



# Standard Test Methods for Rubber—Evaluation of Oil-Extended Solution BR (Polybutadiene Rubber)<sup>1</sup>

This standard is issued under the fixed designation D 3484; 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 formulas, mixing procedures, and test methods for the evaluation and production control of oil-extended polybutadiene rubber (OE-BR) polymerized in an appropriate solution.

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— Tension<sup>2</sup>
- D 1646 Test Methods for Rubber—Viscosity, Stress Relaxation and Pre-Vulcanization Characteristics (Mooney Viscometer)<sup>2</sup>
- D 2084 Test Method for Rubber Property—Vulcanization Using Oscillating Disc Cure Meter<sup>2</sup>
- D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets<sup>2</sup>
- D 3896 Practice for Rubber from Synthetic Sources— Sampling<sup>2</sup>
- D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries<sup>2</sup>

### 2.2 ISO Standard:

- ISO 2476 Rubber, Butadiene (BR) Solution Polymerized Types—Test Recipe and Evaluation Characteristics<sup>3</sup>

<sup>1</sup> 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.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 09.01.

<sup>3</sup> Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

## 3. Significance and Use

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

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

## 4. Standard Test Formulas

### 4.1 Standard Formulas:

Material	NBS SRM No.	Quantity, Parts by Mass	
Formula No.		1	2
OE-BR	—	100.00 + Y <sup>A</sup>	100.00
Zinc oxide	370	3.00	3.00
Sulfur	371	1.50	1.50
Stearic acid	372	2.00	2.00
Oil furnace black <sup>B</sup>	378	60.00 (100 + Y)	60.00
TBBS <sup>C</sup>	384	0.90 (100 + Y)	0.90
Batch factor for mill <sup>D</sup> – Formula 1	4.0 – 0.036 Y		

– Formula 2 4.0

Batch factor for internal mixer<sup>D</sup>

– Formula 1 [1170 (1.020 + 0.00044 Y)/total formula parts]

– Formula 2 7.7

Batch factor:

MIM<sup>E</sup> – Formula 1 70 (1.020 + 0.00044 Y)/total formula parts]

– Formula 2

Cam head 0.44

Banbury head 0.38

<sup>A</sup> Y = parts of oil by mass per 100 parts base polymer in masterbatch.

<sup>B</sup>The current Industry Reference Black may be used in place of NBS 378, although slightly different results may be obtained.

<sup>C</sup>*N-tert-butyl-2-benzothiazolesulfenamide*.

<sup>D</sup>For mill and internal mixer mixes, weigh the rubber and carbon black to the nearest 1.0 g, the sulfur and accelerators to the nearest 0.02 g, and all other compounding materials to the nearest 0.1 g.

<sup>E</sup>For MIM batches, weigh the rubber and carbon black to the nearest 0.1 g, the compound 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 black, be prepared to improve accuracy in 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.

4.2 Formula 1 is written based on 100 parts of rubber while Formula 2 is written on the basis of 100 parts of the masterbatch. Either formula may be used, but these will not give the same results.

NOTE 1—Formula 2 is specified in ISO Standard DIS 2476 for oil extended BR.

**5. Sample Preparation**

5.1 For test intended for referee purposes obtain and prepare the test samples in accordance with Practice D 3896.

**6. Mixing Procedures**

6.1 The following four mixing test methods are offered:

- 6.1.1 *Method A*—Internal Mixer Procedure (6.2),
- 6.1.2 *Method B*—Internal Mixer/Mill Procedure (6.3),
- 6.1.3 *Method C*—Mill Procedure (6.4), and
- 6.1.4 *Method D*—Miniature Internal Mixer Procedure (6.5).

NOTE 2—It is not implied that comparable results will be obtained by these test methods.

NOTE 3—Since the mill handling characteristics of the solution polybutadiene rubbers are somewhat more difficult than that of other rubbers the use of one of the internal mixer procedures is recommended (Method A, B, or D). The mill procedure (Method C) may be used provided a good carbon black dispersion is obtained.

**6.2 Method A—Internal Mixer Procedure:**

6.2.1 For general mixing procedure refer to Method D 3182.

**6.2.2 Mixing Cycle—Initial Mix:**

6.2.2.1

	Duration, min	Accumulative, min
Adjust the internal mixer temperature to achieve the discharge conditions outlined in 6.2.2.5. Close the discharge gate, start the rotor at 8.1 rad/s (77 rpm) and raise the ram.	0	0

6.2.2.2

	Duration, min	Accumulative, min
Charge one half 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

6.2.2.3

	Duration, min	Accumulative, min
Allow the batch to mix.	3.0	3.5

6.2.2.4

	Duration, min	Accumulative, min
Raise the ram and clean the mixer throat and the top of the ram. Lower the ram.	0.5	4.0

6.2.2.5

	Duration, min	Accumulative, min
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.	2.0 max	6.0 max

6.2.2.6 Determine and record the batch mass; if the mass differs by more than 0.5 % of the theoretical mass, discard the batch.

