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INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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FRONT-WHEEL-DRIVE CONSTANT VELOCITY JOINT BOOT SEALS

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Introduction—This SAE Recommended Practice is intended as a guide toward performance related standard practice and is subject to change to keep pace with experience and technical advances.

1. ***Scope***—This SAE Recommended Practice outlines recommended practices for qualification testing and performance related criteria of elastomeric boot seals integral to constant velocity joint applications in surface vehicles. Typically, these applications are referred to as front-wheel-drive halfshafts or axles, but can also be utilized in rear-wheel-drive halfshafts and propeller shaft applications. For additional information regarding CV joint systems and their applications refer to SAE AE-7 "Universal Joint and Driveshaft Design Manual." The grease quantities, clamps, and clamping mechanisms of an installation are considered to be the same as OEM or service designation. They are to be adequate and are not addressed in this document.

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1.1 **Purpose**—The purpose of this document is to establish a uniform practice for those in the surface vehicle industry that specify and/or manufacture CV joint boot seals (boots) for OEM or aftermarket use with respect to qualification testing for physical and mechanical properties.

2. References

2.1 **Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE AE-7—Universal Joint and Driveshaft Design Manual

SAE J200—Rubber Materials in Automotive Applications

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM D 395—Rubber Property—Compression Set

ASTM D 412—Rubber Properties in Tension

ASTM D 471—Rubber Properties—Effect of Liquids

ASTM D 573—Rubber—Deterioration in an Air Oven

ASTM D 624—Rubber Property—Tear Resistance

ASTM D 1149—Rubber Deterioration—Surface Ozone Cracking in a Chamber

ASTM D 2000—Rubber Products in Automotive Applications

ASTM D 2137—Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics

ASTM D 2240—Rubber Property—Durometer Hardness

ASTM D 2663—Rubber Compound—Dispersion of Carbon Black

ASTM D 3395—Rubber Deterioration—Dynamic Ozone Cracking in a Chamber

2.1.3 DIN AND ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

DIN 53 504—Determination of tensile strength at break, tensile strength, elongation at break and stress values in a tensile test

ISO 37—Rubber, vulcanized—Determination of tensile stress—strain properties, Second Edition

3. Application

3.1 This method is for use in evaluating performance related operational capabilities and material properties of rotating CV joint boot seals for:

a. Outboard steering CV joint installation for operation at approximately 40 degrees angle.

b. Inboard plunging (stroking) CV joint installation for operation at approximately 20 degrees angle at maximum extended length and minimum compressed length.

3.2 This practice is applicable to boot seals of flexible elastomeric material, including synthetic rubbers and a wide range of materials with similar characteristics. This includes polychloroprene (NEOPRENE)●, ethylene/acrylic (VAMAC)●, and silicone rubber. Thermoplastic boot seals, such as those of polyester composition, are not included.

3.3 Property guidelines are recommended for mechanical and physical properties, as well as environmental deterioration, of compound slab and as-molded product specimens.

3.4 Boot seal molders are encouraged to mold material family identification symbols to aid in recycling and/or disposal of CV joint boot seals at the end of their life cycle.

4. Performance Test Procedures

4.1 The test parameters and performance requirements of the CV joint boot seals are summarized in Table 1. Refer to the Sections 5 and 6 for specific test details.

5. Outboard CV Joint Boot Seal (Rotating, Non-Plunging)—For each of the following tests, assemble a new boot seal to the shaft and CV joint with the proper clamps and grease quantities. A minimum of 2 boot seals should be run per test. The assembly is mounted in a horizontal plane for the following tests.

5.1 Cold Test—-40 °C (Figure 1)

5.1.1 At 0 degree angle, allow the assembly to soak at room temperature (22 °C) for 12 h minimum prior to starting test. After the 12 h soak cycle, rotate the assembly at 1000 RPM, 0 degree angle and room temperature for 5 min in order to uniformly distribute the grease. The ambient soak is required to allow the elastomer compliance to adjust to the sealing surfaces and clamps.

