



Adhesive/Sealant, Room Temperature Vulcanizing, Alkoxy Cure for Engine Sealing

1 Scope

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

1.1 Material Description. This standard describes the material and performance requirements of a one component, room temperature vulcanizing (RTV), silicone rubber formed-in-place gasket (FIPG) for use in GM assembly plant operations and service.

This adhesive/sealant requires no catalyst or heat to cure. When applied, it reacts with moisture in the air releasing an alcohol (methanol) by-product and fully cures to an elastomeric product, adhering to most clean surfaces without need of a primer. Adhesively bonded and fully cured adhesive/sealant acts as a barrier against oil migration across mating surfaces. The curing reaction releases no methyl ethyl ketoxime (MEKO).

1.2 Symbols. Not applicable.

1.3 Applicability. FIPG for sealing engine covers, pans or mating of other components for oil seal integrity or to restrict dust or unwanted air and water intrusion. This sealant complies with MEKO-free requirements. It is intended for oil use only.

1.3.1 Application Temperature and Assembly Sequence. Unless otherwise specified by the adhesive/sealant manufacturer, apply this adhesive/sealant on the intended surface whose temperature is from 20 °C to 40 °C. At temperatures < 20 °C, adhesion and cure rate slows. It is the responsibility of the applicator and the adhesive/sealant manufacturer to establish the accepted conditions, e.g., process time from applied bead to assembly to air test, temperature and adhesive/sealant cure rate to provide acceptable adhesion and leak test performance. See Assembly, Sealing and Fastening Bill of Materials (BOM) Level II for minimum process time.

1.3.1.1 Continuous Upper Temperature. Up to 165 °C as defined by SAE J2236 (see 3.2.2.1 and Table 3). Use temperature is a material strength measurement, not related to adhesion performance.

1.3.2 Other Surface Treatments. The adhesive/sealant approved to this standard must be applied after paint or coated part treatments (e.g., cathodic electrodeposition paint operation (ELPO)/Uniprime coatings of stamped steel covers). It is the responsibility of the applicator and the adhesive/sealant manufacturer to establish the accepted conditions, e.g., time, temperature and coating cure to provide acceptable adhesion and leak test performance. Use standard test panels if available.

1.3.3 Cleanliness of Mating Joint Surfaces. It is the responsibility of the applicator and the adhesive/sealant manufacturer to establish the accepted surface conditions, e.g., washer cleaner concentrations, drying time, and storage protection from airborne contaminants to provide acceptable adhesion and leak test performance.

1.3.3.1 Monitoring Cleaning/Washing System Changes on Adhesion. It is the responsibility of the sealant applicator to evaluate changes in chemical cleaning/washing systems over time for parts where sealant is applied. Changes must be supported by lap shear data to evaluate the effect on sealant adhesion. Run the appropriate Table 2 test panels through the relevant washer system changes in production scale or in a pilot size operation. The values must meet or exceed Table 3 values. Any joints receiving plasma treatment as a surface preparation method in production don't require data monitoring of a change in cleaner/washer.

1.3.4 Gap Limitations. Adhesive/sealant is capable of sealing a **gap from 0.1 mm to 1.5 mm**. This is a design control limit determined from the pressure blowout resistance (see Table 1).

1.4 Remarks.

1.4.1 Cost. For North America this MEKO-free sealant is more expensive (\$0.45 USD to \$0.62 USD cents per engine) than MEKO containing adhesive/sealants (e.g., 9986495) based on regional pricing of drums in 2017 for the Cylinder Set Strategy (CSS) engine program. See 1.4.1.2.

1.4.1.1 Cost Applicability. Cost content information is intended to prevent widespread use of MEKO-free sealants for regions where no regulations require it. Contact the Global Purchasing and Supply Chain fluids buyer for current regional cost. Compliance to MEKO-free regulations is a cost driver with little significance to long term exposure risk as supported by airborne measurement and sealant dispensing in well ventilated areas.

1.4.1.2 Sealant unit cost increases with decreasing container size. When conducting cost studies, remember that sealant cost for the same container size will vary with the global region because the supplier has no global unitized pricing for this sealant and currency value fluctuations at the time of purchase.

1.4.1.3 International MEKO limits. At the time of publication, Brazil, Canada, China, Korea and the USA have no MEKO requirements. Only Europe at 1% maximum and Mexico at 2% have airborne limits.

1.4.2 Process Behavior.

1.4.2.1 Cure Rate. The higher the humidity, the faster the cure. Faster cure is desired for narrow flanged joints where air leak pressure is applied soon after the final sealant joint is completed. This adhesive/sealant is slower than ketoxime or acetoxym adhesive/sealants from 10% to 100% relative humidity (RH). Depth of cure inward from an exposed edge for 7 d at 20 °C is 5.7 mm versus 7.1 mm for 9982257.

