



Adhesive/Sealant, Room Temperature Vulcanizing, Oxime Cure for Engine Sealing Applications

1 Scope

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.

1.1 Material Description. This silicone adhesive/sealant requires no catalyst or heat to cure. When applied wet (uncured) it reacts with moisture in the air (condensation cure) releasing a Methyl Ethyl Ketoxime (2-Butanone) (MEKO) 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.

1.2 Symbols. Not applicable.

1.3 Applicability. Formed-In-Place Gasket 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 product 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 18 °C to 40 °C. Below 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 Usage Temperature. Up to +175 °C as defined by SAE J2236 (see 3.2.2.1 and Table 3). Use temperature as 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 and maintain 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, do not 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 0.7 mm as measured and specified using the pressure blowout resistance test (see 3.2.1.1 and Table 1).

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

1.4.1 Cost. Unless otherwise specified, pricing shall be based on 20 kg (5 gal) pails compared with existing products. Material cost comparison is sealant price per mass (grams) times specific gravity. The quantity of

sealant per pail varies with manufacturer. Cost comparison for decision making must be from engine specific use (grams per component, engine) and annual volumes.

1.4.1.1 Sealant unit cost increases with decreasing container size. When conducting cost studies remember that sealant cost will vary with the global region.

1.4.1.2 Based on the 2013 High Feature V6 engine usage this MEKO sealant costs \$.50 cents less per engine than 9986350 non-MEKO sealant.

1.4.2 Process Behavior. This section compares the process behavior to competitive sealant cure systems.

1.4.2.1 Cure Rate. This silicone adhesive/sealant is slower than acetoxys adhesive/sealants but faster than alkoxy cure sealants (e.g., 9986350) from 10% to 100% Relative Humidity (RH). Depth of cure inward from an exposed edge of two aluminum square plates for seven (7) days at 20 °C is 7.1 mm.

1.4.2.2 Open Time to Joint Assembly. All Room Temperature Vulcanizing (RTV) sealant joints must be closed and clamped within eight (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 (2) adjacent fasteners untightened. See 7.1.1 and 7.1.5.

1.4.3 Joint Performance. This adhesive/sealant lateral joint movement in millimeters (onset of cohesive or adhesive failure) on metal and plastic substrates is in Table 3. Once the lateral joint movement limit is exceeded, tensile and shear strength in megapascals is better than alkoxy cure systems (e.g., 9986350) and lower than acetoxys 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 change in bond strength due to sealant and/or process variation (e.g., ineffective surface cleanliness, build variations, etc.) provided it mimics the actual production application with all its known variables. It shall not be used to set a single process condition such as open time because tack free time as tested and defined (See 7.1.1, 7.1.2 and 7.1.4) is the proper test and can be measured immediately on site under changing conditions.

1.4.4.1 Worst Case Test Conditions. Since bond line adhesion is the most essential sealant property, the conditions per 1.4.4.1.1 shall be considered for testing the robustness of a sealant.

1.4.4.1.1 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 seven (7) day cure period). Seven (7) days is the industry standard for all cured test conditions.
- A joint step chamfer to maximize joint movement capabilities of the sealant.

1.4.5 Regulatory Restrictions. This sealant is approved for use in every global region except the European Union due to restrictions on the release of methyl ethyl ketoxime (2-butanone) during curing.

1.4.6 Reference Oil ASTM SF105. The current supply of ASTM SF105 will be exhausted by May 2018 as the base stock oil is no longer available. Until a suitable replacement is developed, use GMW16955, Code F oil on the next revision.

2 References

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

2.1 External Standards/Specifications.

ASTM A48	ASTM D429	ASTM SF105	MIL-A-46146
ASTM B209	ASTM D471	IEEE/ASTM SI 10	SAE 1008/1010
ASTM C649	ASTM D892	ISO 37	SAE J243
ASTM C679	ASTM D1002	ISO 1817	SAE J1864
ASTM C1183	ASTM D3677	ISO 845	SAE J2236
ASTM D297	ASTM D4339	ISO 4587	SAE J2643
ASTM D412	ASTM F2523	ISO 4650	

2.2 GM Standards/Specifications.

9985776	GMW3059	GMW15735	GMW16955
9986350	GMW3155	GMW16678	GMW17205
GMW3016	GMW14270	GMW16855	GMW17224

2.3 Additional References.

- American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070 USA
- Assembly, Sealing and Fastening Bill of Materials (BOM) Level II
- Global Document Management (GDM)
- GM Regulatory Resources (GMR2) Program - portal [<https://gmr2.ttsvcs.com/gmr2portal/Home.aspx>]

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 seven (7) days unless otherwise specified, then condition for 1 h to 24 h at 23 °C ± 3 °C and 50% ± 5% Relative Humidity (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. If practical, report data in the appropriate International System of Units (SI) using the latest Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing and Materials International (ASTM); IEEE/ASTM SI 10 document.

3.1.3 Test Conditions. Unless otherwise specified, testing shall be conducted at 50% RH and 23 °C. If temperature and humidity are known to not significantly affect test results, use a 20% to 90% relative humidity range and an 18 °C to 32 °C temperature range. All test conditions must be within ± 2 h, ± 2 °C and ± 5% RH of the specified numbers unless otherwise indicated.

3.1.4 Test Frequency. The following tests (see 3.1.4.1a thru 3.1.4.1e) should be identified in the supplier process control plan and performed at the frequency indicated once the requirements of Table 1: Material Properties - Uncured Adhesive/Sealant Requirements are complete.