5.1.2 Set the joint angle at 35 degrees, soak the assembly for 8 h minimum at -40 °C prior to running the test.

5.1.3 Accelerate the assembly to 100 RPM within 5 s. Run for 10 min at 100 RPM at 35 degrees angle, while maintaining -40 °C.

5.1.4 Re-soak for 50 min minimum at -40 °C.

5.1.5 Repeat 5.1.3 and 5.1.4 for 20 cycles.

5.1.6 PASS/FAIL CRITERIA—The boot seal shall have no through cracks, holes, excessive deformation or distress, grease leakage or discharge.

5.2 Radial Expansion Test—(Figure 2)

5.2.1 A determination of the static profile of the boot seal is made by mechanical probe, light beam, or photography prior to starting the test.

5.2.2 The test is conducted at room temperature (22 °C) and 0 degree joint angle.

5.2.3 The assembly is accelerated gradually to 1500 RPM within 2 min. Rotation at 1500 RPM is to be maintained for 10 min minimum.

5.2.4 PASS/FAIL CRITERIA—Radial expansion should not exceed 5 mm during 5.2.3.

5.3 Hot Test—(Figure 3)

5.3.1 This test can be conducted with either new boot seals or the boot seals that have completed the radial expansion test (5.2).

5.3.2 Soak the assembly at 80 °C for 2 h minimum prior to running test. Run at 1000 RPM for 20 h at 80 °C with a constant 10 degree angle.

5.3.3 Continue with the same boot seal and adjust test angle to 40 degrees. If the CV joint cannot attain 40 degrees angle, then set angle at 2 degrees less than its maximum attainable angle. Run at 200 RPM for 5 h minimum at 80 °C.

5.3.4 PASS/FAIL CRITERIA—The boot seal shall have no through cracks, holes, excessive deformation or distress, grease leakage or discharge. During hot tests the light oils from the grease can permeate through the boot seal material. The presence of this oil film on the outside surface of the boot seal is acceptable.

TABLE 1—TEST PARAMETERS AND PERFORMANCE REQUIREMENTS SUMMARY

	Cold	Radial Expansion	Hot
Outboard CV Joint Boot Seal (Non-Plunging):			
Reference	5.1	5.2	5.3
Ambient Soak (h) (after clamping)	12	0	
Grease Distribution	5 min @ 1000 RPM	—	5 min @ 1000 RPM
Temperature (°C)	-40	22	80
Initial Soak (h) (@ angle and temperature)	8	0	2
Angle	35°	0°	10° | 40°
Speed (RPM)	100	1500	1000 | 200
Requirement	20 cycles[1] Minimum	≤5 mm Radial Growth for 10 minutes	20 h | 5 h Minimum
Inboard CV Joint Boot Seal (Plunging):			
Reference	6.1	6.2	6.3
Ambient Soak (h) (after clamping)	12	0	
Grease Distribution	5 min @ 1000 RPM	—	5 min @ 1000 RPM
Temperature (°C)	-40[2]	22	80[3]
Initial Soak (h) (@ angle and temperature)	8	0	2
Angle	12°	0°	12°
Speed (RPM)	100	1500	1000
Plunge (Stroke) Position	+10 mm | -10 mm	0 mm	+10 mm | -10 mm
Requirement	10 cycles | 10 cycles[1] Minimum	≤ 5 mm Radial Growth for 10 min	20 h | 20 h Minimum

[1] A cycle is 10 min running and 50 min at rest.
[2] For VAMAC applications, temperature = -30 °C
[3] For VAMAC and silicone rubber applications, temperature = 150 °C

