



SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Test Standard for Vulcanized Rubber and Thermoplastic Elastomer
Determination of Compressive Stress Relaxation (CSR) Response

RATIONALE

Changes in this Test Standard are intended to make improvements in the previous Test Method to ensure the quality of results in its use.

INTRODUCTION

This document describes the test method that measures the counterforce of a material by an intermittent method at ambient temperature, before and after exposure to specified fluids and/or test temperatures, at discrete time intervals. This document is a supplement to ASTM D6147 and ISO 3384 procedures for CSR testing. However, it differs significantly in that it is focused on one CSR test fixture, test specimen, apparatus list, test method, and a defined equipment test capability. This test method focuses on the use of the ASD or HP CSR Test Jig and the specific test fixtures and test methods used to test the CSR Response for elastomer materials. The objective of this test fixture and test method is to define a test configuration, apparatus, and procedure that will provide consistent CSR results, when a range of elastomer materials are tested after exposure to elevated temperatures and/or fluids that are used in automotive applications, to provide an estimate of their capability and potential performance in applications as static seals. It also provides a perspective at how discrete CSR Test Jigs like these can provide a means to evaluate reasonable size test specimens with high precision, that are small enough to reflect cross sections of static seals, yet large enough to provide high resolution in dimension and force measurements with a reasonable Shape Factor that reflects a useful seal configuration.

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1. SCOPE

The scope of this document is to define a test method for performing the Compression Stress Relaxation (CSR) Test with the Automotive Standard (ASD) or HP CSR Jig using the appropriate test fixtures, configurations, and procedures. This standard defines the equipment needed, guidelines for running the test, and the format for generating the results and analyzing the data.

1.1 Purpose

This document describes test procedures and conditions for determining the loss in counterforce of a 12.7-mm (0.500-inch) diameter button compressed in an ASD or HP CSR Jig at a constant deformation, measured at room temperature at periodic intervals, after exposure to elevated temperatures and/or fluids. It is designed for testing of vulcanized rubber and thermoplastic elastomers with an instantaneous Type A Hardness from 45 to 90 (refer to ASTM D2240). Samples are molded and cured in accordance with ASTM D3182. This document is specific to the use of the ASD CSR jig, a required apparatus list, and a specific test method including a quality check for the total system. This document was developed based on testing new and aged specimens. This method can involve hazardous materials, operations, and equipment. This method does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

SAE J2643 Standard Reference Elastomers (SREs) for Characterizing the Effect of Liquids on Vulcanized Rubbers

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9500, www.astm.org.

ASTM D471 Standard Test Method for Rubber Property - Effect of Liquids

ASTM D572 Standard Test Method for Rubber - Deterioration by Heat and Oxygen

ASTM D573 Standard Test Method for Rubber - Deterioration in an Air Oven

ASTM D1566 Standard Terminology Relating to Rubber

ASTM D2240 Standard Test Method for Rubber Property - Durometer Hardness

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

ASTM D3767 Standard Practice for Rubber - Measurement of Dimensions

ASTM D6147 Test Method for Vulcanized Rubber and Thermoplastic Elastomer - Determination of Retained Sealing Force (Stress Relaxation) in Compression

ASTM E145 Specification for Gravity - Convection and Force Ventilation Ovens

2.1.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org>.

ISO 3384 Rubber, vulcanized or thermoplastic - Determination of stress relaxation in compression at ambient and elevated temperatures

ISO 23529 Rubber - General Procedures for Preparing and Conditioning Test Pieces for Physical Test Methods

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Recommended Practice.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

AS568 Aerospace Size Standard for O-Rings

SAE J2236 Standard Method for Determining Continuous Upper Temperature Limit of Elastomers

Tuckner, P., "Compression Stress Relaxation Test Comparisons and Development," SAE Technical Paper 2000-01-0752, 2000, <https://doi.org/10.4271/2000-01-0752>.

Tuckner, P., "Compression Stress Relaxation Testing - Comparisons, Methods, and Correlations," SAE Technical Paper 2001-01-0742, 2001, <https://doi.org/10.4271/2001-01-0742>.

Tuckner, P., "The Effects of Configuration on Sealing Force Measurement and Compression Stress Relaxation Response," SAE Technical Paper 2003-01-0946, 2003, <https://doi.org/10.4271/2003-01-0946>.