1.4.2.2 Open Time to Joint Assembly. All RTV sealant joints must be closed and clamped within 8 minutes of the sealant application to the mating flange. Clamped is defined as having a minimum of 80% of the fasteners tightened to the final torque with no two adjacent fasteners untightened (see 7.1, Lateral Joint Movement).

1.4.3 Joint Performance. Measured by lap shear strength (ISO 4587), this sealant has sufficient elongation to maintain adhesion in joints with moderately different rates of thermal expansion. At 1.5 mm it has excellent gap sealing capability. This adhesive/sealant has comparable lateral joint movement (onset of cohesive or adhesive failure) to other alkoxy cure sealants (e.g., 9986493) and good shear strength to metals, however, adhesion to plastics is weak with 100% adhesive separation to nylon. Once the lateral joint movement limit is exceeded (onset of sealant tear), tensile and shear strength is lower than ketoxime and acetoxym cure systems on all metal substrates.

1.4.4 Proper Use of Test Methods. Testing for this standard is based on coupon surfaces and conditions different from those of assembly or service. Standard tests permit comparison between products while attempting to represent a worse case condition related to end use. Testing actual production processes and surfaces is necessary before actions are taken. Use the test matched with the desired property/definition.

For example: Lap Shear strength may be used to measure the effect of sealant and/or process variation (e.g., ineffective surface cleanliness, build variations, etc.) on bond strength provided it mimics the actual production application with all its known variables. Lap shear is a cured property, not a wet uncured characteristic. It shall not be used to set individual process conditions such as open time because tack free time as tested and defined (see 7.1; Cure Speed, Certificate of Analysis, Lateral Joint Movement, Tack Free Time, etc.) is the proper test and can be measured immediately on site under changing conditions.

1.4.4.1 Worst Case Test Conditions. Since bondline adhesion is the most essential sealant property, the following conditions shall be considered for testing the robustness of a sealant.

Adhesion: Worst finish (e.g., smooth or as cast surface finish); worst contaminated surface (e.g., oily or washer residue), maximum recommended gap, slowest cure speed (e.g., lowest temperature and humidity for 7 d cure period). Seven (7) days is the industry standard for all cured test conditions.

1.4.5 Surface Treatments to Promote Joint Adhesion. Demanding and enforcing part cleaning control through cleaning process specifications is necessary for optimum sealant to joint bond life. Surface treatment chemicals (e.g., Henkel BONDERITE) formulated for specific base metals are applied in washer systems or by liquid-soaked applicator to maximize bond performance. These are not cleaners, as maximizers are only effective on a washed surface, but properly applied and protected may be globally shipped and perform long after the application.

1.4.6 Regulatory Restrictions. This sealant is approved for use in every global region.

1.4.7 Fuel Dilution in Engine Oil. This sealant lap shear testing to GMW16678, Condition A, Solution E fuel dilution (see Table 3, Note 1) produced adhesive not cohesive separation from the test panel substrates. Testing of production surfaces for adhesion evaluation is mandatory for engine joints where the fluid level is above the joint whether the engine is on or off. The results on engine joints exposed to measured fuel dilution conditions will dictate use.

1.4.8 Foam Stability. The curing sealant has a tendency to foam in GM Dexos® 0W20 oil. The 0W20 oil by itself foams in ASTM D892, Sequence II and III tests. The values after 5 minutes and 10 minutes in Table 1 represent the sealant contribution portion of the foaming limits. The sealant contribution to foaming will not dissipate until the sealant is fully cured and the oil changed.

2 References

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

2.1 External Standards/Specifications.

ASTM A48	ASTM D892	IEEE/ASTM SI 10	SAE J1864
ASTM B209	ASTM D1002	ISO 37	SAE J2236
ASTM C679	ASTM D1875	ISO 4587	SAE J2643
ASTM C1183	ASTM D4339	MIL-A-46146	
ASTM D412	ASTM F2523	SAE 1008/1010	
ASTM D429	EPA Method 24	SAE J243	