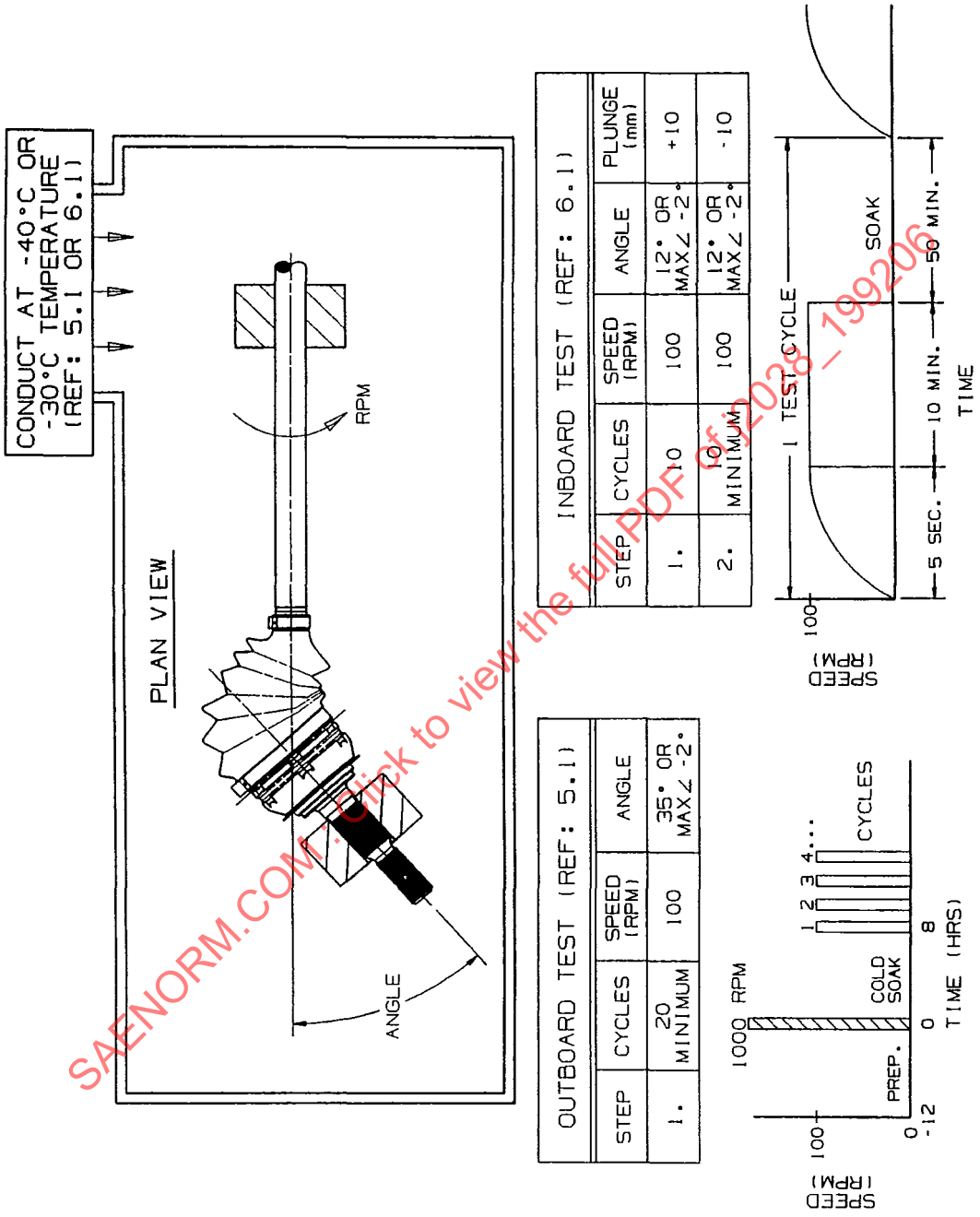


FIGURE 1—COLD TEST

