



Standard Test Methods for Rubber—Evaluation of IR (Isoprene Rubber)¹

This standard is issued under the fixed designation D 3403; 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.

1. Scope

1.1 These test methods specify the standard materials, test formula, mixing procedures, and test methods for the evaluation and production control of isoprene rubber (IR).

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

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.*

2. Referenced Documents

2.1 ASTM Standards:

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension²
- D 1646 Test Methods for Rubber—Viscosity, Stress Relaxation, and Pre-Vulcanization Characteristics (Mooney Viscometer)²
- D 2084 Test Method for Rubber Property—Vulcanization Using Oscillating Disk Cure Meter²
- D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets²
- D 3896 Practice for Rubber from Synthetic Sources—Sampling²
- D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries²
- E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method³

3. Significance and Use

3.1 These tests are mainly intended for referee purposes but may be used for quality control of rubber production. They may also be used in research and development work and for comparison of different rubber samples in a standard formula.

3.2 These tests may also be used to obtain values for customer acceptance of rubber.

4. Standard Test Formula

4.1 Standard Formula:

Material	Standard Testing Materials	NIST SRM No.	Quantity, Parts by Mass
Isoprene rubber (IR)	100.00
Zinc oxide ^A	...	370	5.00
Sulfur ^B	SRM371	371	2.25
Stearic acid ^B	SRM372	372	2.00
Oil furnace black ^C	IRB	378	35.00
TBBS ^{B,D}	RM8384	384	0.70
Total			144.95
Batch factor for mill mix ^E			3.00
Batch factor for internal mixer ^E			10.00
Batch factor for MIM mix ^F (Cam Head)			0.50
Batch factor for MIM mix ^F (Banbury Head)			0.43

^A An IRM is being prepared and will be included in these test methods at the December 1993 meeting.

^B Available from NIST.

^C The current Industry Reference Black (IRB) shall be used.

^D *N-tert-butyl-2-benzothiazolesulfenamide*.

^E For mill and internal mixer batches, weigh the rubber, carbon black and oil to the nearest 1.0 g, the sulfur and accelerator to the nearest 0.02 g, and the other compounding materials to the nearest 0.1 g.

^F For MIM batches, weigh the rubber and carbon black to the nearest 0.1 g, the compounding material blend to the nearest 0.01 g, and the individual compounding materials, if used, to the nearest 0.001 g.

For the MIM procedure, it is recommended that a blend of compounding materials, excluding carbon black, be prepared to improve accuracy in the weighing of these materials. The compounding material blend is prepared by blending a proportional mass of each material in a bioconical or vee blender. A mortar and pestle may be used for blending small quantities.

5. Sample Preparation

5.1 Obtain and prepare the test samples in accordance with Practice D 3896.

6. Mixing Procedures

6.1 The compound may be prepared in an internal mixer, on a mill, or in a miniature internal mixer. It is not implied that comparable results will be obtained. The following mixing procedures are provided:

6.1.1 *Method A—Internal Mixer for Initial and Final Mix—(6.2),*

6.1.2 *Method B—Initial Internal Mix with Final Mill Mix—(6.3),*

¹ These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and are the direct responsibility of Subcommittee D11.23 on Synthetic Rubber.

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² *Annual Book of ASTM Standards*, Vol. 09.01.

³ *Annual Book of ASTM Standards*, Vol. 14.02.

6.1.3 Method C—Mill Mix, (6.4), and

6.1.4 Method D—Miniature Internal Mix (6.5).

6.2 Method A—Internal Mixer for Initial and Final Mix:

6.2.1 For general mixing procedures refer to Practice D 3182.

6.2.2 Mixing Cycle for Initial Mix:

6.2.2.1

Adjust the internal mixer temperature to achieve the discharge conditions outlined in 6.2.2.5. Close the discharge gate, start the rotor, and raise the ram.

6.2.2.2

Charge ½ of the rubber, all the zinc oxide, carbon black, stearic acid, and then the other ½ of the rubber. Lower the ram.

6.2.2.3

Allow the batch to mix.

6.2.2.4

Raise the ram and clean the mixer throat and the top of the ram. Lower the ram.

6.2.2.5

Allow the batch to mix until a temperature of 170°C (338°F) or a total mixing time of 6 min is reached, whichever occurs first. Discharge the batch.

