then drink plenty of water.
Seek immediate medical advice.

5 Fire fighting measures

- **Suitable extinguishing agents**

CO2, extinguishing powder or water jet. Fight larger fires with water
Jet or alcohol-resistant foam.
For safety reasons unsuitable extinguishing agents
Water with a full water jet.

HEXION Specialty Chemicals

Safety Data Sheet

Trade name :

- **Special hazards caused by the material, its products of combustion or resulting gases:**
  Can be released in case of fire
  Carbon monoxide (CO)
  Under certain fire conditions, traces of other toxic gases cannot be excluded, e.g.:
  Hydrogen chloride (HCl)
- **Protective equipment:**
  Wear full protective suit
  Wear self-contained breathing apparatus.
- **Additional information:**
  Collect contaminated fire fighting water separately. It must not enter Drains.
  Dispose of fire debris and contaminated fire fighting water in accordance with official regulations.

6 Accidental release measures

- **Person-related safety precautions:**
  Wear protective equipment. Keep unprotected persons away.
- **Measures for environmental protection:**
  Do not allow product to reach sewage system or water bodies.
  Do not allow to enter the ground/soil.
- **Measures for cleaning/collecting:**
  Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).
  Dispose of contaminated material as waste according to item 13.

7 Handling and storage

- **Handling**
- **Information for safe handling:**
  Ensure good ventilation/exhaustion at the workplace.
- **Information about protection against explosions and fires:**
  No special measures required.
- **Storage**
- **Requirements to be met by storerooms and containers:**
  Prevent any penetration into the ground.
- **Information about storage in one common storage facility:** Not required
- **Further information about storage conditions:**
  Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

- **Additional information about design of technical systems:**
  No further data : see item 7.
- **Personal protective equipment**
- **General protective and hygienic measures**
  Take off immediately all contaminated clothing
  Wash hands during breaks and at the end of the work.
  Avoid contact with the eyes and skins.
- **Breathing equipment:** Not necessary if room is well-ventilated.
- **Protection of hands:**
  Plastic gloves
- **Material of gloves**
  Butyl rubber, BR
  Nitrile rubber, NBR
  Penetration time of glove material
  The exact break trough time has to be found out by the manufacturer of the protective gloves and has to be observed.
- **Eye protection:** Tightly sealed safety glasses.
- **Body protection:** Protective work clothing.

HEXION™ Specialty Chemicals

Safety Data Sheet

Trade name

9 Physical and chemical properties:

- **General information**
  - **Form:** Fluid
  - **Color:** Light yellow
  - **Odor:** Weak, characteristic
- **Change in condition**
  - **Boiling point/Boiling range:** > 200 °C (DIN 53171)
- **Flash point:** > 250 °C (ISO 2719)
- **Ignition temperature:** 460 °C (DIN 51794)
- **Decomposition temperature:** > 200 °C (DIN 53171)
- **Vapour pressure at 20 °C** < 0.1 hPa
- **Density at 25 °C :** 1.17±0.01 g/cm³ (DIN 53217)
- **Solubility in / Miscibility with**
  - **Water:** Not miscible or difficult to mix
- **Viscosity:**
  - **dynamic at 25 °C:** 13000 – 14000 mPa*s (ISO 9371)

10 Stability and reactivity

- **Thermal decomposition / conditions to be avoided:**
  No decomposition if used according to specifications.
- **Dangerous reactions**
  May produce violent reactions with bases and numerous organic substances including alcohols and amine exothermic polymerization
- **Dangerous products of decomposition:** Irritant gases/vapors

11 Toxicological information

- **Acute toxicity:**
- **LD 50 values that are relevant for classification:**

25068-38-6 Bisphenol A-epichlorohydrin resin, mw≤700		
Oral	LD50	11400 mg/kg (rat)
Dermal	LD50	>2000 mg/kg (rabbit)

- **Primary irritant effect:**
- **on the skin:** Irritant to skin and mucous membranes.
- **on the eye :** Irritant effect.
- **Sensitization:** Sensitization possible by skin contact.
- **Additional toxicological information:**
  When used and handled according to specifications, the product does not have any harmful effects according to our experience and the information provided to us.

12 Ecological information:

- **Information about elimination (persistence and degradability):**
- **Other information:** The product is slightly biodegradable.
- **Type of test Effective concentration Method Assessment**

Rainbow trout	LC 50 (96h)	1.5 – 7.7 mg/l
Daphnia magna	EC 50 (24h)	1.1 – 3.6 mg/l
Green algae	EC 50 (96h)	220 mg/l

(bisphenol-A-epichlorohydrin resin MG≤700)

- **General notes:**
  Do not allow product to reach underground or surface water or sewage system.

13 Disposal considerations

- **Product:**
- **Recommendation**
  Remove according to local authority recommendations, e.g. convey to a suitable incinerator.