2.2 GM Standards/Specifications.

9982257	GMW3016	GMW16678	GMW17332
9985776	GMW3059	GMW16855	
9986493	GMW14270	GMW17205	
9986495	GMW15735	GMW17224	

2.3 Additional References.

- ACT Test Panels available at <https://acttestpanels.com/pages/test-panels>
- American Petroleum Institute (API), 1220 L Street, NW, Washington, DC 20005-4070 USA
- ASTM Service Fluids (e.g., ASTM Service Fluid 105) available at <https://www.smithersrapra.com/testing-services/by-material/reference-materials/astm-oils>
- Axle Products, Incorporated; <http://axelproducts.com/>
- Component Technical Specifications (CTS)
- Gardner cup(s) available at <https://gardco.com/pages/density/wpg.cfm>
- Global Document Management (GDM)
- GM Material Property Database (contact the GM Lead Engineer for further instructions)
- GM Materials: GM Dexos® 0W20, 50W oil(s)
- GM Regulatory Resources (GMR2) Program - portal (<https://gmr2.ttsvcs.com/gmr2portal/Home.aspx>)
- Henkel BONDERITE available at <https://www.henkel-adhesives.com/us/en/about/our-brands/bonderite.html>
- Q-Panels available at <https://www.q-lab.com/q-panel-selector/>
- Statement of Requirements (SOR), Component
- Surtronic Duo Surface Roughness Tester available at <https://www.taylor-hobson.com/products/surface-profilers/handheld-surtronic/surtronic-duo-surface-roughness-tester>
- Uniprime by Vista available at <https://www.vistapaint.com/products/4000>

3 Requirements

3.1 Requirements on Test Specimens. Test specimens shall be prepared by the adhesive/sealant supplier according to their established process or practices. Cure for 7 d unless otherwise specified, followed by conditioning for 1 h to 24 h at 23 °C ± 3 °C, 55% RH.

3.1.1 Bulk test specimens slab thickness shall be 2.0 mm ± 0.5 mm with no voids or densification lines in an area convenient to the manufacturer.

3.1.2 Test Units. Report data in the appropriate International System of Units (SI) using IEEE/ASTM SI 10.

3.1.3 Test Conditions. Unless otherwise specified, testing shall be conducted at 50% RH and 23 °C. If temperature and humidity are known not to significantly affect test results, use a relative humidity range of 20% to 90% and temperature range of 20 °C to 32 °C. All test conditions must be within ± 2 h, ± 2 °C and $\pm 5\%$ RH of the specified numbers unless otherwise indicated.

3.1.4 Test Frequency.

3.1.4.1 Mandatory tests and frequency for this sealant requirements are located in GMW16855, Appendix B, Table B1. These conditions were agreed to by the approved sealant manufacturer and are captured in the Certificate of Analysis (COA).

3.1.4.2 Minimum Data Requirements. Sealant specification limits (with noted exceptions) are based on data from a minimum of three production lots per mixing site and three to five data points per test requirement. Tentative approval, signified by the letter T, will be given based on data from one production and three laboratory lots. The sealant source shall be responsible for continuing to submit data until the total number of samples is met for full qualifications as stated in the first line of this paragraph. Appropriate industry statistical standards, methods or practices should be used when generating data.

3.1.5 Sealant Compliance to Document References and Changes. Use the latest published version at the time of submission for approval. After initial approval the purpose of this subsection is to manage future changes and provide approved sealant compliance to those changes in a timely manner.

3.1.5.1 Role and Responsibility. After initial approval, if the referenced standard changes, GM expects the sealant supplier to monitor industry standard documents for changes and evaluate the impact of the change to determine if it affects required limits. GM is responsible for timely notification to suppliers of its own test standards referenced in this document.

3.1.5.2 New Data Requirements and Timing. A change herein is defined as procedural and/or a new limit or range requirement. Data is required only where the change level affects specified limits. A sealant supplier only needs to acknowledge awareness and use for procedure only change(s) that do not produce a requirement change (e.g., conversion of a regional to a global standard). A supplier is only required to run or acknowledge a change(s) that occurred since the initial full data approval. Data must be submitted to GM Engine Material Engineering within 180 business days of the published revision (dd/mm/yyyy) in GM Global Document Management (GDM for GM Standards) or date document arrives at the external standards contract distributor. Time limits may be extended for regulatory health and safety issues only. No testing is required if the revised document has no changes (revision date only change) or the changes don't involve fit, form or function as defined in GMW17205.

3.1.5.3 How Document Changes Affect Sealant Compliance. All product produced after the changes are published in GDM shall meet the new requirements. Product approved under the previous edition requirements and already in the delivery pipeline or in inventory will be used until the product expiration date is reached or the product is used. Decisions involving regulatory changes will be handled separately and existing product may be immediately removed as a result.