6.2.2.6 Determine and record the batch mass. If the mass differs by more than $\pm 5\%$ of the theoretical mass, discard the batch.

6.2.2.7

Pass the batch immediately through the standard laboratory mill three times, set at 6.0 mm (0.25 in.) and 70 \pm 5°C (158 \pm 9°F).

6.2.2.8 Rest the stock for 1 to 24 h.

6.2.3 Mixing Cycle for Final Mix:

6.2.3.1

Cool the internal mixer with full cooling water on the rotor to 40 \pm 5°C (104 \pm 9°F), start the rotor, raise the ram.

6.2.3.2

Leave the cooling water on and the steam off, charge ½ of the masterbatch, with all the sulfur and accelerator rolled into this portion of the masterbatch before feeding to the mixer. Add the remaining portion of the masterbatch. Lower the ram.

6.2.3.3

Allow the batch to mix until a temperature of 110 \pm 5°C (230 \pm 9°F) or a total mixing time of 3 min is reached, whichever occurs first. Discharge the batch.

6.2.3.4 Determine and record the batch mass. If the mass differs by more than $\pm 5\%$ of the theoretical mass discard the batch.

6.2.3.5

With the mill roll temperature set at 70 \pm 5°C (158 \pm 9°F) and opening at 0.3 mm (0.032 in.); pass the rolled batch endwise through the mill six times.

6.2.3.6

Open the mill to give a minimum thickness of 6 mm (0.25 in.) and pass the stock through the mill four times, folding it back on itself each time.

6.2.3.7 From this batch cut enough sample to allow testing of compound viscosity in accordance with Test Method D 1646 or curing characteristics in accordance with Test Method D 2084, or both, if these are desired. Condition the specimen for 1 to 24 h at 23 \pm 3°C (73.4 \pm 5.4°F) before testing.

6.2.3.8 If tensile stress is required, sheet off the compound from the mill at a setting to give a finished gage of approximately 2.2 mm (0.085 in.) by passing the folded stock between the rolls set at 50 \pm 5°C (122 \pm 9°F) four times always in the same direction to obtain the effects of mill direction. Cool on a flat, dry metal surface.

6.2.3.9 For routine laboratory testing, condition the sheeted compound for 1 to 24 h at 23 \pm 3°C (73.4 \pm 5.4°F) and a relative humidity not greater than 55 %. For maximum precision, condition for 1 to 24 h in a closed container to prevent absorption of moisture from the air or in an area controlled at 35 \pm 5 % relative humidity.

6.3 Method B—Initial Internal Mix with Final Mill Mix:

6.3.1 For general mixing procedures, refer to Practice D 3182.

6.3.2 Mixing Cycle for Initial Mix—Follow the procedure outlined in 6.2.2.

6.3.3 Mixing Cycle for Final Mix:

6.3.3.1

With the temperature set at 70 \pm 5°C (158 \pm 9°F) and the opening at 1.90 mm (0.075 in.), band the masterbatch on the slow roll.

6.3.3.2

Add the accelerator, taking care to avoid any loss. Sweep the mill pan and add until all the pigment is in the batch. Make three ¼ cuts from each side.

6.3.3.3

Duration, min	Accumulative, min
2.5 max	3.0 max

Duration, min	Accumulative, min
2.0	5.0

Duration, min	Accumulative, min
1.0	6.0

Duration, min	Accumulative, min
0	0

Duration, min	Accumulative, min
3.0	3.0

Duration, min	Accumulative, min
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Add the sulfur and that which falls into the mill pan. Make one $\frac{3}{4}$ cut from each side.

3.0

6.0

6.3.3.4

Cut the batch from the mill and set the mill roll opening at 0.8 mm (0.032 in.). Pass the rolled stock endwise through the mill six times.

Duration,
min
2.0

Accumulative,
min
8.0

6.3.3.5

Open the mill to give a minimum batch thickness of 6 mm (0.25 in.) and pass the batch through the rolls four times, folding it back on itself each time.

Duration,
min
1.0

Accumulative,
min
9.0

6.3.3.6 Determine and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.3.3.7 From this batch, cut enough sample to allow testing of compound viscosity in accordance with Test Method D 1646 or curing characteristics in accordance with Test Method D 2084, or both, if these are desired. Condition the specimen for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) before testing.

