



Engine Cover Gaskets

1 Scope

This standard describes the materials and performance requirements for fuel and oil vapor resistant gaskets, used in automotive engine cover applications. Engine Oil Pan gaskets are specified in GMW3083. The constructional and component features covered by this commodity standard are described in 1.1.2 and Table 2. Do not use this document for applications outside the Scope and 1.3, of this standard.

1.1 Material Description. Materials covered by this specification are divided into classes and types of oil and fuel resistant elastomers. Table 1 describes the Class (B, C, etc.) of elastomers meeting the designated temperature range, and Type 1 and Type 2 meeting the designated application (gasoline or diesel engine). Part performance requirements are in 3.9 and Tables 5, 7, 9, 11 and 16. See Remarks in 1.4 through 1.4.3.

1.1.1 Part Constructions. Construction usage code letters that apply to this standard are listed in Table 2.

1.1.1.1 Code letters designate specific tests that apply only to that construction and/or material for detail drawing specifications. See Section 8.

1.2 Symbols. Plastic and rubber parts shall be marked with a symbol to designate the type of material from which the part was fabricated for the purpose of collection and handling of parts for recycling.

1.2.1 Elastomer Marking Symbol. Mark rubber parts weighing more than 200 g per GMW3116.

For example:

- Fluorocarbon >FKM<.
- If practical, place the part number, your company Association for Rubber Product Manufacturers (ARPM) letter code, cavity number and mold date (mm/yy) on the part. Characters shall be visible, and not in a location that adversely affects form, fit, or function.

1.2.2 Plastic Marking Symbol. Mark plastic parts weighting more than 100 g per GMW3116.

For example:

- Polyamide with Glass Fibers >PA-GF30<

1.3 Applicability. See Table 1. Only parts fitting the scope and application may use this specification. Because of the differences in engine cover system design within GM, covers including crankcase vapor function shall be tested to Tables 14 and/or 15.

1.4 Remarks. Approved compound properties for each type of elastomer are listed in Tables 4, 6, 8, 10, 12, 13, 14 and 15. Table values by type are a compilation of data from multiple approved compounds and hardness ranges.

1.4.1 Plastic carrier (Cp) gaskets with coolant ports require heat and hydrolysis stabilized nylon per GMW16270. Gaskets without coolant ports may use heat stabilized nylon per GMW3038. See Table 2.

1.4.2 Fluorocarbon Behavior in Fuel Diluted Oil. For methanol and ethanol diluted oil conditions the percent fluorine level (higher is desired) is most important. In biodiesel diluted conditions with oil, the cure type (peroxide) and no metal oxides take precedence over percent fluorine. The metal oxides have no significant impact on fluorocarbon (FKM) Type II, III, IV or V peroxide cure systems. There is no impact on color choice for carbon black filled and mineral filled systems. There are variations in what are called metal oxides. For example, ceramic type mineral systems are metal oxides and are being used successfully in mobility systems where zinc, calcium or magnesium oxides would not be successful in that application.

1.4.3 This standard contains provisions for gaskets with crankcase vent function (see 3.1.7).

1.4.4 Select the class and type intended for the end use needs. Table 1 temperatures represent the continuous operating range for all approved compounds in that class as measured in air at atmospheric pressure.

1.4.5 Compounds Represented in Tables. The majority of elastomer compounds represented in the current property tables are for sealing metal to metal joints where micro-hardness ranges from 55 International Rubber Hardness Degrees (IRHD) to 75 IRHD. Plastic covers use lower hardness gaskets where part micro-hardness ranges from 40 IRHD to 60 IRHD. Adjustments in existing tables or new tables may be required as softer gaskets for metal to composite cover joint applications are developed.