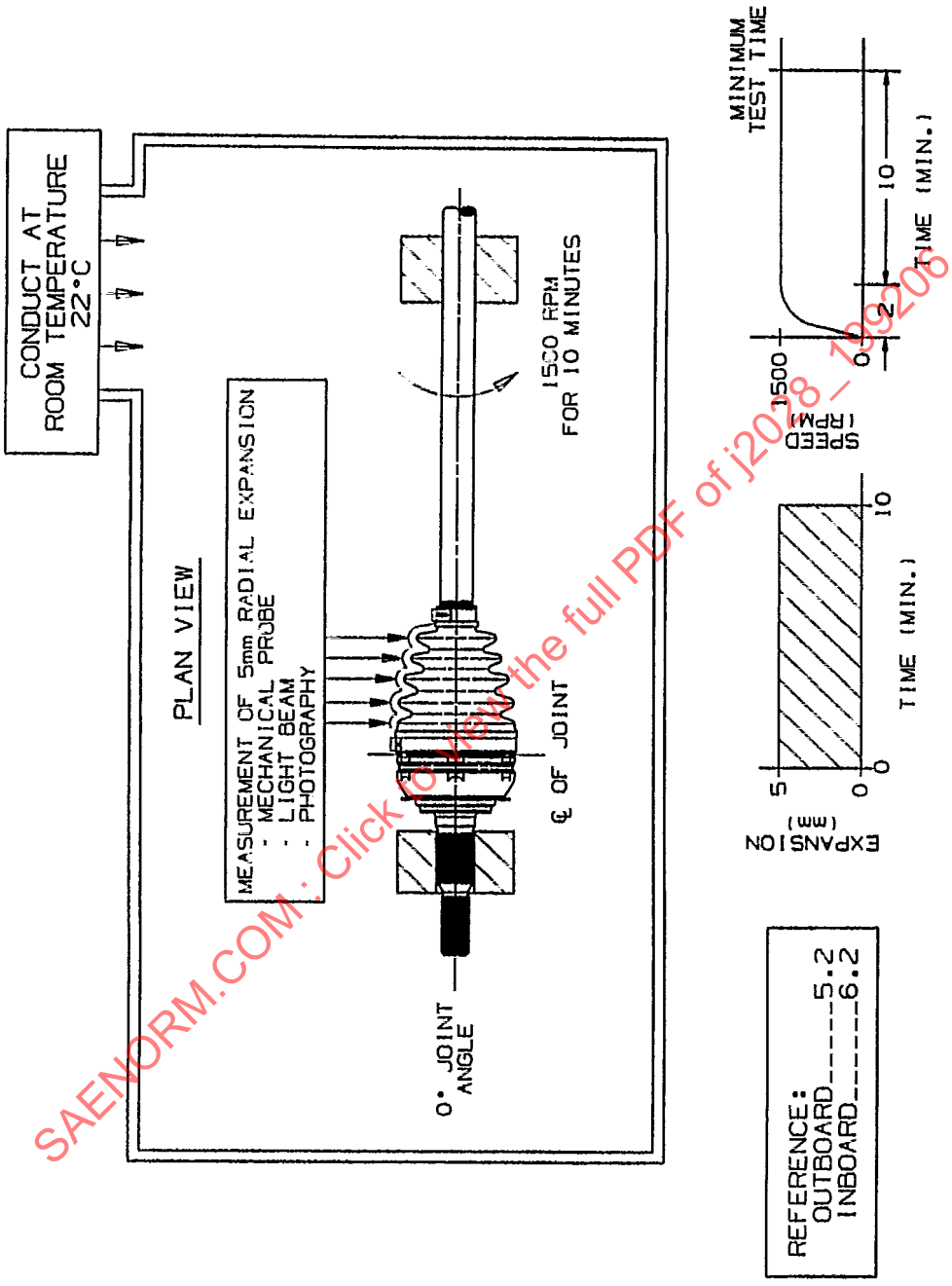
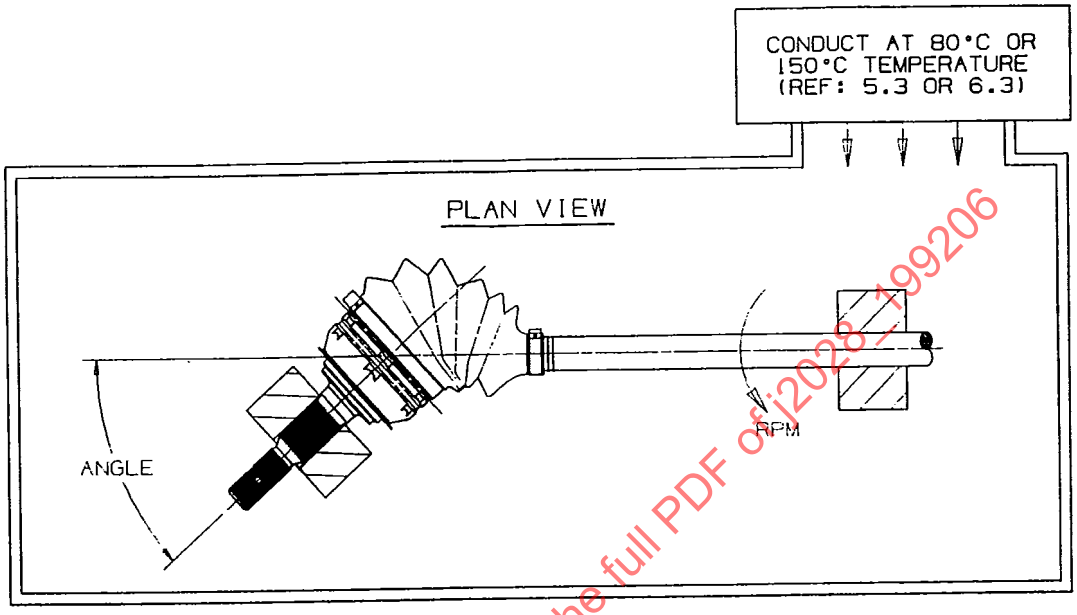


