Designation: D3403 – 07 (Reapproved 2016)

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

This standard is issued under the fixed designation D3403; 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 cover 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:*[2]

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D1646 Test Methods for Rubber—Viscosity, Stress Relaxation, and Pre-Vulcanization Characteristics (Mooney Viscometer)

D2084 Test Method for Rubber Property—Vulcanization Using Oscillating Disk Cure Meter

D3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets

D3896 Practice for Rubber From Synthetic Sources—Sampling

D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

D5289 Test Method for Rubber Property—Vulcanization Using Rotorless Cure Meters

D6204 Test Method for Rubber—Measurement of Unvulcanized Rheological Properties Using Rotorless Shear Rheometers

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

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*—See Table 1.

5. Sample Preparation

5.1 Obtain and prepare the test samples in accordance with Practice D3896.

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),

6.1.3 *Method C—Mill Mix,* (6.4), and

6.1.4 *Method D—Miniature Internal Mix* (6.5).

6.2 *Internal Mixer for Initial and Final Mix (Method A):*

6.2.1 For general mixing procedures refer to Practice D3182.

6.2.2 *Mixing Cycle for Internal Mixer Initial Mix (Methods A,B)*—See Table 2.

6.2.2.1 After mixing according to Table 2, measure and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.2.2.2 Pass the batch immediately through the standard laboratory mill three times, with a mill opening of 6.0 mm (0.25 in.) and roll temperature of 40 ± 5°C (104 ± 9°F).

6.2.2.3 Allow the batch to rest for 1 to 24 h.

[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 Rubbers.

Current edition approved June 1, 2016. Published July 2016. Originally approved in 1975. Last previous edition approved in 2011 as D3403 – 07 (2011). DOI: 10.1520/D3403-07R16.

[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.

TABLE 1 Standard IR Test Formula

Material	IRM-SRM No.[A]	Quantity, Parts by Mass
Isoprene rubber (IR)	...	100.00
Zinc oxide	[A]	5.00
Sulfur	[A]	2.25
Stearic acid	[A]	2.00
Oil furnace black[B]	[A]	35.00
TBBS[C]	[A]	0.70
Total		144.95
Batch factor for mill mix[D]		3.00
Batch factor for internal mixer[D]		10.00
Batch factor for MIM mix[E] (Cam Head)		0.50
Batch factor for MIM mix[E] (Banbury Head)		0.43

[A] Use current IRM/SRM.
[B] The current Industry Reference Black (IRB) shall be used.
[C] TBBS is *N-tert*-butyl-2-benzothiazolesulfenamide.
[D] For mill and internal mixer batches, weigh the rubber, carbon black, and oil to the nearest 1.0 g, the sulfur and the TBBS accelerator to the nearest 0.02 g, and the other compounding materials to the nearest 0.1 g.
[E] For MIM mixes, 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 the accuracy of the weighing of these materials. This material blend is prepared by blending a proportional mass of each material in a dry powder blender such as a biconical blender or vee blender. A mortar and pestle may be used for blending small quantities.

TABLE 2 Internal Mixer - Initial Cycle

	Duration, min	Accumulative, min
Adjust the internal mixer temperature to achieve the discharge conditions outlined below. Close the discharge gate, start the rotors at 8.1 rad/s (77 r/min), and raise the ram.	0.0	0.0
Charge one-half of the rubber, all of the zinc oxide, carbon black, stearic acid, and then the other one-half of the rubber. Lower the ram.	0.5	0.5
Allow the batch to mix.	3.0	3.5
Raise the ram, and clean the mixer throat and the top of the ram. Lower the ram.	0.5	4.0
Allow the batch to mix until a temperature of 170°C (338°F) or a total of 6 min is reached, whichever occurs first. Discharge the batch.	2.0	6.0

6.2.3 *Mixing Cycle for Internal Mixer Final Mix (Method A)*—See Table 3.

6.2.3.1 After mixing according to Table 3, measure and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.2.3.2 If required, cut samples from the batch to allow testing of compound viscosity and processability in accordance with Test Methods D1646 or D6204, and vulcanization characteristics in accordance with Test Methods D2084 or D5289.

6.2.3.3 If tensile stress strain tests are required, sheet off to a finished thickness of approximately 2.2 mm (0.087 in.) and condition the compound according to Practice D3182.

