



Heat Cured Silicone Rubber for Engine Coolant Sealing

1 Scope

This specification covers the materials and performance of silicone rubber sealings in the cooling circuit.

Note: The words **must**, **shall** or **will** as used in this document mean a mandatory requirement.

1.1 Material Description. Commercial compounds are divided into the following types:

1.1.1 Type A. Compression set resistant silicone (VMQ) gasket or o-ring compound(s) in contact with engine coolant for application temperatures with a functional temperature range of (-40 to +175) °C (continuous) as defined by ASTM D1329 TR10 and SAE J2236 respectively.

1.1.2 Type B. Tear resistant silicone (VMQ) gasket or o-ring compound(s) with a functional temperature range of (-40 to +175) °C (continuous) as defined by ASTM D1329 TR10 and SAE J2236 respectively. Recommended for higher coolant temperature applications (see Table 2 "Coolant Resistance").

1.2 Symbols. Identify the elastomer nomenclature using ASTM D1418 or ISO 1629.

1.3 Applicability. Engine coolant temperatures rarely exceed +120 °C. Heat cured silicone rubber described in this standard is used where the joint flange temperature up to +175 °C continuous occurs due to the close proximity to exhaust gas recirculation, turbo, heat exchangers and other heat generating components. Consult GM Materials Engineering for excursion conditions beyond +175 °C.

1.3.1 Other Coolant Standards. Use GMW14747 for coolant joints not exposed to hydraulic fluids during initial assembly or service. Use GMW14751 for joints sealing oil and coolant simultaneously. Use GMW17474 for joints with incidental exposure to hydraulic fluids during assembly or service.

1.4 Remarks.

1.4.1 High compression set occurs in soft silicone compounds. Compounds where the minimum hardness is 50 Shore A or less are not recommended.

1.4.2 Properties for Tables 2 and 3 were developed from heat cured silicones with a hardness range from (50 to 80) Shore A.

1.4.3 Due to its high gas and fluid permeability, silicone gasket design shall consider a wider contact footprint at the mating surface, increased sealing contact pressure and width (e.g. no 3 mm by 5 mm groove) compared to EPDM or HNBR compounds. Type B is recommended with nominal hardness starting at 70 Shore A or 80 Shore A especially joints subject to pressure up to 517 kPa (75 psi), with flow and immersion consistent with the normal application environment.

1.4.4 O-rings. Some prints/drawings identify "D" or race track shapes as o-rings. To avoid confusion, testing and table data only apply to the ASTM D1414 definition of an o-ring.

1.4.4.1 Tensile and elongation properties of o-rings are measured by spool separation, however during this step the elongation across the specimen width is not uniform. To minimize data variation, the recommended ratio of ring ID to cross section width should be $\geq 9 : 1$. Of greater interest is tensile stress at (20 to 50) % elongation because it is closer to the performance range of the o-ring.

Note: The ratio for SAE AS568-214 size is 7 : 1.

1.4.4.2 Compression Set. Testing a whole o-ring for compression set is not permitted. Air trapped in the o-ring inside diameter results in a different thermal condition between the inside and outside surface of the specimen.

1.4.5 Rubber Adhesion to Carrier (Edge Molded Design). Rubber shall be secure to the carrier over the entire contact length. On a fully cured part, attempts to remove the rubber using pliers or other gripping tools in a 90° or 180° pull (to the carrier) shall result in tearing of the rubber. A cut (up to 12 mm) between the rubber and carrier is permitted to facilitate gripping of the rubber. A clean adhesive failure (rubber to carrier) is not acceptable. Nondestructive test alternative using an interference fit, post die for small openings or a straight segment rule die that deflects or bends the edge bonded rubber is permitted. For open segment tests, the carrier must be securely clamped to prevent movement during deflection of the edge bonded elastomer. The interference of the die edge to the elastomer profile must make contact at the mid-point of the flexible extension from the bonded edge. One pass (downward and upward) is sufficient. There must be no loss of elastomer to metal adhesion or elastomer cracking under 2x magnification.

1.4.6 Elastomers used in part of assembly (POA) are usually selected by supplier specific criteria and often remain unspecified or unidentified on end user prints and drawings. As the original equipment manufacturer (OEM) end user, GM reserves the right (through directed buy) to define common rather than source specific requirements. Use this document in the appropriate Statement of Requirements, Appendix C and corporate prints and drawings using paragraph 8 "Coding".