2.2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9500, www.astm.org.

ASTM D395 Standard Test Method for Rubber Property - Compression Set

ASTM D892 Standard Test Method for Foaming Characteristics of Lubricating Oils

ASTM D1349 Standard Practice for Rubber - Standard Temperatures for Testing

ASTM D1418 Standard Practice for Rubber and Rubber Latices - Nomenclature

ASTM D3183 Standard Practice for Rubber - Preparation of Pieces for Test Purposes from Products.

ASTM D4483 Standard Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries

ASTM D4678 Standard Practice for Rubber - Preparation, Testing, Acceptance, Documentation and Use of Reference Materials

2.2.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org>.

ISO 188 Rubber, vulcanized or thermoplastic - Accelerated aging and heat resistance tests

ISO 1629 Rubber and latices - Nomenclature

ISO 17025 General requirements for the competence of testing and calibration laboratories

3. DEFINITIONS

3.1 REACTION FORCE/SEALING FORCE

The counterforce that an elastomer sample exerts on its mating surfaces when it is compressed.

3.2 COMPRESSIVE STRESS

The time-dependent force, measured at a constant compressive strain, divided by the original cross-sectional area over which the force is applied.

3.3 FORCE RETENTION/% RETAINED SEALING FORCE

The sealing force exerted by the sample after exposure to a defined environment for a specified period of time, as a percent of its initial sealing force, determined at room temperature, after a defined period of time (in this test, that time interval is defined as 60 minutes) following the sample's initial compression to a constant deformation and held at room temperature until tested.

3.4 THERMOPLASTIC ELASTOMER

Refer to ASTM D1566.

3.5 THE AUTOMOTIVE STANDARD (ASD) COMPRESSION STRESS RELAXATION (CSR) TEST JIG

High Pressure (HP) CSR Test Jig has a slightly smaller outside diameter with a larger inside cavity diameter to enable it to fit in a 1-L or 2-L Parr High Pressure (HP) pressure vessel and uses larger diameter shims that can better accommodate higher compression of the test specimen without the risk of sliding off the shim. Both use the same Test Configuration, Test Specimen, and Indenter Pin.

Was formerly known as the Dyneon Compression Stress Relaxation Test Jig.

3.6 ELECTROMECHANICAL UNIVERSAL TESTING MACHINE (EMUTM)

A mechanical device controlled with electronics and software that has moving parts that can deform fixtures or components at a defined controlled rate and measures the associated load response from the configuration.

3.7 SYSTEM STIFFNESS

The slope of the initial linear response of the load deflection curve in a CSR test. This slope reflects the load frame stiffness, the load cell stiffness, and the sample stiffness.

3.8 SAMPLE STIFFNESS

The slope of the second linear response of the load deflection curve in a CSR test. This slope reflects the stiffness of the sample being tested.

3.9 STIFFNESS RATIO

This value is the ratio of the System Stiffness divided by the Sample Stiffness.

4. APPARATUS

The following apparatus is required for running this test method:

4.1 Suitable room with a stable and known environment (required)

4.2 ASD or HP CSR Jig Set

These items are identified and displayed in Section A.1 and include the following items listed directly below (required).

4.2.1 ASD or HP CSR Jig

4.2.2 ASD or HP Shim Set for an ISO 3384, 12.7-mm (0.500-inch) diameter button (cylindrical disk) (required)

4.2.3 ASD or HP (3) Centering Wedges

Used to center shims and samples in ASD CSR Jig.

4.2.4 ASD or HP Centering Cup

Used to align centering wedges for centering shims and sample.

4.2.5 ASD Indenter Pin

Used to compensate for perpendicular misalignment between the EMUTM and the ASD or HP CSR Jig.

4.2.6 Allen Wrench for cap screws 3/16 inch (4.5 mm, slightly undersized) (required)

4.3 Multi-cavity mold for 12.7-mm (0.500-inch) button (cylindrical disk) samples (required)

4.4 Digital Drop Gauge or Dial or digital caliper measuring device, per ASTM D3767 or ISO 23529, for measuring button thickness with the capability of measuring to 0.025 mm (0.001 inch) (required) or better

4.5 Parker Super O-Lube 2 ounces (Amazon) to lubricate button surfaces (required)

4.6 Pyrometer and Thermocouple

Digital Pyrometer and Thermocouple capable of measuring ASD CSR Jig temperature, test fluid, and room temperatures within $\pm 2^\circ\text{C}$ of the specified temperatures (required). An Omega (<http://www.omega.com/>) Miniature Style Thermocouple probes (Part # KMQSS-062[26]-6 or similar) with a sheath diameter of 1.6 mm (0.062 inch) can be easily inserted into a jig.