6.3.3.8 If tensile stress is required, sheet off the compound from the mill at a setting to give a finished gage of approximately 2.2 mm (0.085 in.) by passing the folded stock between the rolls set at $50 \pm 5^\circ\text{C}$ ($122 \pm 9^\circ\text{F}$) four times always in the same direction to obtain the effects of mill direction. Cool on a flat, dry metal surface.

6.3.3.9 For routine laboratory testing, condition the sheeted compound for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) and a relative humidity not greater than 55 %. For maximum precision, condition for 1 to 24 h in a closed container to prevent absorption of moisture from the air or in an area controlled at $35 \pm 5\%$ relative humidity.

6.4 Method C—Mill Mix:

6.4.1 For general mixing procedures, refer to Practice D 3182.

6.4.2 Mixing Cycle:

6.4.2.1

With the mill roll temperature set at $70 \pm 5^\circ\text{C}$ ($158 \pm 9^\circ\text{F}$) and the opening at 0.20 mm (0.008 in.), pass the rubber through the rolls twice without banding.

Duration,
min
1

Accumulative,
min
1

6.4.2.2

Band the rubber on the slow roll with the mill opening at 1.40 mm (0.55 in.). Make two $\frac{3}{4}$ cuts from each side.

Duration,
min
2

Accumulative,
min
3

6.4.2.3

Set the mill opening at 1.70 mm (0.067 in.), add the zinc oxide. Make one $\frac{3}{4}$ cut from each side.

Duration,
min
2

Accumulative,
min
5

6.4.2.4

Duration,
min

Accumulative,
min

Add the carbon black evenly across the mill at a uniform rate. When about half the black is incorporated, add the stearic acid and open the mill to 1.90 mm (0.075 in.). Make one $\frac{3}{4}$ cut from each side, then add the remainder of the carbon black.

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NOTE 1—Do not cut any stock while free carbon black is evident in the bank or on the milling surface. Be certain to return any materials that drop through the mill to the milling stock.

6.4.2.5

Add the accelerator, taking care to avoid any loss. Sweep the mill pan and add until all the pigment is in the batch. Make three $\frac{3}{4}$ cuts from each side.

Duration,
min
3

Accumulative,
min
22

6.4.2.6

Add the sulfur and that which falls into the mill pan. Make one $\frac{3}{4}$ cut from each side.

Duration,
min
3

Accumulative,
min
25

6.4.2.7

Cut the stock from the mill. Set the opening at 0.80 mm (0.032 in.) and pass the rolled stock endwise through the mill six times.

Duration,
min
2

Accumulative,
min
27

6.4.2.8

Open the mill to give a minimum stock thickness of 6 mm (0.25 in.) and pass the stock through the rolls four times, folding it back on itself each time.

Duration,
min
1

Accumulative,
min
28

6.4.2.9 Determine and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.4.2.10 From this stock, cut enough sample to allow testing of compound viscosity in accordance with Test Method D 1646, or curing characteristics in accordance with Test Method D 2084, or both, if these are desired. Condition the specimen for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) before testing.

6.4.2.11 If tensile stress is required, sheet off the compound from the mill at a setting to give a finished gage of approximately 2.2 mm (0.085 in.) by passing the folded stock between the rolls set at $50 \pm 5^\circ\text{C}$ ($122 \pm 9^\circ\text{F}$) four times always in the same direction to obtain the effects of mill direction. Cool on a flat, dry metal surface.

6.4.2.12 For routine laboratory testing, condition the sheeted compound for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) and a relative humidity not greater than 55 %. For maximum precision, condition for 1 to 24 h in a closed container to prevent absorption of moisture from the air or in an area controlled at $35 \pm 5\%$ relative humidity.

6.5 Method D—Miniature Internal Mix:

6.5.1 For general mixing procedures refer to Practice D 3182. Mix with the head temperature of the miniature internal mixer maintained at $60 \pm 3^\circ\text{C}$ ($140 \pm 5^\circ\text{F}$) and the unloaded rotor speed set at 6.3 to 6.6 rad/s (60 to 63 rpm).