FIGURE 2—RADIAL EXPANSION TEST



OUTBOARD TEST (REF: 5.3)			
STEP	TIME (HRS.)	SPEED (RPM)	ANGLE
1.	20	1000	10°
2.	5 MINIMUM	200	40° OR MAX ∠-2°

INBOARD TEST (REF: 6.3)				
STEP	TIME (HRS.)	SPEED (RPM)	ANGLE	PLUNGE (mm)
1.	20	1000	12° OR MAX ∠ -2°	+10
2.	20 MINIMUM	1000	12° OR MAX ∠ -2°	-10

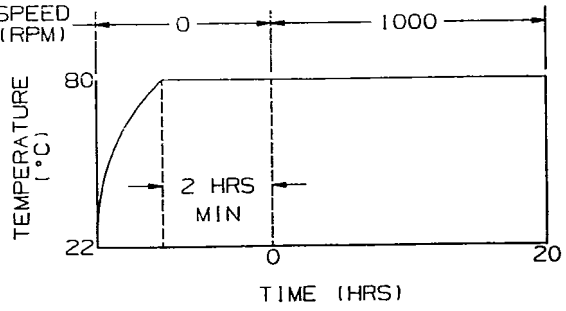
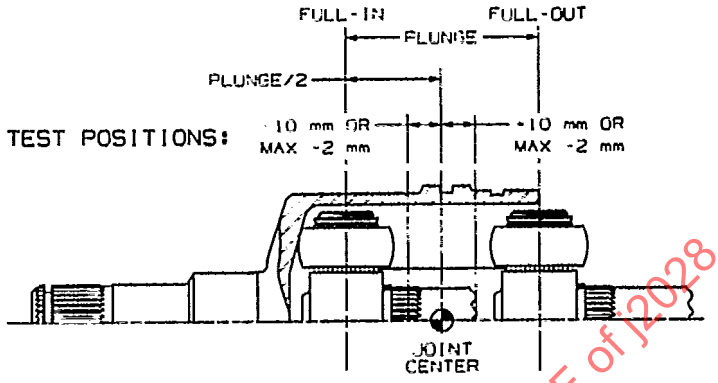
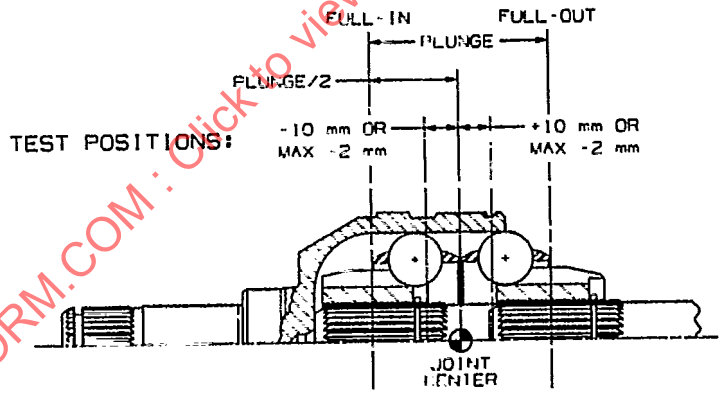