Table 1: Material and Application Criteria Designation

Class	Type	Temperature Range Degrees Celsius Note 1	Application	Elastomer Note 2	Table Reference
B	1	-20 to 165	Gas engine. Moderate low temperature. Legacy and non-fuel dilution tested.	ACM	4, 5, 12, 13
B	2	-20 to 165	Diesel engine. Moderate low temperature. Legacy and non-fuel dilution tested.	ACM	4, 5, 12, 13
B	3	-25 to 165	Gas engine. Improved low temperature. Fuel dilution 5% to 10% by volume. Under constant immersion or high exposure.	ACM	4, 5, 12, 13
B	4	-20 to 165	Diesel engine. Moderate low temperature. B10 dilution 5% to 10% by volume. Under constant immersion or high exposure.	ACM	4, 5, 12, 13
C	1	-18 to 150	Gas engine. Legacy and non-fuel dilution tested.	HNBR	6, 7, 12, 13
C	2	-18 to 150	Diesel engine. Legacy and non-fuel dilution tested.	HNBR	6, 7, 12, 13
C	3	-25 to 150	Gas engine. Better low temperature. Fuel dilution 5% to 10% by volume. Under constant immersion or high exposure.	HNBR	6, 7, 12, 13
C	4	-25 to 150	Diesel engine. Better low temperature. Fuel dilution 5% to 10% by volume. Under constant immersion or high exposure.	HNBR	6, 7, 12, 13
D	1	-15 to 175	Gas engine. Legacy and non-fuel dilution tested. High temperature resistance.	FKM/FPM	8, 9, 12, 13
D	2	-15 to 175	Diesel engine. Legacy and non-fuel dilution tested. High temperature resistance.	FKM/FPM	8, 9, 12, 13
D	3	-29 to 165	Gas engine. Improved low temperature, high cost. Flex fuel and oil resistant.	FKM/FPM	8, 9, 12, 13
D	4	-29 to 165	Diesel engine. Improved low temperature, high cost. Flex fuel and oil resistant.	FKM/FPM	8, 9, 12, 13
E	1	-25 to 165	Gas engine. Fuel dilution 5% to 10% by volume. Under constant immersion or high exposure.	AEM	10, 11, 12, 13
E	2	-25 to 165	Diesel engine. B10 dilution 5% to 10% by volume. Under constant immersion or high exposure.	AEM	10, 11, 12, 13

Class	Type	Temperature Range Degrees Celsius Note 1	Application	Elastomer Note 2	Table Reference
Supplemental Testing					
S	1	Not Applicable	Gas engine (especially turbo). BMW Worst Case Used Oil testing required where crankcase ports are part of the gasket design and function.	ACM, AEM, FKM/FPM, HNBR	14
S	2	Not Applicable	Turbo Diesel engine only. BMW Worst Case Used Oil testing for crankcase vapor resistant.	ACM, AEM, FKM/FPM, HNBR	15

Note 1: As defined by ASTM D1329 TR10 and SAE J2236 respectively.

Note 2: Nomenclature as defined by ASTM D1418 or ISO 1629.

Note: ACM = Polyacrylate, AEM = Ethylene Acrylic, FKM/FPM = Fluorocarbon Rubber, HNBR = Hydrogenated Nitrile Rubber, BMW = Bavarian Motor Works.

Table 2: Construction Usage Code Letters

Construction Feature	Code Letters
Elastomer with Carrier: Plastic carriers are designated with a lower case letter "p" after this letter.	Cp
Elastomer with Carrier: Metal carriers use a lower case "m" after this letter.	Cm
Elastomer Only: Press-in-place designs for a machined or as cast groove.	E
Sealants: Formed-in-place compounds, e.g., Room Temperature Vulcanized (RTV) sealants are specified by 998 bulk part number released by GMNA. Print notes shall reference the appropriate functional performance elements of this standard if sealants are the chosen compounds. See example in 8.1.	S

2 References

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

2.1 External Standards/Specifications.

ASTM D297	ASTM D1418	ISO 37	ISO 4650
ASTM D395	ASTM D1505	ISO 48	ISO 7111
ASTM D412	ASTM D2240	ISO 815	ISO 7619-1
ASTM D471	ASTM D3182	ISO 1101	ISO/IEC 17025
ASTM D624	ASTM D3677	ISO 1629	ISO/TS 16949
ASTM D1094	ASTM E1131	ISO 1817	SAE J1351
ASTM D1329	IEEE/ASTM SI 10	ISO 2781	SAE J2236
ASTM D1415	ISO 34-1	ISO 2921	SAE J2979

2.2 GM Standards/Specifications.

GMW3038	GMW3155	GMW16095	GMW16955
GMW3059	GMW14724	GMW16270	GMW17081
GMW3083	GMW14914	GMW16317	GMW17113
GMW3116	GMW15117	GMW16678	GMW17205