6.5.2 Prepare the rubber by passing it through a mill one time with the temperature set at $70 \pm 5^\circ\text{C}$ ($158 \pm 9^\circ\text{F}$) and an

opening that will give a sheet approximately 0.5 mm (0.02 in.) thick. Cut the sheet into strips that are approximately 25 mm (1 in.) wide, if desired.

6.5.3 Mixing Cycle:

6.5.3.1

	Duration, min	Accumulative, min
Charge the mixing chamber with the rubber strips, lower the ram and start the timer.	0.0	0.0

6.5.3.2

	Duration, min	Accumulative, min
Masticate the rubber.	0.5	0.5

6.5.3.3

	Duration, min	Accumulative, min
Raise the ram and add the zinc oxide, sulfur, stearic acid, and TBBS that have previously been blended, taking care to avoid any loss.	1.0	1.5

6.5.3.4

	Duration, min	Accumulative, min
Add the carbon black, sweep the orifice, and lower the ram.	1.0	2.5

6.5.3.5

	Duration, min	Accumulative, min
Allow the batch to mix, raising the ram momentarily to sweep down, if necessary.	6.5	9.0

6.5.3.6 Turn off the motor, raise the ram, remove the mixing chamber, and discharge the batch. Record the maximum batch temperature indicated, if desired.

6.5.3.7 Pass the batch through a mill at $70 \pm 5^\circ\text{C}$ ($158 \pm 9^\circ\text{F}$) and 0.5 mm (0.020 in.) opening once, then twice at 3 mm (0.12 in.) opening.

6.5.3.8 Determine and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.5.3.9 Cut a specimen for testing vulcanization characteristics in accordance with Test Method D 2084, if required. Condition the specimens for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) before testing.

6.5.3.10 If either compound viscosity or stress-strain testing is required, pass the rolled stock endwise through the mill six times with the mill temperature at $70 \pm 5^\circ\text{C}$ ($158 \pm 9^\circ\text{F}$) and a roll separation of 0.8 mm (0.032 in.).

6.5.3.11 Cut a specimen to allow testing of compound viscosity in accordance with Test Method D 1646, if required.

6.5.3.12 If tensile stress is required, sheet off the compound from the mill at a setting to give a finished gage of approximately 2.2 mm (0.085 in.) by passing the folded compound between the mill rolls set at $70 \pm 5^\circ\text{C}$ ($158 \pm 9^\circ\text{F}$) four times always in the same direction to obtain the effects of mill direction. Cool on a flat, dry metal surface.

6.5.3.13 For routine laboratory testing, condition the sheeted compound for 1 to 24 h at $23 \pm 3^\circ\text{C}$ ($73.4 \pm 5.4^\circ\text{F}$) and a relative humidity not greater than 55 %. For maximum precision, condition for 1 to 24 h in a closed container to prevent absorption of moisture from the air or in an area controlled at 35 ± 5 % relative humidity.

7. Testing Procedures

7.1 Cure Meter Measurements of Vulcanization Characteristics:

7.1.1 Test shall be in accordance with Test Method D 2084.

7.1.2 The recommended standard test conditions are:

7.1.2.1 Oscillation frequency of 1.7 Hz (100 cpm),

7.1.2.2 Oscillation amplitude of 1 ± 0.03 degrees,

7.1.2.3 A die temperature of either $150 \pm 0.3^\circ\text{C}$ ($302 \pm 0.5^\circ\text{F}$) or $160 \pm 0.3^\circ\text{C}$ ($320 \pm 0.5^\circ\text{F}$), and

7.1.2.4 No preheat of the sample.

7.1.3 The recommended standard test parameters are ML, MH, ts1, t'50, and t'90.

7.2 Stress-strain Measurements of Vulcanization Characteristics:

7.2.1 Test sheets shall be prepared and vulcanized in accordance with Practice D 3182.

7.2.1.1 The recommended standard vulcanization times are 20, 30, 40, and 60 min at 135°C (275°F) with the 40 min cure preferred when only one curing time is used.

7.2.1.2 Condition the cured sheets for 16 to 96 h at a temperature of $23 \pm 3^\circ\text{C}$ before running the stress-strain tests.

NOTE 2—Quality control of production may require testing within 1 to 6 h to provide close surveillance of the plant operation, however, slightly different results may be obtained.

