



Adhesive/Sealant, Silicone, Room Temperature Vulcanizing, Oxime 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 silicone adhesive/sealant requires no catalyst or heat to cure. When applied wet (uncured) it reacts with moisture in the air (condensation cure) 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 methyl ethyl ketoxime (two (2)-butanone) and is not acceptable for use in Europe.

1.2 Symbols. Not applicable.

1.3 Applicability. Formed-in-Place Gasket (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.

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 (65 °F to 104 °F). 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 the Assembly, Sealing and Fastening Bill of Materials (BOM) Level II for minimum process time.

1.3.2 Other Surface Treatments. The adhesive/sealant approved to this standard must be applied after paint or coated part treatments (e.g., electrodeposition (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.

1.3.4 Gap Limitations. Adhesive/sealant capable of sealing a gap from 0.1 mm to 1.0 mm (the blowout test determines the maximum gap).

1.3.5 Unlike silicone sealant chemistry, silicone sealant poses no contamination risk to oxygen sensors or increased oil foaming due to oil absorption and extraction during curing.

1.4 Remarks.

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 Methyl ethyl ketoxime (MEKO) sealants are a 0.40 United States Dollar (USD) less per engine cost versus non-MEKO containing sealants. Unless your application region regulations (not product engineering) requires MEKO free sealant, a MEKO product is more cost effective.

1.4.2 Process Behavior.

1.4.2.1 Cure Rate. This adhesive/sealant has a lower viscosity, faster cure and higher elongation than 9986493 MEKO-free alcohol adhesive/sealant from 10% to 100% relative humidity (RH). Depth of cure inward from an exposed 1 mm edge for 7 days at 20 °C, 50% RH is 2.3 mm (see 3.2.2.4 and 7.1 Glossary; Cure Speed).

1.4.2.2 Open Time to Joint Assembly. All room temperature vulcanizing (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 (2) adjacent fasteners untightened.

1.4.2.3 Shelf Life Limitations. This sealant is packaged in service and repair cartridges with foil sealed ends. With proper storage, the un-opened sealed packaging has a 9 month shelf-life. Once opened, shelf life is limited by how well the opened container is protected against moisture before it is emptied.

1.4.2.3.1 Large Scale Operations. Due to the moisture sensitivity of this sealant, use small pails 20 L (5 gal) maximum with strict limits on storage stock rotation. Product left in delivery lines over extended holiday periods may require a purge.

1.4.2.4 Materials Engineering recommends all RTV adhesive/sealant (regardless of cure system) be used in a ventilated area.

1.4.3 Joint Performance. Lap shear strength of alcohol cure silicone adhesive/sealants is lower than silicone ketoxime and acetoxym cure systems on all metal substrates.

1.4.3.1 This MEKO adhesive/sealant higher elongation is best in joints with significant differences in thermal expansion or motion. The MEKO-free alkoxy version (9986493) works best on oily (contaminated) metal surfaces producing cohesive rather than adhesive failures.

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.

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.

1.4.4.1.1 Adhesion Conditions. 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 day cure period). **Note:** Seven (7) days is the industry standard for all cured test conditions.

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 (two (2)-butanone) during curing.

1.4.6 Fuel Dilution in Engine Oil. This sealant lap shear testing to GMW16678 A-E fuel dilution produced adhesive with cohesive separation from the test panel substrates (see Table 3, ^{Note 1}). Testing of production surfaces for adhesion evaluation is mandatory for engine joints where the fluid level is higher than the joint whether the engine is on or off. The results on engine joints exposed to measured fuel dilution conditions will dictate use.

2 References

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

2.1 External Standards/Specifications.

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

2.2 GM Standards/Specifications.

9982257	GMW3059	GMW16678	GMW17332
9985776	GMW3155	GMW16855	
9986493	GMW14270	GMW17205	
GMW3016	GMW15735	GMW17224	

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2.3 Additional References.

- Assembly, Sealing and Fastening Bill of Materials (BOM) Level II
- Environmental Protection Agency (EPA) Method 24, Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings
- Guide for the Use of the International System of Units (SI)
- Industry Standard Documents
- List of Current Factory Fill Oils
- Previously Approved Production Adhesive/Sealant (9982257)
- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02
- Supplier Process Control Plan

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 days unless otherwise specified, followed by conditioning for 1 h to 24 h at 23 °C ± 3 °C, RH 55%.

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 SI units (reference Guide for the Use of the International System of Units) using the latest 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 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 ±5% RH of the specified numbers unless otherwise indicated.

3.1.4 Test Frequency. The following tests should be identified in the supplier process control plan and performed at the frequency indicated once the requirements of material properties for uncured adhesive/sealants (see Table 1) are complete.

3.1.4.1 Run the following on every batch or lot by the adhesive manufacturer. Color, dirt, 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 by assembly plant personnel or 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 once for initial approval.