6.3 *Internal Mixer Initial Mix with Final Mill Mix (Method B):*

TABLE 3 Internal Mixer - Final Cycle

	Duration, min	Accumulative, min
Adjust the internal mixer temperature to 40 ± 5°C (104 ± 9°F), turn off steam and turn on full cooling water to the rotors, start the rotors at 8.1 rad/s (77 r/min), and raise the ram.	0.0	0.0
Charge one-half of the batch, with all the sulfur and accelerator rolled into this portion of the batch before feeding to the mixer. Add the remaining portion of the batch. Lower the ram.	0.5	0.5
Allow the batch to mix until a temperature of 110 ± 5°C (230 ± 9°F) or a total mixing time of 3 min is reached, whichever occurs first. Discharge the batch.	2.5	3.0
With the rolls of a standard laboratory mill maintained at 40 ± 5°C (104 ± 9°F), and set at 0.8 mm (0.032 in.) opening, pass the rolled batch endwise through the mill six times.	2.0	5.0
Open the rolls to give a minimum thickness of 6 mm (0.25 in.) and pass the compound through four times, folding it back on itself each time.	1.0	6.0

6.3.1 For general mixing procedures, refer to Practice D3182.

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

6.3.3 *Mixing Cycle for Mill Final Mix (Method B)*—See Table 4.

6.3.3.1 After mixing according to Table 4, measure and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.3.3.2 If required, cut samples from the batch to allow testing of compound viscosity and processability in accordance with Test Methods D1646 or D6204, and vulcanization characteristics in accordance with Test Methods D2084 or D5289.

TABLE 4 Mill Final Mixing Cycle

	Duration, min	Accumulative, min
Set the mill opening at 1.90 mm (0.075 in.) and temperature at 70 ± 5°C (158 ± 9°F). Band the masterbatch on the slow roll.	0	0
Add the TBBS accelerator, taking care to avoid any loss. Sweep the mill pan and add until all the accelerator is in the batch. Make three ¾ cuts from each side.	3	3
Add the sulfur and that which falls into the mill pan. Make one ¾ cut from each side.	3	6
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.	2	8
Open the mill to give a minimum stock thickness of 6 mm (0.25 in.) and pass the compound through the mill four times, folding it back on itself each time.	1	9

6.3.3.3 If tensile stress strain tests are required, sheet off to a finished thickness of approximately 2.2 mm (0.087 in.) and condition the compound according to Practice D3182.

6.4 *Mill Mixing (Method C):*

6.4.1 For general mixing procedures, refer to Practice D3182.

6.4.2 *Mill Mixing Cycle*—See Table 5.

6.4.2.1 After mixing according to Table 5, measure and record the batch mass. If it differs from the theoretical value by more than 0.5 %, discard the batch.

6.4.2.2 If required, cut samples from the batch to allow testing of compound viscosity and processability in accordance with Test Methods D1646 or D6204, and vulcanization characteristics in accordance with Test Methods D2084 or D5289.

6.4.2.3 If tensile stress strain tests are required, sheet off to a finished thickness of approximately 2.2 mm (0.087 in.) and condition the compound according to Practice D3182.

6.5 *Miniature Internal Mixer (Method D):*

6.5.1 For general mixing procedures refer to Practice D3182. Mix with the head temperature of the miniature internal mixer maintained at 60 ± 3°C (140 ± 5°F) and the unloaded rotor speed set at 6.3 to 6.6 rad/s (60 to 63 r/min).

6.5.2 Prepare the rubber by passing it through a mill one time with the temperature set at 70 ± 5°C (158 ± 9°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 *MIM Mixing Cycle*—See Table 6.

TABLE 6 Miniature Internal Mixer Cycle

	Duration, min	Accumulative, min
Charge the mixing chamber with the rubber strips, lower the ram, and start the timer.	0.0	0.0
Masticate the masterbatch.	0.5	0.5
Raise the ram, and add the previously blended zinc oxide, sulfur, stearic acid, and TBBS, taking care to avoid any loss.	1.0	1.5
Add the carbon black, sweep the orifice, and lower the ram.	1.0	2.5
Allow the batch to mix, raising the ram momentarily to sweep down, if necessary.	6.5	9.0

6.5.3.1 After mixing according to Table 6, turn off the motor, raise the ram, remove the mixing chamber, and discharge the batch. Record the maximum batch temperature indicated, if desired.

6.5.3.2 Immediately pass the discharge from the mixer twice through a standard mill maintained at 70 ± 5°C (158 ± 9°F) with a roll separation of 0.5 mm (0.020 in.) once, then twice at a separation of 3 mm (0.12 in.) in order to dissipate heat. Pass the rolled batch endwise through the mill six times with an opening of 0.8 mm (0.032 in.) to enhance the dispersion.

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

TABLE 5 Mill Mixing Cycle

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.