2.3 Additional References.

- Association for Rubber Product Manufacturers (ARPM), Indianapolis, Indiana (www.arpminc.com)
- 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, Ann Arbor, Michigan (www.axelproducts.com)
- Component Statement of Requirements (SOR)
- Component Technical Specification (CTS)
- Environmental Protection Agency Stewardship Program
- Handbook for Molded, Extruded, Lathe Cut and Cellular Products
- ISP-The Testing Institute Salzbergen GmbH & Co. KG (www.isp-testing.com)
- Vehicle Technical Specifications (VTS)

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 3: 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 Minimum Data Requirements. Elastomer compound candidates specification values (with noted exceptions) are statistically based on a six (6) sigma limit spread in normal distribution data from a minimum of six (6) production lots and three (3) to five (5) data points per test requirement. Tentative approval, signified by the letter **T**, will be given based on data from one (1) production and three (3) laboratory lots or three (3) production lots. Tier 1 sources shall be responsible for continuing to submit data until the total number of samples is met for full qualifications as stated in the first (1st) line of this paragraph. Appropriate industry statistical standards, methods or practices should be used when generating data.

3.1.2 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 Number of Test Specimens. New elastomer approvals shall be based on the median of five (5) specimens per test unless otherwise specified. Tests designated as once for initial approval, not for further statistical analysis, shall be run on a minimum of three (3) specimens, with each specimen meeting the stated requirements. A GM data reporting sheet is available for this standard and will be used to submit all test results. The template document is available from GM Powertrain Materials Engineering.

3.1.4 Test Frequency. Chemical requirements per 3.8.1, long term aging tests, (e.g., ≥ 1008 h) in Tables 4, 6 and 8 and part performance requirements in Table 16, except part micro-hardness and adhesion, shall be performed once for initial approval. Should the compound change as defined in 3.4, all tests shall be repeated. Unless otherwise specified in the test procedure, all once for initial approval tests and compression set tests shall be run on three (3) specimens from one (1) production batch with each meeting the requirements. The noted exceptions, part micro-hardness and adhesion (carrier gaskets) shall be run on five (5) random samples at two (2) widely diverging points on the part from each of three (3) production lots. Report all individual values. The remaining tests in Tables 4 through 8 shall be performed on a minimum of six (6) batches described in 3.1.1. Upon completion of the data requirements for table development, the approved compound source is only required to satisfy ISO/TS 16949 requirements, PPAP (Appendix C), and the approved supplier's internal test frequency. For statistical reporting of data, use the GMW14724 test matrix available from GM Powertrain Group (GMPTG) Materials Engineering. Report all individual values.

3.1.5 Qualifying to Existing Table Requirements. Each candidate elastomer compound shall meet the table, and section item requirements. Individual compound property tests represent characteristics that are significant to the intended usage (from Table 1, temperature range and application columns). All table data can represent the collective property profile of more than one (1) compound and hardness. Therefore, it may be inappropriate to use this data for quality control of a single compound.

3.1.5.1 All elastomer approvals are granted based on ASTM D3182 slab data. Part table testing becomes relevant for validation, audit, or field studies after the part is available and produced from production intent tooling. When more than one (1) production source or tool is providing parts, it is the Tier 1 source responsibility to evaluate parts from multiple mold cavities and tooling as required by the design and release responsible product engineer.

3.1.5.2 A material approval may be granted to gas or diesel only, or both. Such use distinctions shall be captured in the design and material approval database by the responsible engine material engineer.

3.1.6 Global or Cross Regional Compounds. Compound formulations produced in more than one (1) mix facility but sharing a common compound identification, shall be subject to review. The level of testing and approval may be by polymer source and/or mix site depending on the variation permitted in ingredient selection and process conditions. Approvers are responsible for tracking production compound history and managing local variation as part of the formal approval process. Approval and material database records will capture the relevant mix locations.

3.1.6.1 Contingency. As part of the approval process, each compound supplier shall have a designated alternative mix operation. Compound from that location(s) shall be evaluated to 3.1.1 tentative approval conditions.