3.1.5.4 Table Requirements. Sealant tests and development for 9986350 are derived from GMW16855. Changes to GMW16855 must be monitored in accordance to 3.1.4. The table properties in 9986350 represent only those GMW16855 tests that required data for the specific product and/or the accepted deviations between GM Engine Materials Engineering and the sealant manufacturer. The GMW16855 tests that have specified limits (denoting exceptions) will be run in advance of 9986350. These tests will be listed in Table 1 in ***bold italics*** to confirm their acceptable completion.

3.1.6 Compound Characterization for Finite Element Modeling. The sealant qualifying to this standard must also be entered into the hyperelastic GM Material Property Database (contact the GM Lead Engineer for further instructions) for finite element modeling unless otherwise specified as not required by the Component Statement of Requirements (SOR) or Component Technical Specifications (CTS). If no SOR or CTS exists for sealant or a Finite Element Analysis (FEA) requirement is not listed, the default is to require FEA data collection.

Note: Axel Products, Incorporated is GM's sole global contract test facility as the equipment and test methods used are unique and confidential. Data developed for FEA purposes by another test facility is not recognized. 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. Sealant approval cannot proceed without a submission for FEA characterization.

3.2 Requirements on Delivery.

3.2.1 Sealant Requirements - Uncured. See Table 1.

3.2.1.1 Blowout. Modified ASTM F2523 fixtures with 30 degree and 45 degree chamfer (see Appendix A, A2). Blowout is tested immediately after sealant application to the test fixture to determine the maximum gap allowed under the global air pressure and time requirements for an uncured joint. Testing of this sealant has shown no significant difference in test results between these fixtures.

3.2.1.2 Color. See Table 1. Properties in Tables 1 and 3 are based on the black color. Both colors must pass all requirements of this standard. An exact color match to a standard is not required provided sufficient contrast is measurable at the point of sealant application. Color variation is needed for contrast against light or dark substrates for ease of optical detection.

3.2.1.3 Viscosity. See Table 1 extrusion rate. Subparagraphs were not applicable.

3.2.1.4 Homogeneity. Using the setup in GMW17224, Figure 1 spread the adhesive/sealant on the flat surface. The adhesive/sealant shall be homogeneous, without lumps, gas bubbles, and/or inclusions.

3.2.1.5 Noncorrosive to Metals. See Appendix A, A1.2 for procedure. Evaluate the compatibility of cure reaction by-product with metals. C1 = copper, C2 = 1008/1010 steel, C3 = AA319 or AA356T6 aluminum, C4 = other. If metals are coated, test on production approved coating as specified on the sealant applied joint.

3.2.1.6 Odor (ASTM D4339). Material shall not have an objectionable odor in the uncured state and shall not have a perceptible odor after cure. Use the previously approved production adhesive/sealant as a reference (e.g., 9982257) or earlier batches of this sealant that had no objectionable odor. GM Engine Materials Engineering recommends all RTV adhesive/sealant (regardless of cure system) be used in a ventilated area.

3.2.1.7 Oil Gel Test. No gel must be formed after following the (Appendix A, A1.1) procedure run at 23 °C ± 2 °C temperature and 50% RH ± 5% RH.

3.2.1.8 Specific Gravity. To be determined, and set as part of the specification, at the time of approval. For uncured adhesive/sealant use the ASTM D1875 Gardner cup.

3.2.1.9 Storage Stability (GMW15735). The material when conditioned to the recommended supplier storage conditions (8 °C to 21 °C) must be capable of passing all the performance requirements in Table 1.

3.2.1.9.1 Shipping Stability (GMW15735). As shipped, the material shall be capable of passing all the performance requirements in Table 1. Run the low temperature stability GMW15735, Cycle B.

3.2.1.9.2 Shelf Life. The shelf life of the material, as shipped, in closed containers shall be a minimum of 183 d at a temperature not to exceed 28 °C. The sealant manufacturer defines shelf life from the date of manufacture of that batch (e.g., typically 1 year). The end user shall manage batch shelf life consistent with their usage rate requirements and not accept 183 d product if the product inventory consistent with that time period can't be fully consumed within the 183 d.

Note: All product to GM shall have a manufacturer applied "Do Not Use After" date on the shipping container that shall establish the remaining shelf life.

Note: Under no circumstances shall expired adhesive/sealant be used for production build.

3.2.1.10 Pumpability. Using the previous production adhesive/sealant as a guide, this adhesive/sealant shall be able to be applied through current production dispensing systems. No loss in pump output or increase beyond normal wear or service intervals due to adhesive/sealant shall occur.

3.2.1.11 Silica Producing Volatiles (GMW17224). Start the extraction (GMW17224, Method A) within 8 h of the end of the 1 d cure (see GMW17224, Test Vehicle/Test Piece).