7.2.2 Prepare test specimens and obtain tensile stress, tension, and elongation in accordance with Test Method D 412.

8. Precision and Bias

8.1 This precision and bias section has been prepared in accordance with Practices D 4483 and E 691. Refer to these practices for terminology and other statistical details.

8.2 The results in this precision and bias section give an estimate of the precision of the test method with the materials (isoprene rubber) used in the particular interlaboratory program as described below. The precision parameters should not be used for acceptance/rejection testing 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.

8.3 A Class III, Type 2 interlaboratory precision program was conducted. 6 laboratories participated and 2 materials were used. A test result is the value obtained from 1 determination. Testing was repeated 2 times separated by 1 week. Therefore, $p = \underline{6}$, $q = \underline{2}$, and $n = \underline{2}$. Samples of 2 types of IR were distributed to the participating laboratories. Other materials required by the D 3403 recipe were provided by the participating laboratories. The following tests were run on the mixed samples:

Table 1	Mooney Viscosity testing ML_{4+1} @ 100°C
Table 2	Stress/Strain testing- cure 35 min @ 145°C , report 100 % modulus, 300 % modulus, tensile @ break, Elongation @ break.
Table 3	Cure meter testing-ODR type, 160°C 1°arc , 1.7 Hz
Table 4	Cure meter testing-MDR type, 160°C , 0.5°arc , 1.7Hz

8.4 The precision of this method may be expressed in the format of the following statements that use what is called an "appropriate value" of 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 Tables 1-4 closest to the mean level under

TABLE 1 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)

PROPERTY>		UNITS> MOONEY UNITS					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	50.1	2.4	6.9	13.7	2.4	6.9	13.7
A	51.3	1.9	5.4	10.5	3.3	9.3	18.0
*POOL/AVE	50.7	2.2	6.2	12.2	2.9	8.2	16.1

s= repeatability standard deviation in measurement units
r= repeatability ($2.83 \times s$)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility ($2.83 \times S$)
(R)= reproducibility in percent of the mean

TABLE 2 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)

PROPERTY>		UNITS> mPa					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	2.03	0.10	0.27	13.42	0.31	0.88	43.60
A	2.11	0.11	0.32	15.04	0.31	0.87	41.08
*POOL/AVE	2.07	0.10	0.30	14.28	0.31	0.87	42.31

PROPERTY>		UNITS> mPa					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	8.94	0.43	1.21	13.58	0.82	2.31	25.83
A	9.22	0.46	1.30	14.09	0.84	2.38	25.81
*POOL/AVE	9.08	0.44	1.26	13.85	0.83	2.34	25.83

PROPERTY>		UNITS> mPa					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	28.22	1.26	3.58	12.68	1.26	3.58	12.68
A	28.28	1.85	5.23	18.49	1.93	5.46	19.33
*POOL/AVE	28.25	1.58	4.48	15.86	1.63	4.62	16.35

PROPERTY>		UNITS> %					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
A	576.00	15.02	42.50	7.38	23.69	67.03	11.64
B	582.75	17.12	48.44	8.31	21.09	59.69	10.24
*POOL/AVE	579.38	16.10	45.56	7.86	22.43	63.47	10.95

s= repeatability standard deviation in measurement units
r= repeatability ($2.83 \times s$)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility ($2.83 \times S$)
(R)= reproducibility in percent of the mean

consideration at any given time, for any given material in routine testing operations.

8.5 Repeatability—The repeatability, r, of this test method has been established as the appropriate value tabulated in

TABLE 3 ASTM D 3403 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)
OSCILLATING DISK CURE METER

PROPERTY>		UNITS> dNm					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
A	5.58	0.17	0.47	8.47	0.49	1.40	25.05
B	6.05	0.14	0.39	6.46	0.33	0.94	15.58
*POOL/AVE	5.96	0.15	0.43	7.27	0.42	1.19	20.00

PROPERTY>		UNITS> dNm					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	36.40	0.92	2.59	7.11	2.19	6.19	17.00
A	38.70	0.69	1.94	5.02	2.00	5.67	14.65
*POOL/AVE	37.55	0.81	2.29	6.10	2.10	5.93	15.80