4.7 An Electromechanical Universal Testing Machine (EMUTM) (Loadframes) capable of measuring counterforce on CSR test fixtures and equipped to compress the test specimen at a uniform controlled rate between 0.4 and 1.3 mm/min (0.02 and 0.05 in/min). This instrument should show a zero force load response variation of less than 0.1 N. This instrument should be capable of measuring compression forces in the desired range with a resolution and accuracy of at least $\pm 1\%$ of the initial value (required). This instrument should be able to measure at least 400 data points uniformly distributed over the recommended deflection of 0.1 mm (0.004 inch). The System Stiffness of this EMUTM should be at least 5X higher than the Sample Stiffness for the configuration being tested (recommended). Calculation of the Stiffness Ratios is noted in Section 8. Depending on the system, it may be necessary and desirable to use a machine with a suitable deflectometer (Linear Variable Differential Transducer, LVDT) with a stroke range about twice that necessary to run the test in order to measure the test deflection, independent from the load cell and crosshead response, to provide a higher system stiffness.

4.8 Loadframe Test Fixtures

The CSR Loadframe Test Fixtures should include a Hard Fixed Hardened Plunger, a Hard Fixed Pedestal, with Centering Features to enable the centering of the CSR Jigs axially aligned with the Load Cell and Plunger. The Plunger Face should be parallel to the face of the Pedestal to within 1 degree. The Pedestal should have a means to attach a Deflectometer if needed. An example of the Test Configuration is shown in Figure 1.

4.9 EMUTM Software to capture and plot force versus deflection data (required)

Examples of these kinds of Software include Instron's Bluehill 3/ Bluehill Universal, MTS's TestWorks 4/Testsuite TW, or other Loadframes and Software with comparable capability. See an example of the plot from the TestWorks software in Figure 2.

4.10 Excel File or equivalent to record data (required) (General Format noted in Appendix B)

4.11 Ovens (required)

The ovens should have precise cabinet temperature control obtained through air exchange and circulation uniformity (in time and space) and are critical to measurement repeatability and reproducibility at isothermal temperatures. Small units capable of obtaining ± 1.0 °C around a set temperature are best suited for CSR measurement. Select ovens with air exchange rates based on ASTM E145 requirements should be considered.

4.12 Other Optional Accessories

4.12.1 Basket for Oil Testing

Used with 1-gallon Paint Can or Stainless Steel Test Containers (holds 28 ASD CSR jigs). See Section A.2.

4.12.2 Pressure Vessel and Basket for Coolant Testing - 2-L Parr Pressure Vessel basket (holds 18 ASD CSR jigs) (see Section A.3)

4.12.3 Pressure Vessel and Stirring Hot Plate

Use device similar to that described in ASTM D572 for coolant testing. For test mixtures requiring stirring to maintain uniformity, use a stirring hot plate with temperature control. Provisions for a pressure gauge and relief valve are also required (see Section A.4).

4.12.4 Compression Stress Relaxation (CSR) Spring Test Set (Optional) (see Section A.5)

5. TEST SPECIMEN

5.1 Samples should be prepared using good molding procedures and equipment to achieve good, consolidated void-free and defect-free samples with smooth parallel flat surfaces observed with normal corrected vision (refer to ASTM D3182 and SAE J2643).

5.2 Molded Button of diameter $12.7 \text{ mm} \pm 0.5 \text{ mm}$ ($0.500 \text{ inch} \pm 0.010 \text{ inch}$) and thickness $6.3 \text{ mm} \pm 0.3 \text{ mm}$ ($0.250 \text{ inch} \pm 0.005 \text{ inch}$)

5.3 Button thickness measurements are taken from the center of the button

5.4 Measure thickness using a digital drop gauge or dial or digital caliper (see 4.4) in a central area to avoid edge effects

5.5 Number of Test Specimens

A minimum of three test specimens shall be used for each material.