HEXION™ Specialty Chemicals

Safety Data Sheet

Trade name :

- **European waste catalogue**
  The waste code classification is to be carried out according to the european Waste Catalogue (EWC) specifically for each branch of industry and each type of process.
- **Uncleaned packagings:**
- **Recommendation:** Disposal must be made according to official regulations

14 Transport information

- **Land transport ADR/RID (cross-border)**
- **ADR/RID Class:** 9 Miscellaneous dangerous substances and articles.
- **Hazard Index Number:** 90
- **Substance Index Number:** 3082
- **Packaging group:** III
- **Label:** 9
- **Designation of goods:** 3082 ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (Epoxide derivatives)
- **Maritime transport IMDG:**
- **IMDG Class:** 9
- **UN Number:** 3082
- **Label** 9 + MP
- **Packaging group:** III
- **Marine pollutant:** yes
- **Correct technical name:** ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (Epoxide derivatives)
- **Air transport ICAO-TI and IATA-DGR:**
- **ICAO/IATA Class:** 9
- **UN/ID Number:** 3082
- **Label** 9
- **Packaging group:** III
- **Correct technical name:** ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (Epoxide derivatives)

15 Regulatory information

- **Designation according to EC guidelines:**
  The product has been classified and labeled in accordance with EC Directives / Ordinance on Hazardous Materials (GefStoffV)
  Symbol N:
  Recommendation of "Association of plastics Manufacturers in Europe (APEM) – Epoxy Resin Committee
- **Code letter and hazard designation of product:**
  Xi Irritant
  N Dangerous for the environment
- **Risk phrases:**
  R 36/38 Irritating to eyes and skin.
  R 43 May cause sensitization by skin contact.
  R 51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
- **Safety phrases**
  28 After contact with skin, wash immediately with plenty of soap and water
  37/39 Wear suitable protective clothing, gloves and eye/face protection.
  61 Avoid release to the environment. Refer to special instructions/ safety data sheets.

HEXION™ Specialty Chemicals

Safety Data Sheet

Trade name :

· **Special designation of certain preparations:**
Contain epoxy constituents. See information supplied by the manufacturer.

16 Other information

This data is based on our present knowledge. However, it shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· **Contact:**
Mr. Allen Park(Technical Team) Tel.:82-52-231-5173

SAFETY DATA SHEET
according to applicable EC directive

HUNTSMAN

Ident-No.:

Version *1*
Revision Date 05.02.2004

Print Date 03.03.2004

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product information

Trade name :

Use : Hardener for coating systems

Company : Huntsman Advanced Materials
(Hong Kong) Ltd
Suite 2303-2306
Tower 1, The Gateway
No. 25 Canton Road
Kowloon, Hong Kong

Telephone : +85221488800
Telefax : +85224871428
Emergency telephone number : (852) 9681 0383 (Local)/ +41 61 966 40 00 (Global)

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical nature

Polyaminoamide
substance

Hazardous components

Chemical Name	CAS-No.	Symbol(s):	R-phrase(s)	Concentration [%]
triethylenetetramine EC-No.: 203-950-6	112-24-3	C	R21 R34 R43 R52/53	= 10.00
polyaminoamide adduct (R41)		Xi	R41	> 90.00

3. HAZARDS IDENTIFICATION

Irritating to skin.
Risk of serious damage to eyes.
May cause sensitization by skin contact.

4. FIRST AID MEASURES

Inhalation : Move to fresh air.
If symptoms persist, call a physician.

Eye contact : Rinse immediately with plenty of water for at least 15 minutes.
Call a physician immediately.

Skin contact : Wash off immediately with soap and plenty of water removing all contaminated clothes and shoes.
If skin irritation persists, call a physician.

Ingestion : Immediately give plenty of water (if possible charcoal slurry).
If a person vomits when lying on his back, place him in the recovery position.

Oxygen or artificial respiration if needed.
Do not induce vomiting.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	:	Water spray. Carbon dioxide (CO_2). Foam. Dry powder.
Extinguishing media which must not be used for safety reasons	:	High volume water jet.
Special protective equipment for fire-fighters	:	Wear self-contained breathing apparatus and protective suit.
Further information	:	Burning produces obnoxious and toxic fumes. Carbon oxides. Nitrogen oxides.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	:	Keep away from sources of ignition - No smoking. Avoid contact with skin, eyes and clothing. Do not breathe vapours/dust.
Environmental precautions	:	Prevent product from entering drains. Do not contaminate surface water. Avoid subsoil penetration.
Methods for cleaning up	:	Soak up with inert absorbent material and dispose of as hazardous waste.

7. HANDLING AND STORAGE

Handling

Advice on safe handling	:	sensitizing Avoid formation of aerosol. Ensure adequate ventilation. Handle and open container with care. Keep away from sources of ignition - No smoking.

Storage

Further information on storage conditions	:	Keep away from food, drink and animal feeding stuffs. Keep container tightly closed. Keep at temperatures between 2 and 40°C.
Storage hazard class Huntsman Advanced	:	Storage class 12, Liquids, not dangerous

SAFETY DATA SHEET
according to applicable EC directive

HUNTSMAN

Ident-No:

Version *1*
Revision Date 05.02.2004

Print Date 03.03.2004

Materials

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Control parameters	Update	Basis
triethylenetetramine	112-24-3			

Engineering measures

No special precautions required.