FIGURE 3—HOT TEST

FOR STROKING OR PLUNGING JOINT:
POSITION OF JOINT CENTER OR
MIDPOINT OF PLUNGE.



ROLLER TYPE JOINT



BALL TYPE JOINT

REFERENCE: 6.a

FIGURE 4—JOINT CENTER

6. Inboard CV Joint Boot Seal (Rotating, Plunging)—For each of the following tests, assemble a new boot seal to the shaft and CV joint with the proper clamps and grease quantities. A minimum of 2 boot seals should be run per test. The assembly is mounted in a horizontal plane for the following tests.

a. Definition of Joint Center and Test Position (Figure 4)

(1) Joint Center of a plunging CV joint is defined as the average of two positions of plunge (stroke). Full-in is defined as metal-to-metal contact of the inner joint members and the outer member(s). Internal springs and centering devices should be removed prior to making this measurement and be re-installed for testing. Full-out is defined as the maximum extended condition due to mechanical stops or the capability of the joint to transmit full torque.

(2) Total plunge length variation for testing should be ±10 mm from the joint center. If the plunge capability of the joint is less than 24 mm, the plunge should be retracted from the plunge limit of the joint. The joint is positioned 2 mm from both the full-in and full-out positions at the test angle, so as not to test in an interference or potentially damaging condition.

6.1 Cold Test—-40 °C (Figure 1)

6.1.1 At 0 degree angle, allow the assembly to soak at room temperature (22 °C) for 12 h minimum prior to starting test. After the 12 h soak cycle, rotate the assembly at 1000 RPM, 0 degree angle and room temperature for 5 min in order to uniformly distribute the grease. The ambient soak is required to allow the elastomer compliance to adjust to the sealing surfaces and clamps. Plunge position is not critical for this portion of the test and may be set at joint center ±10 mm.

6.1.2 At 12 degrees joint angle and +10 mm plunge from joint center, soak the assembly for 8 h minimum at -40 °C prior to running the test. If the joint cannot attain 12 degrees angle, then set angle at 2 degrees less than its maximum attainable angle.

6.1.3 At the previous angle and plunge, accelerate the assembly to 100 RPM within 5 s. Run for 10 min at 100 RPM at 12 degrees angle.

6.1.4 Re-soak for 50 min minimum at -40 °C.

6.1.5 Repeat 6.1.3 and 6.1.4 for 10 cycles.

6.1.6 Continue with the same sample. Repeat 6.1.2 through 6.1.5 with plunge set at -10 mm from joint center for 10 cycles minimum.

6.1.7 For ethylene/acrylic (VAMAC)® applications, conduct the previous test at -30 °C rather than -40 °C.

6.1.8 PASS/FAIL CRITERIA—The boot seal shall have no through cracks, holes, excessive deformation or distress, grease leakage or discharge.