6.2.2.7

	Duration, min	Accumulative, min
Pass the batch immediately through the standard laboratory mill three times, set at 6.0 mm (0.25 in.) and 40 ± 5°C (104 ± 9°F).	1.0	7.0 max

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

**6.2.3 Final Mix:**

6.2.3.1

	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 rpm), and raise the ram.	0	0

6.2.3.2

	Duration, min	Accumulative, min
Charge ½ 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

6.2.3.3

	Duration, min	Accumulative, min
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 max	3.0 max

6.2.3.4 Determine and record the batch mass; if the mass differs by more than 0.5 % of the theoretical mass, discard it.

6.2.3.5

	Duration, min	Accumulative, min
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 rolls six times.	2.0	5.0

6.2.3.6

	Duration, min	Accumulative, min
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

6.2.3.7 Cut enough sample for testing of compound viscosity in accordance with Test Method D 1646 or vulcanizing characteristics in accordance with Test Method D 2084, as described in 7.2, or both, if these are desired. Condition the specimen for 1 to 24 h at 23 ± 3°C (73.4 ± 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 ± 5°C (122 ± 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 ± 3°C (73.4 ± 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 ± 5 % relative humidity.

**6.3 Method B—Internal Mixer/Mill Procedure:**

**6.3.1 Mixing Cycle—Initial Mix:**

6.3.1.1 Prepare the initial mix in the internal mixer according to the procedure outlined in 6.2.2.

**6.3.2 Final Mix:**

**6.3.2.1**

With the mill rolls maintained at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) and set at 1.5-mm (0.06-in.) opening, band on the front roll the amount of batch based on two times the formula.

**6.3.2.2**

Add slowly the required amounts of sulfur and accelerator.

**6.3.2.3**

Make three  $\frac{3}{4}$  cuts from each side.

**6.3.2.4**

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

**6.3.2.5**

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

6.3.2.6 Determine and record the batch mass. If it differs from the theoretical value by more than 0.5 % reject it.

6.3.2.7 From the batch cut enough sample for testing of compound viscosity in accordance with Test Method D 1646 or vulcanizing characteristics with oscillating disk curemeter in accordance with Test Method D 2084 as described in 7.2, 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.

6.3.2.8 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.

6.3.2.9 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.

NOTE 4—If the amount of one compound is not enough for the test specimens, another compound should be prepared.

**6.4 Method C—Mill Procedure:**

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

**6.4.2 Mixing Cycle:**

**6.4.2.1**

With rolls temperature set at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) and opening of 1.2 mm (0.005 in.), band the rubber on the front roll.

**6.4.2.2**

Add the zinc oxide evenly across the rolls. Make two  $\frac{3}{4}$  cuts on each side.

**6.4.2.3**

Add  $\frac{1}{2}$  of the carbon black evenly across the rolls. Make two  $\frac{3}{4}$  cuts on each side and then add the stearic acid evenly across the rolls. Continue to make  $\frac{3}{4}$  cuts from each side as necessary during the remaining time.

NOTE 5—Do not cut the batch while free carbon black is evident in the bank or on the milling surface.

**6.4.2.4**

Open the rolls to 1.8 mm (0.07 in.) and add the remaining carbon black evenly across the rolls, making sure all materials in the pan are added to the batch. Make two  $\frac{3}{4}$  cuts from each side.

**6.4.2.5**

Add the sulfur and the accelerator evenly across the rolls.

**6.4.2.6**

Make three  $\frac{3}{4}$  cuts from each side.

**6.4.2.7**

Cut the batch from the rolls. Set the roll openings at 0.8 mm (0.032 in.). Pass the rolled batch through the rolls endwise six times.

**6.4.2.8**

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

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

6.4.2.10 From the batch, cut enough sample for testing of compound viscosity in accordance with Test Method D 1646 or vulcanizing characteristics in accordance with Test Method D 2084, as described in 7.2, 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

Duration, min	Accumulative, min
0	0

Duration, min	Accumulative, min
2.0	2.0

Duration, min	Accumulative, min
10.0	12.0

Duration, min	Accumulative, min
0	0

Duration, min	Accumulative, min
1.0	1.0

Duration, min	Accumulative, min
2.0	3.0

Duration, min	Accumulative, min
2.0	5.0

Duration, min	Accumulative, min
1.0	6.0

Duration, min	Accumulative, min
12.0 to 16.0	24.0 to 28.0

Duration, min	Accumulative, min
2.0	26.0 to 30.0

Duration, min	Accumulative, min
2.0	28.0 to 32.0

Duration, min	Accumulative, min
2.0	30.0 to 34.0

Duration, min	Accumulative, min
1.0	31.0 to 35.0

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 Mixer Procedure:**

6.5.1 For general mixing procedure, refer to Practice D 3182.

6.5.1.1 Adjust the head temperature of the miniature internal mixer to  $60 \pm 3^\circ\text{C}$  ( $140 \pm 5^\circ\text{F}$ ), and set the unloaded rotor speed at 6.3 to 6.6 rad/s (60 to 63 rpm).