Personal protective equipment

Respiratory protection	:	In case of insufficient ventilation wear suitable respiratory equipment.
Eye protection	:	Tightly fitting safety goggles. Face-shield.
Hand protection	:	rubber or plastic gloves
Skin and body protection	:	Protective suit. Safety shoes.
Protective measures	:	Do not breathe vapours/dust. Keep away from sources of ignition - No smoking. Avoid contact with skin, eyes and clothing.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	:	liquid
Colour	:	brown
Odour	:	amine-like
pH	:	11 at (20 °C) 1:1 in water
Boiling point	:	> 200 °C
Thermal decomposition	:	> 250 °C
Flash point	:	> 200 °C Method: DIN 51758 (Pensky-Martens Closed Cup)
Vapour pressure	:	< 10 Pa at 20 °C
Density	:	0.96 g/cm3 at 20 °C Method: DIN 51757

Water solubility	:	at 20 °C Note: practically insoluble
Miscibility with water	:	immiscible
Viscosity, dynamic	:	300 - 600 mPa.s at 75 °C

10. STABILITY AND REACTIVITY

Conditions to avoid	:	Note: Take necessary action to avoid static electricity discharge.
Materials to avoid	:	Strong acids and strong bases. Strong oxidizing agents.
Hazardous decomposition products	:	Carbon oxides. Nitrogen oxides. Burning produces obnoxious and toxic fumes.

11. TOXICOLOGICAL INFORMATION

Acute oral toxicity	:	LD50 rat Dose: > 2,000 mg/kg
Eye irritation	:	Risk of serious damage to eyes. rabbit
Skin irritation	:	irritating rabbit dermal
Sensitization	:	Causes sensitization. guinea pig dermal

12. ECOLOGICAL INFORMATION

Ecotoxicity effects

Further information on ecology

Additional ecological information	:	Avoid subsoil penetration. Prevent product from entering drains. Do not contaminate surface water.

13. DISPOSAL CONSIDERATIONS

Product	:	Must be incinerated, when in compliance with local regulations.

Container	:	Empty containers can be landfilled after cleaning, when in compliance with the Environmental Protection (Duty of Care) Regulations 1991.
Contaminated packaging	:	Waste Key Number: 305055

14. TRANSPORT INFORMATION

Land transport

ADR:

Regulation: Not dangerous goods

RID:

Regulation: Not dangerous goods

Sea transport

IMDG:

Regulation: Not dangerous goods

Air transport

IATA-DGR:

Regulation: Not dangerous goods

15. REGULATORY INFORMATION

Labelling according to EEC Directive

Labelling required

Symbol(s):	:	Xi	Irritant
R-phrase(s)	:	R38	Irritating to skin.
		R41	Risk of serious damage to eyes.
		R43	May cause sensitization by skin contact.
S-phrase(s)	:	S24	Avoid contact with skin.
		S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
		S37/39	Wear suitable gloves and eye/face protection.
Hazardous components which must be listed on the	:	triethylenetetramine EC-No.: 203-950-6	

label

polyaminoamide adduct (R41)

National legislation

Water contaminating class : 2 water endangering
Classified according to annex 4 of the German VwVwS for preparations.

Notification status

: CH_BAGT Notification number: 617384

: CH_GIFTKL Notification number: 4

: TSCA no

: AICS yes

: INV (CN) yes

: KECI (KR) yes

16. OTHER INFORMATION

List of R-phrases (Section 2)

R21	Harmful in contact with skin.
R34	Causes burns.
R41	Risk of serious damage to eyes.
R43	May cause sensitization by skin contact.
R52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

All information is based on results gained from experience and tests and is believed to be accurate but is given without acceptance of liability for loss or damage attributable to reliance thereon as conditions of use lie outside our control. Users should always carry out sufficient tests to establish the suitability of any products for their intended applications. No statements shall be incorporated in any contract unless expressly agreed in writing nor construed as recommending the use of any product in conflict of any patent. All goods are supplied subject to Huntsman Advanced Materials General Conditions of Sale.

ประวัติผู้เขียนวิทยานิพนธ์

นางสาวอลิสา เชาว์ไวพจน์

เกิดเมื่อวันที่ 19 กุมภาพันธ์ 2522 ที่จังหวัดกาญจนบุรี

การศึกษา

พ.ศ. 2540-2543 วทบ. (เคมี) คณะวิทยาศาสตร์ มหาวิทยาลัยศิลปากร วิทยาเขตพระราชวังสนามจันทร์

พ.ศ. 2543 ฝึกงานที่แผนกควบคุมคุณภาพ บริษัท Thai Fermentation Industry Co., Ltd. มีนาคม - พฤษภาคม

พ.ศ. 2551-2552 ศึกษาต่อระดับปริญญามหาบัณฑิต ภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ทุนสนับสนุนการวิจัย

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