3.1.7 Supplemental Tests – Resistance to Crankcase Vapor. Elastomers for cover gaskets that include crankcase vapor ports in their design must be tested to BMW Worst Case Used Oil and meet all the requirements of Table 14 (naturally aspirated and turbo gas engines) or Table 15 (turbo diesel only). Pressure vessel testing is required for the 168 h test conditions. No change in test fluid is required for the 168 h. Those labs with a GMW16678 setup may use it (replace the 35 kPa (5 psig) valve with a 690 kPa (100 psig) valve) because constant test fluid stirring is part of the equipment. To maintain consistent results over time, always use the same volume of test fluid to specimen volume. See 3.2.6.1 on fluid ordering and handling.

3.2 Test Preparation and Evaluation.

3.2.1 Test Samples. Unless otherwise specified, the shape and size of test pieces shall be in accordance with the relevant test procedure and comply with 3.1.2.

3.2.1.1 Elastomer Test Specimens Parts. A part must have a 35 mm minimum straight length to qualify for testing. When preparing tensile test specimens from finished parts, in some cases, not all dimensions of the ISO 37 type 4 dumbbell can be obtained as specified, e.g., the width of the ends. These test specimens can still be used, if the narrow portion has the correct specified value and a widening of the ends of the dumbbell exists.

The test specimen should have the following properties:

- The ends of the dumbbell, where it is clamped, should be at least twice the width of the narrow portion of the dumbbell. This increase in width should be symmetrical about the narrow portion of the test specimen.
- The length of the tab ends must be sufficient to ensure secure clamping.

3.2.2 Property Requirements. In Tables 4, 6, 8, 10, 12, 13, 14 and 15, follow ASTM or ISO method requirements for test specimen selection if the compound is anisotropic or mill/flow direction is known. Report results in the direction indicated by the ASTM or ISO method. If no direction is indicated, test and report in the lowest result direction.

3.2.3 Conditioning. Condition as specified in the relevant test procedure.

3.2.4 Equipment. Conforming to the relevant test procedure.

3.2.5 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.

3.2.6 Test Fluids. Test parts (Tables 5, 7, 9 and 11) in designated fluids. Consult the GM engine fuel and lubricant group to obtain further approved source information.

3.2.6.1 BMW Worst Case Used Oil. This test oil developed by BMW and is available from ISP Salzbergen GmbH & Co. KG at www.isp-testing.com. Other suppliers may become available. Because it is a mixture, long term storage will likely result in phase separation (see ASTM D1094 to evaluate phase separation). It must be shaken or stirred to a homogenous mix before entering the pressure vessel. During testing the solution must be constantly stirred. The mixing controls, stability and batch to batch consistency are unknown, therefore, order only the amount required for completing testing. Record the fluid batch number in all test reports.

3.2.7 Compression Set Testing of Parts (Tables 5, 7, 9 and 11). Press-in-place gaskets shall be compressed lying on their side. Side stabilization features must be removed if they occur in the tested length. The minimum specimen width for testing shall be 10 mm minimum. Avoid grinding to reach parallel plane conditions that would introduce unwanted heat into the specimen.

3.3 Test Units. Report data in the appropriate International System of Units (SI) using the Institute of Electrical and Electronic Engineers (IEEE)/ASTM SI 10 document.

3.4 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.

3.4.1 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, assigning a number(s) to the appropriate listed changes, and a Supplier Production Change Request (SPCR). GM report forms are available from GM Powertrain Engine Materials Engineering. Submit a completed D22 form to GMPT Materials Engineering before submitting a SPCR.

3.5 Plastic Constructions (Cp). Part properties have to be defined on part drawing. References to plastic material should contain the appropriate GMW or regional standards for the approved materials. Approved material sources are found in MATSPC. For regional North America applications, use GMW17081 to specify part properties. See Table 2.

3.5.1 Regrind. Regrind is defined in GMW3116. A production part molder/supplier must identify for development and production test parts the intended level and to test to that maximum level. It is the responsibility of the molder/fabricator and material source to establish what level can be used, number of reuses, blend ratios, etc., and provide data that the values stated on the detail drawing can be met (at that regrind (RE) level). Only

dedicated, reprocessed, approved material can be used with virgin stock. Reprocessed feed streams must be separated by percent base polymer (e.g., percent fluorine in FKM/FPM), cure system, and color if integral and used only in like compounds. Parts must be tested for specification limits and validated at the maximum production intent regrind level. A 10% maximum plastic regrind is recommended. Prints without a regrind reference or GMW17081 code are to use 100% virgin material.