6.5.2 Prepare the rubber by passing through a mill one time with the roll temperature set at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) and an opening that would 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 rubber strips into the mixing chamber, 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, add zinc oxide, sulfur, stearic acid, and TBBS that have been previously blended, taking care to avoid any loss.	1.0	1.5

**6.5.3.4**

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

**6.5.3.5**

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

NOTE 6—If only measurement of curemeter parameters is required, a 5-min mixing cycle may be used, reducing the step in 6.5.3.5 to 2.5 min.

6.5.3.6 Turn off the motor, raise the ram, remove the mixing chamber, and discharge the batch. Measure and record the batch temperature if desired.

6.5.3.7 Pass the batch between the rolls of a mill maintained at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) and 0.5-mm (0.020-in.) opening once, then twice at 3-mm (0.125-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 From the batch, cut a specimen for testing vulcanization characteristics in accordance with Test Method D 2084, as described in 8.2, if required. 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.

6.5.3.10 If either compound viscosity or stress-strain testing is required, pass the rolled compound endwise between the rolls six times with the rolls set at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) and 0.8 mm (0.032 in.).

6.5.3.11 Obtain a specimen for compound viscosity in accordance with Test Method D 1646, if required. 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.

6.5.3.12 If a 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 mill rolls set at  $40 \pm 5^\circ\text{C}$  ( $104 \pm 9^\circ\text{F}$ ) 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  $35 \pm 5\%$  relative humidity.

**7. Preparation and Testing of Vulcanizates**

7.1 For stress-strain testing, prepare the test sheets and vulcanize them in accordance with Practice D 3182.

7.1.1 The recommended standard vulcanization times for the compounds prepared by Methods A, B, and C are 25, 35, and 50 min at  $145^\circ\text{C}$  ( $293^\circ\text{F}$ ). The recommended standard vulcanization time for compounds prepared by Method D (MIM) is 35 min at  $145^\circ\text{C}$  ( $293^\circ\text{F}$ ).

7.1.2 Condition the cured sheets for 16 to 96 h at a temperature of  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 3.6^\circ\text{F}$ ).

NOTE 7—Quality control of rubber production may require testing within 1 to 6 h to provide close surveillance of the plant operations, however, slightly different results may be obtained.

7.1.3 Prepare test specimens and obtain the tensile stress, tension, and elongation in accordance with Test Methods D 412.

7.2 An alternative to measuring vulcanization characteristics by means of tensile stress measurements on vulcanizates is the measurement of vulcanization characteristics with a cure meter in accordance with Test Method D 2084.

7.2.1 The recommended standard test conditions are 1.7 Hz (100 cpm) oscillation frequency,  $1 \pm 0.03^\circ$  amplitude of oscillation,  $160 \pm 0.3^\circ\text{C}$  ( $320 \pm 0.5^\circ\text{F}$ ) die temperature, 30-min test, and no preheating.

7.2.2 The recommended standard test parameters are  $M_L$ ,  $M_H$ ,  $t_{51}$ ,  $t'_{50}$  and  $t'_{90}$ .

**8. Precision and Bias**

8.1 The precision and bias section deals with test results obtained in an interlaboratory program organized according to ASTM Practice D 4483. Refer to this practice for terminology and other statistical calculation details.

8.2 The precision results in this section give an estimate of the precision of this method with the materials used in the particular interlaboratory test program as described below. The precision parameters should not be used for acceptance or

rejection testing of any group of materials without documentation that the parameters are applicable to the group of materials and the specific testing protocols of the test method.

8.3 A Class 3, Type 2 interlaboratory test program was conducted in 1996 with ten participating laboratories. One test run included weighing of ingredients, preparation of mill mixes (compounds), testing of compound Mooney viscosities, cure meter testing of compounds, vulcanization of compounds and stress/strain testing of the vulcanizates. Cure meter testing was conducted at 160°C (320°F) and 1.7 Hz (100 cpm) with a 1° arc for the oscillating disk cure meter and a 0.5° arc for the moving die cure meter. All ingredients were distributed by one laboratory and two complete test runs were conducted with each of two different compound formulations. The two test runs were one week apart. The precision is given in terms of  $S_r$ ,  $r$ ,  $S_R$ ,  $R$  and  $(R)$  for the measured property values.

8.4 Analysis via D 4483 procedures indicated that there were both h and k outliers in the ten laboratory database. These outliers were eliminated and a subsequent analysis conducted with the final number of laboratories indicated in the precision table.

