



Sealer Compression Density Test

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

This procedure is used to determine the physical behavior of a sealer material under pressure conditions. The materials compressibility/rebound characteristics are determined by this procedure. This test is of value for materials containing fragile filler components such as glass microspheres or plastic microspheres as the results can be used to predict the crush or damage to these components under hydrostatic pressure.

1.1 Purpose. A Johnstone test apparatus or equivalent (see SAE J1864) is used to conduct this test. A sealed steel cylinder (of initial volume of 150.76 cc) is filled completely, with material to be tested, loaded into the check load frame and subjected to a progressive increase in loading upon the pressure cap. This load is applied in a manner which increases the internal hydrostatic pressure of the material by a measured increment (usually 13.8 bar (200 psi)). Any displacement of the pressure cap is measured by means of a dial extensometer or Linear Voltage Displacement Transducer (LVDT). Two (2) additional measurements are taken at each material pressure increment – the air pressure in the loading cylinder (total applied load), and the displacement of the pressure cylinder cap (total compression). By calculating and plotting the material hydrostatic pressure against the percentage compression of the material, a stress-strain plot for the material can be constructed and used to determine effective compressive modulus (resistance to compression) and filler yield point (failure limit of pressure sensitive filler components). Finally, the total material compression for a peak loading pressure can be separated into rebound (elastic) and crush (permanent) compressive elements.

1.2 Applicability. This test procedure is applicable to ultralight sealer materials approved under the following specifications: GMW16070, GMW16680 or any other materials containing glass bubbles as lightweight fillers.

1.3 Remarks. None.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D1475	ASTM D2196	SAE J1524	SAE J1864
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2.2 GM Standards/Specifications.

GMW16070	GMW16680
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2.3 Additional References.

Relevant Material Specification

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 Safety. Equipment must be checked before every test, insure the equipment is operating properly since this test is conducted at high pressure. Procedures for pressurizing and de-pressurizing the system should be prominently posted on the test rig.

3.2 Equipment. Reference Appendix A, Figure A2 and Figure A3.

3.3 Test Vehicle/Test Piece. Sealer material containing fragile filler components such as glass microspheres or plastic microspheres.

3.4 Test Time.

Calendar time: 1.0 days

Test time: 8.0 h

Coordination time: 2.0 h

3.5 Test Required Information. See 5.3.

3.6 Personnel/Skills. Persons performing this test are required to use proper protective equipment, eye protection with side shields and gloves to prevent contact with test materials. Operators should be trained in operating this equipment and conducting this test.

4 Procedure

4.1 Preparation.

4.1.1 Experimental Preparation - Equipment.

4.1.1.1 Connect the multi-stage cylinder to an air source and adjust the air pressure regulator so that there is no pressure supplied to the cylinder. Open the four (4)-way hand valve to confirm that there is no pressure in the system.

4.1.1.2 Place the filled pressure cup assembly into the slot at the base of the stand.

4.1.1.3 Leaving the hand valve open, slowly dial up the air pressure so that the piston of the multi-stage cylinder descends slowly until it contacts the piston cap of the pressure cup assembly. Close the hand valve and dial air pressure to 0 bar (0 psi).

4.1.1.4 Set up the dial extensometer so that it is level and perpendicular to the displacement follower arm. Adjust the extensometer to indicate an initial displacement of 0.00 mm.

4.1.2 Running the Test.

4.1.2.1 Open the hand valve and slowly dial up the air pressure until the gage reads 13.8 bar (200 psi).

4.1.2.2 Close the hand valve and let the cylinder equilibrate for 30 s.

4.1.2.3 Record the air pressure (bar and pounds per square inch (psi)), material pressure (bar and psi) and dial extensometer displacement (millimeters).

4.1.2.4 Repeat steps 4.1.2.1 thru 4.1.2.3 in 13.8 bar (200 psi) increments until the material pressure reaches 330 bar (4500 psi). Record all data as called out in 4.1.2.3.

4.1.2.5 Slowly regulate the air pressure back to 0 bar (0 psi) and let the pressure cup equilibrate for 300 s. Record the final displacement (material rebound step) in millimeters.

