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SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J1497 DEC88

DESIGN GUIDE FOR FORMED-IN-PLACE GASKETS

Foreword—This Reaffirmed Document has been changed only to reflect the new SAE Technical Standards Board Format.

1. Scope

Scope—This SAE Recommended Practice presents information which is intended as a guide for proper designing, selection, application, and servicing of liquid, formed-in-place gasket (FIPG) materials.

1.1 Definition and Description—Formed-in-place gasket materials are liquids of varying consistencies which can be applied to one of the mating joint surfaces before assembly. When parts are mated, the FIPG material is capable of flowing into voids, gaps, scratch marks, and so forth, and cures to form a durable seal. The concept offers a convenient way of manually or automatically dispensing a seal of varying patterns for assembly. Generally, two types of FIPG materials are used, RTV (Room Temperature Vulcanizing) silicones and anaerobic methacrylate esters. Other types of materials are available but restricted to limited applications and, therefore, are not covered in this manual. The following description and properties for each type of material will help determine the recommended choice of material for a given application. One should thoroughly test any application, and independently conclude satisfactory performance before making final selection.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein.

2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 1002—Test Method for Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal)
ASTM D 1084—Test Methods for Viscosity of Adhesives

3. Types of Sealants

3.1 One Component RTV Silicone Sealant—The silicone formed-in-place gasket (FIPG) comprises the application of a paste-like silicone sealant bead to the area of a component which is then assembled, usually within 10 min. The silicone compound flows to form a gasket which then cures to a rubbery solid by absorbing the moisture vapor in the environment (see Figure 1). The application can be done by hand from a collapsible tube, caulking cartridge, or on an automated dispensing system.

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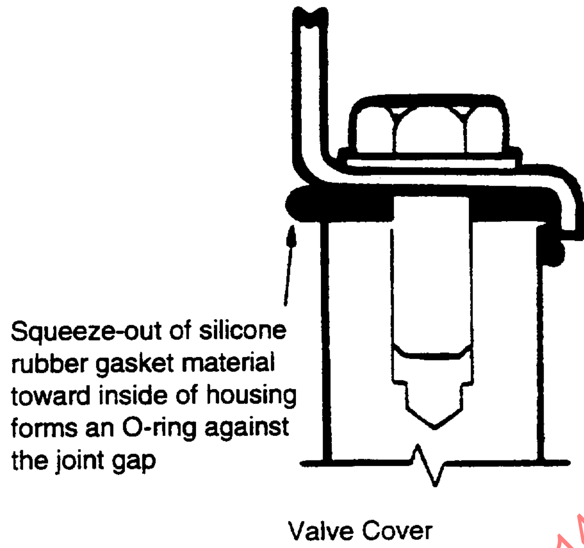


FIGURE 1—JOINT GAP SEAL

3.1.1 THE BASIC CHEMISTRY

3.1.1.1 The FIRST of a three-ingredient silicone sealant is a hydroxy-terminated polysiloxane polymer. See Figure 2.

For most applications, a polydimethyl siloxane polymer is used (R = CH_3). However, for applications where fuel or solvent resistance is necessary, a polymethyl-trifluoropropyl siloxane polymer is used (R = CH_2 CH_2 CF_3). The average molecular weight of the polymers usually ranges from 2.0×10^4 to 1.2×10^5 grams/mole.

The SECOND is the presence of a filler or combination of different fillers like: high surface area silicas, ground quartz, zinc oxide, iron oxide, carbon black, various types of clays and diatomaceous earth.

The THIRD is the moisture vapor affected crosslinking system. It is generally a reactive polyfunctional silane, which is readily hydrolyzable and released during the curing reaction. Examples of the most common crosslinkers and the by-products are shown in Figure 3:

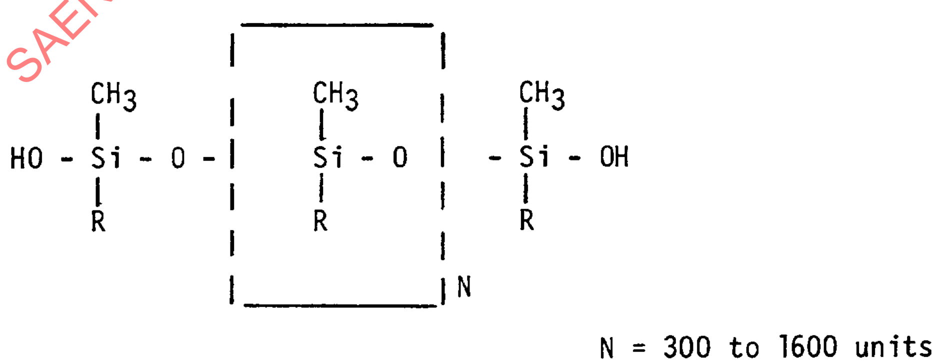


FIGURE 2—HYDROXY-TERMINATED POLYSILOXANE POLYMER

ACETOXY

(1) Methyltriacetoxy Silane - Acetic Acid

$CH_3Si\ (-O-C(=O)-CH_3)_3$ — $CH_3-C(=O)-OH$

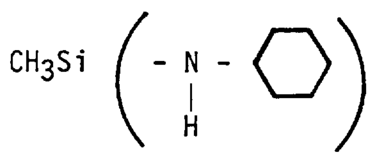
ALKOXY

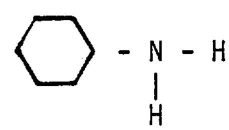
(2) Methyltrimethoxy Silane - Methyl Alcohol

$CH_3Si\ (-O-CH_3)_3$ — CH_3OH

AMINE

(3) Methyltris (cyclohexylamino) Silane - Cyclohexyl Amine





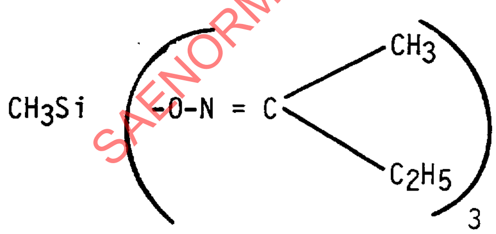
OCTOATE

(4) Methyltrihexanoxy Silane - Hexanoic Acid

$CH_3Si\ (-O-C(=O)-(CH_2)_4CH_3)_3$ — $CH_3(CH_2)_4-C(=O)-OH$

OXIME

(5) Methyltris (methylethylketoxime) Silane - Methyl-ethylketoxime



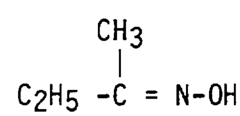


FIGURE 3—EXAMPLES OF THE MOST COMMON CROSSLINKERS AND THE BY-PRODUCTS

3.1.2 Specific Difference In Cure Systems—See Table 1:

TABLE 1—CURE SYSTEM 25 °C (77 °F), 50% RH

	(1)	(2)	(3)	(4)	(5)
Tack Free Time (Hours)	0.25–0.5	0.5–4	0.25–0.5	0.25–0.75	0.25–0.5
Cure Time, Hours	12–16	18–24	12–24	16–24	12–24
Adhesion to Iron/Aluminum (1)	Good/Exc.	Good	Fair/Good	Fair/Good	Good/Exc.
Corrosion to Steel (2)	Heavy	None	None	Slight	None
Corrosion to Aluminum(2)	None	None	Slight	None	None
Exc.—Excellent					

1. Adhesion to plastics is variable and must be individually tested.
2. As tested in a nonvented environment with high humidity per MIL-A-46146A.

3.1.3 Typical Uncured (As Received) Physical Property Ranges

3.1.3.1 *Viscosity/Application Rate*—The rheological properties of the sealant can be measured in terms of blow-out resistance and extrusion rate as well as a traditional viscosity measurement. The viscosity of the sealing compound can be determined in accordance with ASTM D 1084, Method B. The viscosimeter model, spindle number, and speed shall be reported as part of the viscosity determination.

3.1.3.2 *Application Rate Method (Grams/Minute)*

3.1.3.2.1 Apparatus

a. [1]Semco model 250-6 sealant gun
b. [1]Semco plastic nozzle #440 (101.6 mm long × 3.18 mm orifice diameter)
c. [1]Semco plastic cartridge #250-C6, #250-WP wiper, #250-TS Tri-Seal (standard drum sample)
d. Stop Watch

3.1.3.2.2 Procedure

a. Load the cartridge containing the silicone compound into the sealant gun.
b. Remove the seal and clear out any cured RTV. Attach the nozzle to the cartridge.
c. Connect the sealant gun to 620.6 kPa ± 13.8 kPa air supply and extrude 5 to 10 g of compound to prep the nozzle.
d. Extrude the RTV compound in a tared aluminum weighing dish for a period of 10 s, so the test specimen weighs at least 10 g or more.
e. The number of test specimens depends on the quantity of compound. Recommendation is to use at least three and average.
f. $$\text{Grams/minute} = \frac{\text{Weight in Grams}}{10\text{s}} \times \frac{60\text{s}}{\text{Minute}} \quad \text{(Eq. 1)}$$
g. Typical application rates 200 to 450 g/min.