8.5 The precision of the test method may be expressed in the format of the following statements which use an “appropriate

value” of  $r$ ,  $R$ ,  $(r)$  or  $(R)$ , that is, that value to be used in decisions about test results obtained with this test method. The “appropriate value” is that value of  $r$  or  $R$  associated with the mean level in Table 1 closest to the mean level under consideration (at any given time, for any given material) in routine testing operations.

8.6 *Repeatability*—The repeatability  $r$  of this test method has been established as the appropriate value tabulated in Table 1. 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.

8.7 *Reproducibility*—The reproducibility  $R$  of this test method has been established as the appropriate value tabulated in Table 1. 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 value) must be considered to have come from different or non-identical sample populations.

8.8 Repeatability and reproducibility expressed as percent of the mean level,  $(r)$  and  $(R)$ , have equivalent application statements as above for the  $r$  and  $R$  statements, the difference

**TABLE 1 Type 2 Precision Results<sup>A</sup>**

No. of Labs	Property	Formula	Mean	Within Laboratory			Between Laboratory			
				$S_r$	$r$	$(r)$	$S_R$	$R$	$(R)$	
8	Mooney viscosity (ML1+4, 100°C)	#1	85	3.75	10.5	12.4	3.77	10.6	12.5	
8		#2	84	3.57	10.0	12.0	3.70	10.4	12.5	
Cure meter (oscillating disk)										
8	ML (dNm)	#1	12.5	0.63	1.77	14.4	0.92	2.59	20.7	
8		#2	12.2	0.50	1.41	11.5	0.91	2.55	20.9	
8	MH (dNm)	#1	42.2	0.84	2.36	5.6	3.16	8.84	21.0	
8		#2	44.5	1.05	2.94	6.6	3.73	10.40	23.5	
9	ts1 (min)	#1	3.7	0.11	0.30	8.1	0.23	0.64	17.3	
9		#2	3.5	0.23	0.64	18.1	0.30	0.84	23.8	
9	t'50 (min)	#1	7.8	0.38	1.06	13.5	0.38	1.06	13.5	
9		#2	7.5	0.27	0.75	10.0	0.28	0.79	10.5	
9	t'90 (min)	#1	10.0	0.35	0.99	9.9	0.38	1.05	10.5	
9		#2	9.7	0.27	0.75	7.7	0.37	1.05	10.8	
Cure meter (moving die)										
7	ML (dNm)	#1	3.6	0.30	0.84	23.4	0.33	0.91	25.4	
7		#2	3.5	0.18	0.51	14.7	0.28	0.79	22.8	
7	MH (dNm)	#1	18.6	0.45	1.27	6.8	0.89	2.50	13.5	
7		#2	20.4	0.73	2.03	10.0	1.25	3.51	17.2	
7	ts1 (min)	#1	3.2	0.19	0.54	16.7	0.27	0.76	23.6	
7		#2	3.1	0.11	0.32	10.3	0.29	0.82	26.5	
7	t'50 (min)	#1	6.5	0.38	1.05	16.3	0.38	1.05	16.3	
7		#2	6.2	0.17	0.47	7.8	0.20	0.55	8.9	
7	t'90 (min)	#1	8.9	0.54	1.52	17.0	0.55	1.53	17.1	
7		#2	8.6	0.11	0.32	3.7	0.42	1.16	13.5	
Stress/strain										
8	300 % modulus (MPa)	#1	10.8	0.65	1.81	16.7	0.65	1.81	16.7	
9		#2	12.2	0.44	1.24	10.2	0.60	1.69	13.9	
8	Tensile strength (MPa)	#1	17.6	0.83	2.32	13.2	1.13	3.16	18.0	
9		#2	17.1	1.33	3.72	21.8	1.37	3.84	22.5	
8	Ultimate elongation (%)	#1	462	21.2	59.2	12.8	34.6	96.8	21.0	
9		#2	408	23.7	66.3	16.3	26.6	74.4	18.2	

<sup>A</sup>Interlaboratory Test Program (ITP) [Day 1 - Day 2] replicates 1 week apart  
Number of laboratories in ITP after outlier removal indicated in first column  
 $S_r$  = repeatability standard deviation in measurement units  
 $r$  = repeatability =  $2.83 \times S_r$  (in measurement units)  
 $(r)$  = repeatability in percent of the mean  
 $S_R$  = reproducibility standard deviation in measurement units  
 $R$  = reproducibility =  $2.83 \times S_R$  (in measurement units)  
 $(R)$  = reproducibility in percent of the mean

in the two single test results being expressed as a percent of the arithmetic mean of the two test results.

8.9 In test 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 values are exclusively defined by this method. Bias, therefore, cannot be determined.

## **9. Keywords**

9.1 polybutadiene rubber (br); evaluation; oil-extended br; standard formula

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