6.2 Radial Expansion Test—(Figure 2)

6.2.1 A determination of the static profile of the boot seal is made by mechanical probe, light beam, or photography prior to starting the test.

6.2.2 The test is conducted at room temperature (22 °C) and 0 degree joint angle. Plunge position is not critical for this test and may be set at joint center ±10 mm.

6.2.3 The assembly is accelerated gradually to 1500 RPM within 2 min. Rotation at 1500 RPM is to be maintained for 10 min minimum.

6.2.4 PASS/FAIL CRITERIA—Radial expansion should not exceed 5 mm during 6.2.3.

6.3 Hot Test—(Figure 3)

6.3.1 This test can be conducted with either new boot seals or the boot seals that have completed the radial expansion test (6.2).

6.3.2 Set the joint angle at 12 degrees and plunge at +10 mm from joint center. If the joint cannot attain 12 degrees angle, then set angle at 2 degrees less than its maximum attainable angle. Soak the assembly at 80 °C for 2 h minimum prior to running the test. Run at 1000 RPM for 20 h at 80 °C.

6.3.3 Continue with the same boot seal and adjust plunge to be -10 mm from joint center. Run at 1000 RPM for 20 h minimum at 80 °C.

6.3.4 For high temperature applications where materials such as silicone rubber, ethylene/acrylic (VAMAC)●, or similar materials may be required, conduct the above test at 150 °C rather than 80 °C.

6.3.5 PASS/FAIL CRITERIA—The boot seal shall have no through cracks, holes, excessive deformation or distress, grease leakage or discharge. During hot tests the light oils from the grease can permeate through the boot seal material. The presence of this oil film on the outside surface of the boot seal is acceptable.

7. Physical and Material Properties—Boot seal properties should meet or exceed the properties established by ASTM D 2000 or SAE J200. These properties can be referenced by line call out, such as ASTM D 2000 M3BC614A14B14E014F17Z1Z2Z3. Recommended practice for the industry can be found in Tables 2 and 3, and are further explained in 7.1 and 7.2.

7.1 As-Molded Specimen Properties

7.1.1 As-molded specimen material properties to be in conformance with industry practice for rotating CV joint boot seals as shown in Table 2.

7.1.2 Two dumbbell specimens should be cut from each boot seal tested. Cut specimens across the parting line of the seal from the most suitable convolute such that the parting line is centered in the specimen. The specimen should be cut from the boot seal convolute face such that the test length is flat, straight, and undistorted. Tensile strength, modulus, and elongation results from the two specimens should not be averaged. The specifications in Table 2 represent the recommended minimum individual specimen requirements.

7.1.3 Suitable areas of the boot seal for hardness and compression set testing are the neck and convolutes in order to obtain nearly constant cross section and the absence of parting lines.

7.1.4 Refer to Figure 5 for typical as-molded specimen source and Figure 6 for suggested tensile test die dimensions.

7.2 Slab Specimen Properties

7.2.1 Slab specimen material properties to be in conformance with industry practice for rotating CV joint boot seals as shown in Table 3.

8. Notes

8.1 **Key Words**—Front-Wheel-Drive Axles, Halfshafts, CV Joints, Boot Seals, Cold Test, Hot Test, Radial Expansion Test, Performance Requirements, Elastomers, FWD.

TABLE 2—AS-MOLDED SPECIMEN PROPERTIES—ASTM D 2000

	Method	Specification Neoprene	Specification VAMAC	Specification Silicone
Original Properties				
Hardness, Shore A, 2-ply[2]	D 2240	55 to 65 pts	55 to 70 pts	55 to 65 pts
Tensile Strength, MPa	D 412, Die C[1]	10 min	6.4 min	4.8 min
Modulus @ 100%, MPa	D 412	1.2 min	2.2 min	1.2 min
Elongation, %	D 412	250 min	150 min	300 min
Compression Set				
100 °C—22 h, 2-Ply[2]	D 395, Method B	70% max	50% max	35% max
Dispersion				
Carbon Black Dispersion Torn Surface Method—Reflected Light Method	D 2663, Method A	4.0 min	N/A	N/A

[1] The ASTM D 412, Die C is too large for testing some boot seals. Equivalent tensile strength, modulus and elongation properties may be obtained with smaller dumbbells. Suggested dumbbell or specimen dies are shown in Figure 6.