3.1.4.1 Run the following on every batch or lot provided by the adhesive manufacturer.

- Color
- Contaminants
- Homogeneity
- Inclusions, relative density (specific gravity)
- Viscosity (application rate) and tack free time

3.1.4.2 Test stability and extrusion rate at a suitable frequency per the assembly plant personnel or the adhesive/sealant manufacturer until the process conditions, amount and location of adhesive variables are known to ensure compliance. End testing once documented testing data and evidence of process controls are in place.

3.1.4.3 All other tests are completed once for initial approval.

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

3.1.5.1 Roles and Responsibility. After initial approval, if the referenced standard changes, GM Global Propulsion Systems expects the sealant supplier to monitor industry standard documents for change and to 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 their initial full data approval. Data must be submitted to GM Global Propulsion Systems Engine Material Engineering within 180 business days of the published revision (dd/mm/yy) in the Global Document Management (GDM) (for GM Standards) or the date the 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 do not 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 this standard are derived from GMW16855. Changes to GMW16855 must be monitored in accordance to 3.1.4. The Table 1 properties in this standard represent only those GMW16855 tests that required data for the specific product and/or the accepted deviations between GM Global Propulsion Systems Engine Materials Engineering and the sealant manufacturer. The GMW16855 tests that have specified limits (denoting exceptions) will be run in advance of this standard. These tests will be listed in Table 1 in bold italics to confirm their acceptable completion.

3.2 Requirements on Delivery.

- a. Material Properties - Uncured. See Table 1
- b. Material Properties - Cured. See Table 3

3.2.1 Requirements – Uncured (Table 1 Supplement).

3.2.1.1 Blowout. Modified ASTM F2523 fixtures with 30 degree and 45 degree chamfer (See Appendix A, A2).

3.2.1.2 Color. Table 1 and Table 3 properties are based on black. Additional colors are used to provide contrast on applied surfaces for inspection and verification of applied sealant. Additional colors are required to meet all the requirements of this standard.

3.2.1.3 Viscosity. Shall be run for stored container and pumped sealant. See Table 1, Extrusion Rate.

3.2.1.4 Homogeneity. Using the setup in Figure 1 of GMW17224, 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 Aluminum 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 or earlier batches of this sealant that had no objectionable odor.

3.2.1.7 Oil Gel Test. No gel must be formed after following the procedure in Appendix A, A1.1. Run at $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ temperature and $50\% \pm 5\%$ RH. See GM Global Propulsion Systems Materials Engineering Fuels/Fluids/Lubricants and Chemistry Laboratories group for a list of current factory fill oils referenced on the data report sheets.

3.2.1.8 Specific Gravity. Specific to sealant and set as part of the specification, at the time of approval (See Table 1). For uncured adhesive/sealant, use the ASTM D297 pycnometer method or ISO 845.

3.2.1.9 Storage Stability (GMW15735). The material when conditioned to the recommended supplier storage conditions of $8\text{ }^{\circ}\text{C}$ to $21\text{ }^{\circ}\text{C}$ 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 Cycle B of GMW15735.

3.2.1.9.2 Shelf Life. The shelf life of the material, as shipped, in closed containers shall be a minimum of 365 days at a temperature not to exceed $28\text{ }^{\circ}\text{C}$. Shelf life of the material commences upon receipt of the material from the manufacturer. In such cases where the shelf life exceeds the minimum 365 day requirement, the manufacturer shall identify and affix a "Do Not Use After" date on the shipping container that shall establish the shelf life, but in no case shall that be less than the minimum 365 days. Under no circumstances should expired adhesive/sealant be used for production build.

3.2.1.10 Pumpability. Using the previous production adhesive/sealant as a guide, the new 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 within 8 h of the end of the one (1) day cure.

Table 1: Material Properties; Uncured Adhesive/Sealant Requirements

Property	Test Procedure	Unit	Value
Blowout Resistance Note 1	ASTM F2523, 30 kPa air pressure for 60 s at 0.7 mm gap. Sample obtained by filling an empty cartridge from production dispensing system. Test within 20 minutes of sampling	Seconds to blowout	No blow out
Color	Visual		Black or Grey
Extrusion Rate Note 1			
As received in container	ASTM C1183, Use tapered nozzle, 100 mm length and 3.2 mm orifice; 0.62 MPa pressure cartridge	g/minute	140 g/minute to 200 g/minute
Pumped or Sheared	Same conditions. Sample obtained by filling an empty cartridge from production dispensing system. Test within 20 minutes of sampling	g/minute	130 g/minute to 190 g/minute
Homogeneity	Visual		Homogeneous, free of lumps or air bubbles
Noncorrosive to Metals	MIL-A-46146, See Appendix A, A1.2		No visual evidence
Odor	ASTM D4339, Reference this 9982257 the current production material		Lower or equal to reference
Oil Gel Test	See Appendix A, A1.1		No gel formation
Pressure Stability	SAE J1864		No separation or caking
Specific Gravity	ASTM D297		1.49 s.g. $\pm$ 0.02 s.g.
Sag Resistance Note 1	SAE J243, ADS-10, Method C. As received Use pumped sample from extrusion rate test within 20 minutes after sampling	millimeters (mm)	0.5 mm maximum 0.5 mm maximum
Tack Free Time Note 1	ASTM C679. Temperature $20\text{ }^{\circ}\text{C}$ to $32\text{ }^{\circ}\text{C}$, 20% to 90% RH	minutes	10 minutes maximum
Total Volatiles Note 1	GMW17224	Percent (%)	0.6% maximum