4.1.2.6 Perform a density cup measurement upon the compressed material to determine any increase in density and report in gram (g)/cubic centimeter (cc) (g/cc) and pound (lb)/gallon (gal) (lb/gal).

4.2 Conditions. Not applicable.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Compression Test Procedure.

4.3.1.1 Material.

4.3.1.1.1 Record the name of manufacturer, material formula/product code, batch/lot number, date of manufacture and GM specification to which the material is approved or being tested to.

4.3.1.1.2 Determine the initial viscosity of the material using a rheometer (ASTM D2196), and Castor Severs press flow (SAE J1524). Use the spindle, orifice and test parameters called out in the relevant material specification. Report rheometer results in centipoise, and press-flow results in seconds.

4.3.1.1.3 Perform a density measurement (ASTM D1475), report gram (g)/cubic centimeter (cc) (g/cc) and pound (lb)/gallon (gal) (lb/gal) on the material to determine an initial density before start of test.

4.3.1.2 Experimental Preparation – Material.

4.3.1.2.1 Assemble complete pressure chamber (Johnstone pressure chamber, see SAE J1524 or equivalent). Install a 350 bar (5000 psi) pressure transducer, or a 350 bar pressure gauge (show pressure in bar) into one (1) of the ¼ in national pipe thread (NPT) side ports.

4.3.1.2.2 Draw a 355 cc volume of test material into a semco tube taking care not to introduce air.

4.3.1.2.3 Open the bleeder valve on the pressure cup container.

4.3.1.2.4 Push the piston cap to the bottom of the pressure cup container.

4.3.1.2.5 Remove the ¼ in pipe plug from the bottom of the pressure cup. Thread a ¼ in pipe nipple onto the semco tube and dispense material until it flows out the nipple removing any residual air.

4.3.1.2.6 Thread open end of ¼ in nipple into the pressure cup plug hole and fill the pressure chamber until material forces all residual air out of the bleeder hole. Close the bleeder valve.

4.3.1.2.7 Continue to fill the pressure cup until the piston cap reaches the top of the pressure cup. The internal volume of the filled pressure cup is 150.76 cc (9.2 in³).

4.3.1.2.8 Remove the ¼ in nipple and replace with a ¼ in inlet pipe plug.

4.3.1.2.9 Reopen the bleeder valve to relieve any excess material pressure and then close.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation.

5.3.1 Data Calculations and Presentation.

5.3.1.1 For each material pressure measurement point, determine the degree of compression by the following formula:

$$\text{Percent (\%) Compression} = C/l_0.$$

Where:

C = the deflection as measured by the dial extensometer.

l₀ = is the initial length of the material column in the pressure cylinder (usually 97.54 mm (3.84 in)).

5.3.1.2 Construct a plot of the material pressure (y) versus percent (%) compression (x) (see Appendix A, Figure A1).

5.3.1.3 Apply linear regression analysis to the initial portion of the pressure versus compression curve. The slope of the regression function can be, considered to be the, effective compressive modulus of the material. Effective compressive modulus allows the estimation of the amount of compression the material will exhibit under pressure in a dispensing system. This value can be used as a quantitative means of assessing the compressibility of different material systems. To obtain the compressive modulus value, divide the material pressure for each step by the percent (%) compression for that step. Then sum all these values and divide by the number of steps (omitting the zero-pressure and rebound steps). The resulting value is the compressive modulus expressed in pressure units of pound per square inch or bar.

5.3.1.4 Determine the hydrostatic yield pressure of pressure-sensitive components of the material by noting the point of divergence between the initial linear and secondary non-linear portions of the pressure-compression curve. The pressure at the point of divergence signifies the point at which pressure-sensitive compounds of the material begin to experience damage due to hydrostatic pressure. Since the pressure-compression chart is analogous to the stress-strain plots used for solid material compressive and tensile analysis, these well-developed fields can provide many useful techniques for analysis. Depending upon the pressure response of the material being tested, the 0.2% offset method and the 25% to 75% method, can be successfully used to