



Hydrogenated Nitrile Rubber for Engine Coolant and Oil Sealing

1 Scope

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

1.1.1 Type A. All 35% to 43% acrylonitrile (ACN), Hydrogenated Nitrile Butadiene Rubber (HNBR) gasket or O-ring compound(s) in contact with cooling water and engine oil for application temperatures with a functional temperature range of -5 °C to 150 °C as defined by ASTM D1329 TR10 and SAE J2236 respectively.

1.1.2 Type B. All 25% to 34% acrylonitrile ACN HNBR gasket or O-ring compound(s) with a functional temperature range of -29 °C to 150 °C as defined by ASTM D1329 TR10 and SAE J2236 respectively.

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

1.3 Applicability. This standard covers the use of hydrogenated nitrile elastomer whose function is to seal the cooling system (water pump, oil cooler, or front engine cover, etc.) and engine oil system openings with one (1) part. Type A is used where maximum oil resistance is required (see 1.4.1). Type B has slightly less oil resistance, but improved low temperature flexibility.

1.4 Remarks.

1.4.1 The ACN content of HNBR, influences the oil resistance of the compound. High ACN (35% to 43%) provides excellent oil resistance but sacrifices low temperature flexibility. Low temperature HNBR typically has an ACN of 18% to 23%.

1.4.2 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.

1.4.2.1 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 O-ring inside diameter (ID) to cross section width should be 9 to 1 or greater.

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

Of greater interest is tensile stress at 20% to 50% elongation because it is closer to the performance range of the O-ring.

1.4.3 Rubber Adhesion to Carrier (Edge Molded Design). Rubber must 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 degree or 180 degree 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 (1) pass (downward and upward) is sufficient. There must be no loss of elastomer to metal adhesion or elastomer cracking under 2x magnification.

1.4.4 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 (SOR) Appendix C, and corporate prints and drawings using Section 8 Coding.

2 References

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

2.1 External Standards/Specifications.

ASTM D395	ASTM D1418	ISO 1101	JIS K6253
ASTM D412	ASTM D3182	ISO 1629	JIS K6258
ASTM D471	ASTM D4968	ISO 1817	JIS K6261
ASTM D624	ISO 34-1	ISO 16949	SAE AS568-214
ASTM D1329	ISO 37	ISO 17025	SAE J2236
ASTM D1414	ISO 48	JIS K6251	
ASTM D1415	ISO 815-1	JIS K6252	

2.2 GM Standards/Specifications.

GMW3059	GMW16678	GMW17113	GMW17205
GMW3155	GMW16955		

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 and Cellular Products
- Automotive Industry Action Group (AIAG) D22: Best Practice Unified Procedure for Approval of Rubber, Southfield, Michigan (www.aiag.org)
- Axel Products, Incorporated, Ann Arbor, Michigan (www.axelproducts.com)
- Component Technical Specification (CTS)
- GM Global Document Management (GDM)
- Statement of Requirements (SOR), Appendix C

3 Requirements

3.1 Compound Characterization for Finite Element Modeling (Table 1). 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.

3.1.1 Test Samples. Unless otherwise specified, the shape and size of test pieces shall be in accordance with the relevant test procedure and comply with 3.1.5.1. If not otherwise stated, mechanical properties in delivery state and after heat or fluid immersion are to be tested at +23 °C and with the same test methods.

3.1.1.1 Microhardness (Surface). Part microhardness measurements, per ASTM D1415, Type M or ISO 48, Method M. Surface measurements shall follow conditions 3.1.1.1.1 through 3.1.1.1.5.

3.1.1.1.1 A 1.5 mm minimum specimen thickness. Specimen must be solid.

3.1.1.1.2 Measurements from an edge must be 2 mm or more.

3.1.1.1.3 Reading locations must be 6 mm apart; however, the reverse side may be used.

3.1.1.1.4 The top and bottom surfaces must be parallel (5 degrees or less) and flat.

3.1.1.1.5 Repeat readings must be on the same cross sectional thickness.

3.1.1.1.6 Test Area (definition). The test area is the location of the specimen which the indenter is used. The surface to be measured is as molded, not buffed and uncut. The surface shall be smooth, clean, and free from cavities or orange peel. In case of gaskets without flat surface portion, the measurement must be done on the cross section to avoid influence of the shape. In this case, the remark measured on cross section must be stated on drawing and in the test report.