3.6 Facilities. GM North America Powertrain Only. All data must be generated by an ISO/IEC 17025, ISO/TS 16949 or GM accredited laboratory. See 3.6.2.

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

3.6.2 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.

3.7 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3.8 Additional Table Requirements.

3.8.1 Chemical Requirements Characterization Tests. To verify a finished part or slab specimen matches the original validated compound, compare them using one (1) or a combination of the following tests and the tests specified in Table 5, 7, 9 or 11.

3.8.1.1 Infrared Spectroscopy: ISO 4650 or ASTM D3677.

3.8.1.2 Thermogravimetric Analysis, Temperature Scanning Method. ISO 7111 or ASTM E1131, first (1st) derivative to determine composition.

3.8.1.3 Density or Specific Gravity: ASTM D297, hydrostatic method, ASTM D1505, density gradient or ISO 2781. Values shall be included on the part print with a ± 0.02 range for mass calculation.

3.8.1.4 Micro-hardness (Surface). Part micro-hardness measurements, per ASTM D1415, Type M or ISO 48, Method M. Surface measurements shall follow conditions 3.8.1.4.1 through 3.8.1.4.5.

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

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

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

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

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

3.8.1.4.6 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 test report.

3.8.1.4.7 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 micro-hardness measurement pad. The pad must be 4.4 mm $\times$ 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 3.8.3 and all of Appendix A.

3.8.1.4.8 Specimens from sheets test area are 20 mm $\times$ 40 mm and a thickness of 2 mm $\pm$ 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).

3.8.1.4.9 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).

3.8.2 Micro-hardness (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 micro-hardness measurements are made

per ASTM D1415, Type M or ISO 48, Method M. Measurements shall follow the Appendix A, Section A1 conditions.

3.8.3 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.

3.8.4 State of Cure. Use part micro-hardness range (± 4 IRHD) to address a potential under cured part condition. Micro-hardness ten (10) or more points below the specified minimum on new molded parts should be investigated for under cure. The nominal micro-hardness value for prints is established on 30 finished parts spread across the entire six (6) production lot submission (3.1.1 Minimum Data Requirements) before PPAP and must be called out as separate item, not just GMW17377. See 8.1.2. Use compression set per ASTM D395, Method B to evaluate state of cure for parts. Use the Appendix A, Table A1 Cure Test Table, curing the compound at various times and temperatures to set up the test specimens for defining the 90% cure compression set limit. Those compression set specification limits will depend on the final test conditions.

3.8.4.1 Optional Cure Measurement. A Design Release Engineer (DRE) has the option to specify proper cure on the drawing at PPAP when the part shape/profile does not permit accurate repeatable micro-hardness or compression set measurement. Cure measurement is recommended for critical internal parts, compliance to motor vehicle safety standards, or high cost to repair situations. Appendix A, Section A2 describes the procedure to establish a maximum relative cure index using Nuclear Magnetic Resonance (NMR), Dynamic Mechanical Thermal Analysis (DMTA) or solvent techniques.

3.8.4.2 Techniques. Use NMR, GMW15117 DMTA method or extraction by equilibrium solvent swell technique to establish at a maximum relative cure rate index, T2 (1), value (X.XXX) on designated parts before PPAP (the value generated from the NMR testing is compound specific, the X values express the limit to the right of the decimal place). A T2 (1) value below the maximum, means higher cure level. Use 30 finished parts spread across the entire six (6) production lot submission. Specify the Relative Cure Index (RCI) value for NMR or Swell Index extracted (SIE) on the part print and a test frequency after PPAP, if desired. The solvent chosen has a significant effect on test results and shall only be selected by the compound owner. RCI solvent values tend to be lower than NMR, however, the reporting to develop the maximum RCI using the Table A1 (Appendix A) would be the same.

3.9 Performance Requirements.

3.9.1 Gasket. All parts shall meet the criteria identified in 3.9.1.1 through 3.9.1.8.

3.9.1.1 Part Mold Finish. The part mold will conform to ARPM F3 commercial finish from the current Handbook for Molded, Extruded, Lathe Cut and Cellular Products, unless otherwise specified on detail drawing.

3.9.1.2 Part Appearance. No fully cured production parts shall have these conditions when examined under a microscope at 10x magnification (except as noted).

3.9.1.2.1 Surface irregularities, (e.g., knit, splay, flow lines or internal porosity) at 100x magnification of the part that would be objectionable or cause functional failure (confirmed by finite element modeling).