2 References

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

2.1 External Standards/Specifications.

ASTM D412	ASTM D471	ASTM D573	ASTM D624
ASTM D1329	ASTM D1414	ASTM D1415	ASTM D1418
ASTM D3182	ASTM D4968	ISO 34-1	ISO 37
ISO 48	ISO 188	ISO 815-1	ISO 1629
ISO 1817	ISO 16949	ISO 17025	ISO 23529

2.2 GM Standards/Specifications.

GMW3059	GMW3155	GMW3221	GMW15117
GMW16955	GMW17205	GMW17113	

2.3 Additional References.

- Association for Rubber Product Manufacturers (ARPM), Indianapolis, Indiana (www.arpminc.com) O-Ring Inspection Guide, Surface Imperfections Control (OR-1) and the Handbook for Molded, Extruded, Lathe Cut & Cellular Products
- Automotive Industry Action Group (AIAG) D22, Best Practice Unified Procedure for Approval of Rubber and Plastic Formulation Ingredient Changes, 26200 Lahser Road, Suite 200, Southfield, MI 48033-7100
- Axel Products, Incorporated, 2255 S Industrial Hwy, Ann Arbor, Michigan 48104 (www.axelproducts.com)

3 Requirements

3.1 Compound Characterization for Finite Element Modeling. All elastomeric compounds qualifying to this standard must also be entered into the hyperelastic GM Material Property Database for finite element modeling unless otherwise specified by the Component Statement of Requirements (SOR) or Component Technical Specification (CTS). Axel Products, Incorporated is GM's sole global contract test facility as the equipment and test methods used are unique and confidential. A finite element development form is submitted with each elastomeric compound. The form is available from Axel Products, Incorporated or GM Engine Materials Engineering. Follow the form instructions. Table 3 shows where in the part and compound development process the data is characterized for hyperelastic modeling.

Table 1: Candidate Compound Requirements for Finite Element Analysis (FEA) Modeling Data

Part or Component Design Level	Compound Readiness at Submission Time	Intent	Requirements at Time of Characterization ^{Note 1}
Design Development, Production or Production Intent	Available from production batch process only.	Represent properties from all mixing location(s).	One or more of the following: - Production drawing content met - Production Part Approval Process (PPAP) started or successfully completed - Design development before tooling and parts tested - Satisfies all relevant GM documents - Compound selected for production intent process and design

Note 1: All validation testing including GMW3155 may not be completed at the time of compound characterization. Maintaining entries in the database will be reevaluated if the compound was the reason for a non-compliance to test requirements.

3.1.2 Test Samples. Unless otherwise specified, the shape and size of test pieces shall be in accordance with the relevant test procedure and comply with paragraph 3.1.6.1 "Test Standards Equivalency".

If not otherwise stated, mechanical properties in delivery state and after heat or fluid immersion shall be tested at +23 °C and with the same test methods.

3.1.2.1 Print Designations for Micro-hardness Method. The part print shall indicate which hardness method using the word surface in parenthesis or cross section in parenthesis after the numerical range. Slab measurements require no designation after the numerical range.

3.1.3 Conditioning. Conditioning shall be as specified in the relevant Test Procedure.

3.1.3.1 Elastomer Test Specimens Preparation. Specimens used to develop all table properties are die cut specimens from ASTM D3182 sheet stock molded to the same conditions as for actual products, with post cure if applicable. Precondition slabs at 50 % relative humidity (RH) and + 23 °C for at least 16 h before testing. As an option, specimens from non-post cure compounds may be used from production molds. Report cure time and temperature conditions for all molded specimens.

3.1.4 Equipment. Conforming to the relevant Test Procedure.

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

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

3.1.6.1 Test Standards Equivalency. For reasons of cost and convenience, this document lists equivalent industry standards. Equivalency as it applies to this document is stated in ASTM D4968, Appendix A2. Documents may have some minor form differences, but otherwise will give "identical" results to those actions performed as a result of following the ISO standard and "vice versa." Only use the equivalent standards listed in Table 2. This also means the approved compounds are equivalent.

3.1.7 Facilities. Conform to the relevant Test Procedures.

3.1.7.1 GM North America Powertrain Only. All data shall be generated by an ISO 17025, ISO 16949 or GM accredited laboratory.

3.1.8 Deviations. Only improvements (e.g., increase in test time, harsher test media, etc.) or corrections (e.g., publication error, missing information, etc.) from the requirements of this standard are permitted, provided they have been agreed upon between tester and requester. Use of test procedure/condition deviations are considered temporary (up to six (6) months) until a consensus is reached and revisions made to this document by the sponsor. No specification limit deviation or test exemption(s) to accommodate material compliance to this standard is permitted on the production print or any relevant documentation by source or end user. All issues must be worked out through revision of this standard.

3.1.8.1 Exceptions to these requirements are not permitted on GM purchased part drawings. An example of an illegal deviation is:

Material: GMW14751 except age resistance to SAE J2236 change in elongation is -60 % maximum.

In this example, SAE J2236 is a definition and cannot be modified.