[2] Hardness and compression set values are from 2-ply sections of the as-molded boot seal. This total thickness is likely to be less than the recommended values as outlined in procedures of ASTM D 2240 and D 395. Typical as-molded specimen sources are shown in Figure 5.

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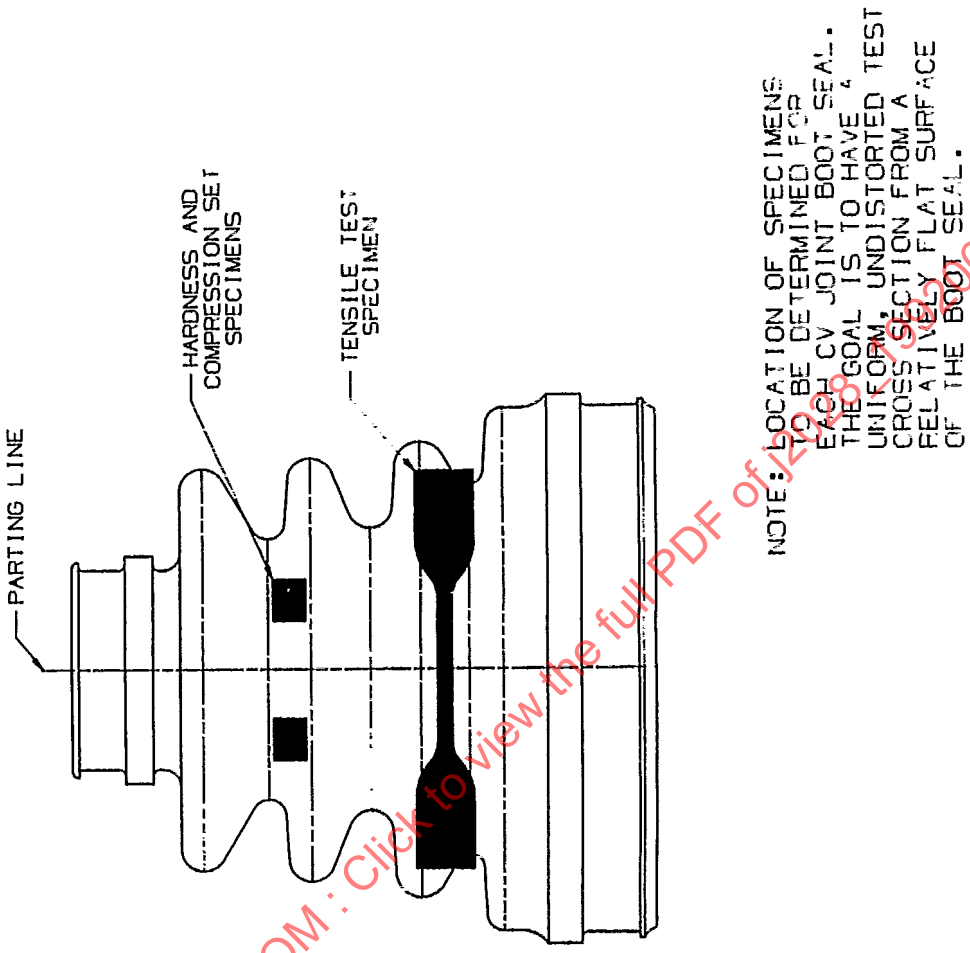

FIGURE 5—TYPICAL AS-MOLDED SPECIMEN SOURCE