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 section 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 Powertrain 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 their initial full data approval. Data must be submitted to GM Powertrain Engine Materials Engineering within 180 business days of the published revision (dd/mm/yy) in GM Global Document Management (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 GM Global Document Management 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 of this standard is derived from GMW16855, Requirements for Formed-In-Place One Component Room Temperature Vulcanizing (RTV) Sealant for Engine Sealing. Changes to GMW16855 must be monitored in accordance to 3.1.4. The Table 1 and Table 2 properties in this 9986495 represent only those GMW16855 tests that require data for the specific product and/or the accepted deviations between General Motors Powertrain (GMPT) Engine Materials Engineering and the sealant manufacturer. The GMW16855 tests that have specified limits (denoting exceptions) will be run in advance of this 9986495. The tests to be run in advance that have specified limits are listed in Table 1 with a Note 1 to confirm their acceptable completion.

3.2 Requirements on Delivery.

- **Material Properties; Uncured.** See Table 1.
- **Material Properties; Cured.** See Table 3.

3.2.1 Requirements; Uncured. See Table 1.

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

3.2.1.2 Color. See Table 1. Properties are based on this color.

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

3.2.1.4 Homogeneity. Using the setup in of GMW17224 see 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. Evaluate the compatibility of cure reaction by-product with metals. Key: C1 = Copper, C2 = 1008/1010 Steel, C3 = AA319 or AA356T6 Aluminum, C4 = Other. If metals are coated, test on production approved coating.

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.

3.2.1.7 Oil Gel Test. No gel must be formed after following the Appendix A, A1.1 procedure run at $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ temperature and $50\% \pm 5\%$ RH. See General Motors Powertrain 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. Set as part of the specification, at the time of approval. For uncured adhesive/sealant use the ASTM D297 pycnometer method or ISO 845.

3.2.1.9 Storage Stability (GMW15735, 4.3.2). 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, 4.3.1). As shipped, the material shall be, capable of passing all the performance requirements in Table 1. Run the low temperature stability 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 279 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 279 day requirement, the manufacturer shall identify and affix a "Do Not Use After" date on the shipping container that shall establish the shelf life. Shelf life shall never be <279 days which is the minimum. 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 (see GMW17224, 4.3.1) within 8 h of the end of the 1 day cure (see GMW17224, 3.3).

Table 1: Material Properties for Uncured Adhesive/Sealant Requirements

Property	Test Procedure	Unit	Value		
Blowout Resistance Note 1	ASTM F2523, 30 kPa air pressure for 60 s at 1.0 mm gap. Sample obtained by filling an empty cartridge from production dispensing system. Test within 20 minutes of sampling.	Seconds to Blowout	No Blowout		
Color	Visual	Not applicable	Dark 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	97 minimum		
Pumped or Sheared	Same conditions. Sample obtained by filling an empty cartridge from production dispensing system. Test within 20 minutes of sampling.	g/minute	97 minimum		
Homogeneity	Visual	Not applicable	Homogeneous, Free of Lumps or Air Bubbles		
Noncorrosive to Metals	MIL-A-46146, See Appendix A, A1.2	Not applicable	No Visual Evidence, C1		
Odor	ASTM D4339, Reference current production material (9982257)	Not applicable	Lower or Equal to Reference		
Oil Gel Test	See Appendix A, A1.1	Not applicable	No Gel Formation		
Pressure Stability	SAE J1864	Not applicable	No Separation or Caking		
Specific Gravity	ASTM D297, hydrostatic method or ISO 845	Specific Gravity	1.36 sp.g ± 0.03 sp.g		
Sag Resistance Note 1	SAE J243, ADS-10, Method C. Use pumped sample from extrusion rate test within 20 minutes after sampling.	Millimeters (mm)	As received 0.5 maximum Pumped 0.5 maximum		
Tack Free Time Note 1	ASTM C679. Temperature 20 °C to 32 °C, RH 20% to 90%	Minutes	8 maximum		
Stability	See 3.2.1.9 to 3.2.1.9.2	Months	9 minimum		
Volatile Organic Compounds	GMW3016, EPA Method 24	Grams/Liter, Percent (%)	2.4% maximum		
Total Volatiles Note 1	GMW17224	Percent (%)	0.6 maximum		
Foam Stability Note 1	ASTM D892, Sequence I, II and III in GM Dexos® 0W20 engine oil following the Appendix A, A1.5 procedure.	Not applicable	Sequence		
			I	II	III
	Reported at 5 minutes, Stability at 10 minutes	Not applicable	5/10	5/10	5/10
Foam Volume	Height in Graduate Cylinder	Milliliters, Maximum	10/0	10/0	5/0
Phase Separation	Visual	Not applicable	None	None	None

Note 1: The GMW16855 tests that have specified limits (denoting exceptions) will be run in advance of this 9986495. The tests to be run in advance that have specified limits are listed in Table 1 with a Note 1 to confirm their acceptable completion.

3.2.2 Requirements; Cured. See Table 3.

3.2.2.1 Continuous Upper Temperature. Test fully cured specimens die cut from slabs/sheets per 3.1. Follow Table 3 test conditions.

3.2.2.2 Lap Shear Strength/Lateral Joint Movement. Test specimens shall be made from the appropriate clean and oily metal panels from Table 2 bonding steel to steel or aluminum to aluminum, unless otherwise specified by the test requester. Bondline thickness is 1.0 mm; cure for 7 days at 23 °C $\pm$ 3 °C and relative humidity at 50% $\pm$ 5%. Test rate is 50 mm/minute.

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