3.9.1.2.2 Torn elastomer (scallops) upon demolding or flash removal.

3.9.1.2.3 Distortion that would not permit proper assembly, pass dimensional requirements, or leads to functional failure.

3.9.1.2.4 Striation or delamination.

3.9.1.2.5 Elastomer excessively soft or tacky to touch.

3.9.1.2.6 Illegible print required identification markings.

3.9.1.2.7 Bloom. Compounds are screened using GMW16317, Method A at 103 °C, the upper temperature in the cycle. Use intended production shipment method packaging (e.g., plastic sealed bags). No bloom is permitted.

3.9.1.2.8 Contamination from other compounds due to improper cleaning of process equipment. Trace element analysis by scanning electron microscope can detect residual contaminants.

3.9.1.3 Color. The elastomer gasket must be uniform in color, with sufficient contrast to be detected by plant optical equipment.

3.9.1.4 Odor (SAE J1351). Test a dry molded gasket within 6 h of the minimum time (typically 48 h) required for an emergency shipment to reach the appropriate GM assembly location. See Table 5 for requirements.

3.9.1.5 Testing part tensile properties per Table 5, 7, 9 and 11 is only possible if ISO 37 Type 4 specimens can be cut from the production part. The remaining tests must be performed on test pieces provided they have suitable dimensions. See 3.2.1.1.

3.9.1.6 Sealability. Unless otherwise specified, test one (1) or more parts on required joint hardware at the minimum load and least material condition stack using GMW3155. Evaluate to GMW3155 criteria for the appropriate part or application.

3.9.1.7 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 90 degree or 180 degree pull (to the carrier) shall result in tearing of the rubber (cohesive). A cut (up to 12 mm) between the rubber and carrier is permitted to facilitate gripping of the rubber. A clean adhesive failure (no rubber to carrier) over the tested distance is not acceptable. This method is used by manufacturing for quality control inspection of a bonded joint.

3.9.1.7.1 Non-destructive Test (Edge Molded Design). This alternative method uses an interference fit, post die for small openings where the die is the exact shape of the opening or a straight segment rule die that passes through the opening and deflects or bends the edge bonded rubber. For open segment tests (e.g., front cover horseshoe shape), the carrier must be securely clamped to prevent movement during deflection of the edge bonded elastomer. The die edge must make contact at the midpoint 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. This alternative method is used for by manufacturing for quality control inspection of a bonded joint.

3.9.1.7.2 Functional Test Adhesion. Rubber must be secure to the carrier per GMW3155 criteria.

3.9.1.8 Specify part micro-hardness IRHD to ASTM D1415 or ISO 48 Method M on the part print. See 3.8.1.4.

3.10 Material Requirements. Material only requirements are summarized in Tables 4, 6, 8, and 10. Materials are approved using the class and type designations in Table 1 and the table references. See 3.1.5 through 3.1.5.2.

3.11 Design Validation Testing. For approval to gas only, run to Type 1 condition in Table 1 (using the table references) for the material class chosen. For approval for diesel only, run to Type 2 conditions in Table 1 (using the table references) for the material class chosen. For approval of a compound to the gas and diesel requirements, run the selected class to Type 1 and Type 2 designated table requirements running all fluids.

3.12 Product Validation Testing/Audit/Inspection Testing. If not defined otherwise, the following testing should be done for production audit testing: Material to the appropriate Table 5, 7, 9 or 11.

3.13 Part Performance Requirements. Per 3.9, Tables 5, 7, 9 and 11. As stated in 3.1.5.1, part testing is only relevant after material approval. Successful completion of GMW3155 is required as part of validation.

Table 4: Properties for ACM ^{Note 1}

Property	Test Procedure	Unit	Value
Micro-hardness			
Class B, All Types	ASTM D1415 or ISO 48, Method M	IRHD	See part drawing ± 4 point range
Hardness			
Class B, All Types	ASTM D2240 or ISO 7619-1	Shore A	To be reported
Density			
Class B, All Types	ASTM D297, ASM D1505 or ISO 2781	Grams/cubic centimeter	To be reported
Elongation at Break			
Class B, All Types	ASTM D412, Die C or ISO 37, Type 2 dumbbell, 200 mm ± 20 mm/minute	Percent	165 Minimum