3.1.1.1.7 Test pieces taken from elastomeric components shall be 4.4 mm width, 6 mm to 20 mm length, and 1.5 mm thickness. Laminated test pieces are not permitted. Press-in-place gaskets may use a stabilization feature as a microhardness measurement pad. The pad must be 4.4 mm × 4.4 mm. The indenter width is 0.4 mm. Only a single measurement can be made from one (1) surface pad. Alternatively, the test pieces can be embedded in plastic resin. For more information, see all of Appendix A.

3.1.1.1.8 Specimens taken from sheets, shall have a test area of 20 mm × 40 mm and a thickness of 2 mm ± 0.5 mm. The upper and lower surface flatness tolerance is 0.1 mm to ISO 1101 and parallelism tolerance 0.2 mm to a diameter of 150 mm (measured on a ASTM D3182 slab before cutting).

3.1.1.1.9 Test pieces taken from elastomeric rings or profiles shall have a diameter of at least 1.5 mm and a thickness of at least 1 mm. The cut area shall be such that the distance between the points of test of the test piece to an edge shall be at least 0.75 mm (in case the test piece is embedded in resin).

3.1.1.2 Microhardness (Cross Section). When part surface measurement is not practical or desired, the cross section of the part is measured when supported in captive resin. Part microhardness measurements are made per ASTM D1415, Type M or ISO 48, Method M. Measurements shall follow the Appendix A, Figure A1 conditions.

3.1.2 Conditioning. Conditioning shall be as specified in the relevant test procedure.

3.1.2.1 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.

3.1.3 Equipment. Conforming to the relevant test procedure.

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

3.1.5 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.

3.1.5.1 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 (International Organization for Standardization) standard and vice versa. Only use the equivalent standards listed in Table 2. This also means the approved compounds are equivalent.

3.1.6 Facilities. Conform to the relevant test procedures.

3.1.6.1 GM North America Powertrain Only. All data must be generated by an ISO 17025, ISO 16949, or a GM accredited laboratory.

3.1.7 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.

3.1.7.1 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.

3.2 Material and Performance Requirements.

3.2.1 Minimum Lot Testing. Material and performance properties are summarized in Table 2. For full approval of a sealing, compliance to the requirements of Table 2 is needed. A minimum of three (3) production lots of compound shall be tested to each of the requirements for Design or Product Validation Testing.

3.2.2 Audit/Inspection Testing. If not defined otherwise, the following testing should be done for production audit testing beyond the approved supplier process plan. Three (3) samples of material shall be tested to each of the requirements for Audit/Inspection Testing. All tests per Table 2, except those at or more than 336 h and Joint Sealing Function.

3.2.3 Product Validation Testing/Audit/Inspection Testing. If not defined otherwise, the following testing should be done for production audit testing:

- Material properties to Table 3.

3.2.4 Table 2 properties for Type B O-rings represent cross section diameters of 1 mm to 3.5 mm.

3.2.4.1 O-ring Test Conditions. Only compounds used for O-rings require testing to O-ring conditions. Table 2 properties for Type B O-rings are from the SAE AS568-214 dimensions.

- Test Spool Diameter: 12.7 mm
- Test Pull Rate: 254.0 mm/minute

3.2.5 Sealability. Test production intent parts on required joint hardware to GMW3155.

3.2.6 Managing Change. Any change in cost, design, function, properties, manufacturing process, and/or location of manufacture to the component or material, requires a new release of the product. It is the sole responsibility of the supplier to immediately provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier before start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.2.6.1 GM North America GM Powertrain Only. Elastomer polymer or ingredient changes to the approved production compounds are made by submitting the Automotive Industry Action Group (AIAG) D22 Template, titled "**Best Practice Unified Procedure for Approval of Rubber**", assigning a number(s) to the appropriate listed changes, and a Supplier Production Change Request (SPCR). GM report forms are available from GM Powertrain (GMPT) Engine Materials Engineering. Submit a completed D22 form to GMPT Materials Engineering before submitting a SPCR.