	Duration, min	Accumulative, min
With the mill roll temperature set at 70 ± 5°C (158 ± 9°F) and the opening at 0.20 mm (0.008 in.), pass the rubber through the mill twice without banding.	1	1
Set the mill opening at 1.40 mm (0.056 in.) and band the rubber on the slow roll. Make two ¾ cuts from each side.	2	3
Set the mill opening at 1.70 mm (0.067 in.), add the zinc oxide. Make two ¾ cuts from each side.	2	5
Add the carbon black evenly across the mill at a uniform rate. When about half of the black is incorporated, add the stearic acid and open the mill to 1.90 mm (0.075 in.). Make one ¾ cut from each side, then add the remainder of the carbon black.	14	19
Add the TBBS accelerator, taking care to avoid any loss. Sweep the mill pan and add until all the accelerator is in the batch. Make three ¾ cuts from each side.	3	22
Add the sulfur and that which falls into the mill pan. Make one ¾ cut from each side.	3	25
Cut the stock from the mill. Set the opening at 0.8 mm (0.032 in.). Pass the rolled stock endwise through the mill six times.	2	27
Open the mill to give a minimum stock thickness of 6 mm (0.25 in.) and pass the compound through the mill four times, folding it back on itself each time.	1	28

6.5.3.4 If required, cut samples from the batch to allow testing of compound viscosity and processability in accordance with Test Methods D1646 or D6204, and vulcanization characteristics in accordance with Test Methods D2084 or D5289.

6.5.3.5 If tensile stress strain tests are required, sheet off to a finished thickness of approximately 2.2 mm (0.087 in.) and condition the compound according to Practice D3182.

7. Testing Procedures

7.1 *Cure Meter Measurements of Vulcanization Characteristics:*

7.1.1 Measure vulcanization characteristics in accordance with Test Method D2084 (Oscillating Disk Cure Meter Method) or Test Method D5289 (Rotorless Cure Meter Method). These methods will not produce equal results.

7.1.2 The recommended Test Method D2084 test conditions are 1.67 Hz (100 cpm) oscillation frequency, 1° oscillation amplitude, 160°C die temperature, 30-min test time, and no preheating. The recommended Test Method D5289 test conditions are 1.67 Hz (100 cpm) oscillation frequency, 0.5° oscillation amplitude, 160°C die temperature, 30-min test time, and no preheating. Test condition tolerances are specified by the test methods.

7.1.3 The recommended standard test parameters are M_L, M_H, t_{s1}, t'50, and t'90.

7.2 *Stress-Strain Measurements of Vulcanization Characteristics:*

7.2.1 An alternative to measuring vulcanization characteristics using a cure meter is to prepare and cure test sheets for tensile stress-strain testing.

7.2.2 Test sheets shall be prepared and vulcanized in accordance with Practice D3182.

7.2.3 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.

7.2.4 Condition and test tensile specimens for tensile stress, tensile strength, and elongation in accordance with Test Methods D412.

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

8. Precision and Bias[3]

8.1 This precision and bias section has been prepared in accordance with Practices D4483 and E691. 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.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D11-1080.

8.3 A Class III, Type 2 interlaboratory precision program was conducted. Six (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 = 6, q = 2, and n = 2. Samples of 2 types of IR were distributed to the participating laboratories. Other materials required by the D3403 recipe were provided by the participating laboratories. The following tests were run on the mixed samples:

Table 7	Mooney Viscosity testing ML_{4+1} @ 100°C
Table 8	Stress/Strain testing- cure 35 min @ 145°C, report 100 % modulus, 300 % modulus, tensile @ break, Elongation @ break.
Table 9	Cure meter testing-ODR type, 160°C1°arc, 1.7 Hz
Table 10	Cure meter testing-rotorless 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 7-10 closest to the mean level under 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 Tables 7-10. 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 7-10. 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) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

TABLE 7 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)

PROPERTY> ML4+1@100C 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× s)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility (2.83× S)
(R)= reproducibility in percent of the mean

TABLE 8 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)

PROPERTY> 100 % UNITS> mPa

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> 300 % UNITS> mPa

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> tensile at break UNITS> mPa

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> elongation at break UNITS> %

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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× s)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility (2.83× 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.

9. Keywords

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

TABLE 9 ASTM D3403 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)
OSCILLATING DISK CURE METER

PROPERTY> ML UNITS> dNm

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> MH UNITS> dNm

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> ts1 UNITS> MINUTES

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> t'50 UNITS> MINUTES

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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> t'90 UNITS> MINUTES

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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× s)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility (2.83× S)
(R)= reproducibility in percent of the mean

TABLE 10 ASTM D3403 CLASS 3 TYPE 2 PRECISION
(MATERIALS IN INCREASING MEAN VALUE ORDER)
ROTORLESS CURE METER

PROPERTY> ML UNITS> dNm

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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

MATERIAL	MEAN VALUE	WITHIN LAB s	WITHIN LAB r	WITHIN LAB (r)	BETWEEN LABS S	BETWEEN LABS R	BETWEEN LABS (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× s)
(r)= repeatability in percent of the mean
S= reproducibility standard deviation in measurement units
R= reproducibility (2.83× S)
(R)= reproducibility in percent of the mean