PROPERTY>		UNITS> MINUTES					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
B	3.93	0.13	0.37	9.36	0.35	0.99	25.28
A	4.23	0.16	0.46	10.97	0.28	0.78	18.53
*POOL/AVE	4.08	0.15	0.42	10.26	0.32	0.89	21.93

PROPERTY>		UNITS> MINUTES					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
A	6.35	0.23	0.66	10.43	0.26	0.73	11.45
B	6.58	0.18	0.51	7.70	0.31	0.86	13.12
*POOL/AVE	6.46	0.21	0.59	9.13	0.28	0.80	12.35

PROPERTY>		UNITS> MINUTES					
MATERIAL	MEAN VALUE	WITHIN LAB			BETWEEN LABS		
		s	r	(r)	S	R	(R)
A	8.49	0.39	1.09	12.87	0.40	1.13	13.33
B	8.82	0.25	0.70	7.99	0.38	1.08	12.19
*POOL/AVE	8.66	0.32	0.92	10.61	0.39	1.10	12.75

s= repeatability standard deviation in measurement units
r= repeatability ($2.83 \times s$)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility ($2.83 \times S$)
(R)= reproducibility in percent of the mean

Tables 1-4. 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 nonidentical sample populations.

8.6 Reproducibility—The reproducibility, R, of this test method has been established as the appropriate value tabulated in Tables 1-4. 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 nonidentical sample populations

8.7 Repeatability and reproducibility, expressed as a percentage of the mean level, (r) and (R), have equivalent application statements as above for r and R. For the (r) and (R)

TABLE 4 ASTM D 3403 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)
MOVING DIE CURE METER

PROPERTY>	ML	UNITS> dNm					
		WITHIN LAB			BETWEEN LABS		
MATERIAL	MEAN VALUE	s	r	(r)	S	R	(R)
A	1.68	0.18	0.51	30.41	0.26	0.72	43.08
B	1.73	0.18	0.50	29.20	0.19	0.53	31.01
*POOL/AVE	1.70	0.18	0.51	29.80	0.22	0.64	37.36

PROPERTY>	MH	UNITS> dNm					
		WITHIN LAB			BETWEEN LABS		
MATERIAL	MEAN VALUE	s	r	(r)	S	R	(R)
B	14.79	0.26	0.74	5.03	0.66	1.88	12.69
A	16.39	0.07	0.20	1.23	0.67	1.89	11.55
*POOL/AVE	15.59	0.19	0.55	3.50	0.67	1.88	12.09

PROPERTY>	ts1	UNITS> MINUTES					
		WITHIN LAB			BETWEEN LABS		
MATERIAL	MEAN VALUE	s	r	(r)	S	R	(R)
B	3.15	0.08	0.24	7.55	0.18	0.51	16.08
A	3.41	0.13	0.37	10.79	0.14	0.39	11.45
*POOL/AVE	3.28	0.11	0.31	9.44	0.16	0.45	13.79

PROPERTY>	t'50	UNITS> MINUTES					
		WITHIN LAB			BETWEEN LABS		
MATERIAL	MEAN VALUE	s	r	(r)	S	R	(R)
A	4.74	0.17	0.49	10.33	0.20	0.56	11.82
B	4.79	0.10	0.27	5.61	0.17	0.47	9.81
*POOL/AVE	4.77	0.14	0.39	8.29	0.18	0.52	10.85

PROPERTY>	t'90	UNITS> MINUTES					
		WITHIN LAB			BETWEEN LABS		
MATERIAL	MEAN VALUE	s	r	(r)	S	R	(R)
A	7.13	0.11	0.32	4.45	0.39	1.12	15.65
B	7.23	0.19	0.54	7.47	0.31	0.88	12.17
*POOL/AVE	7.18	0.16	0.44	6.17	0.35	1.00	13.99

s= repeatability standard deviation in measurement units

r= repeatability ($2.83 \times s$)

(r)= repeatability in percent of the mean

S= reproducibility standard deviation in measurement units

R= reproducibility ($2.83 \times S$)

(R)= reproducibility in percent of the mean

8.8 *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 the test method. Bias, therefore, cannot be determined.

8.9 *Research report*—Report number D11-1080 with details of this test program is available at ASTM headquarters.

9. Keywords

9.1 evaluation of IR; IR (isoprene rubber); polyisoprene

statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

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