1. Semco, a Division of: Products Research & Chemical Corp.

5454 San Fernando Road
Glendale, CA 91203

Also available from other sources.

3.1.3.3 Application Rate Method (Seconds/50 g)

3.1.3.3.1 Apparatus

a. [1] Semco model 250-6 sealant gun
b. Special nozzle (50.8 mm long × 3.18 mm orifice diameter) CR-1010 Steel 1 (***Figure 4)
c. [1] Semco plastic cartridge #250-6, #250-WP wiper, #250-TS Tri-Seal (standard drum sample)
d. Stop Watch
e. Laboratory balance (0.01 g)
f. Weighing Dish
g. Pipe Cleaners (for cleaning nozzles)

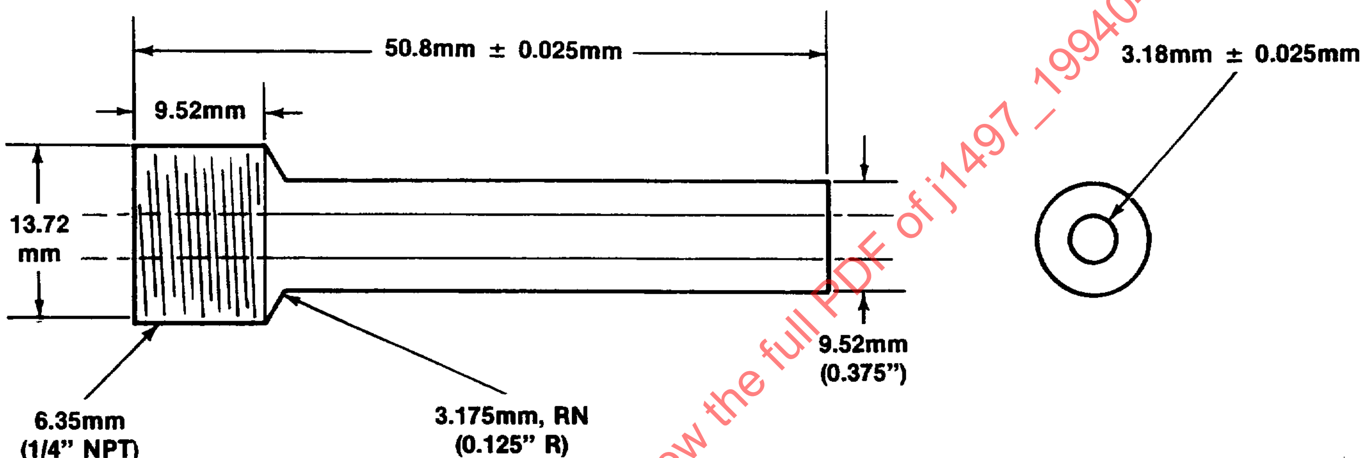


FIGURE 4—SPECIAL NOZZLE

3.1.3.3.2 Procedure

a. Load the cartridge containing the silicone compound into the sealant gun.
b. Remove the seal cap and clear out any cured RTV. Attach the nozzle to the cartridge.
c. Connect the sealant gun to 448.2 kPA ± 13.8 kPa air supply and extrude a few grams of compound to prep the nozzle.
d. Extrude the RTV compound in a tared weighing dish for a period of 10 s, so the test specimen weighs at least 10 g or more.
e. The number of test specimens depends on the quantity of compound; recommendation is at least three and average.
f. $$\text{Seconds} = \frac{50\text{g}}{\text{Weight in Grams}} \times \text{Time (Seconds)} \qquad \text{(Eq. 2)}$$

3.1.3.4 Flow Resistance—The flow test shall be conducted with a flow test jig as shown in Figure 5. Depth of plunger tolerance is critical and shall be controlled within the tolerance during all tests. The flow test jig shall be placed on a table with the front face upward and with the plunger depressed to the limit of its travel. Enough of the silicone compound to fill the recessed cavity of the jig shall be rapidly transferred from a representative sample container. The compound should not be worked with a spatula but shall be leveled off even with the block by scraping with a spatula in two passes, each starting in the center and moving toward the sides of the jig. Within 10 s after the leveling operation, the jig shall be placed on its base and the plunger immediately advanced to the limit of its forward travel. The cylindrical section formed in the flow test jig shall be allowed to flow under its own weight on a vertical surface.

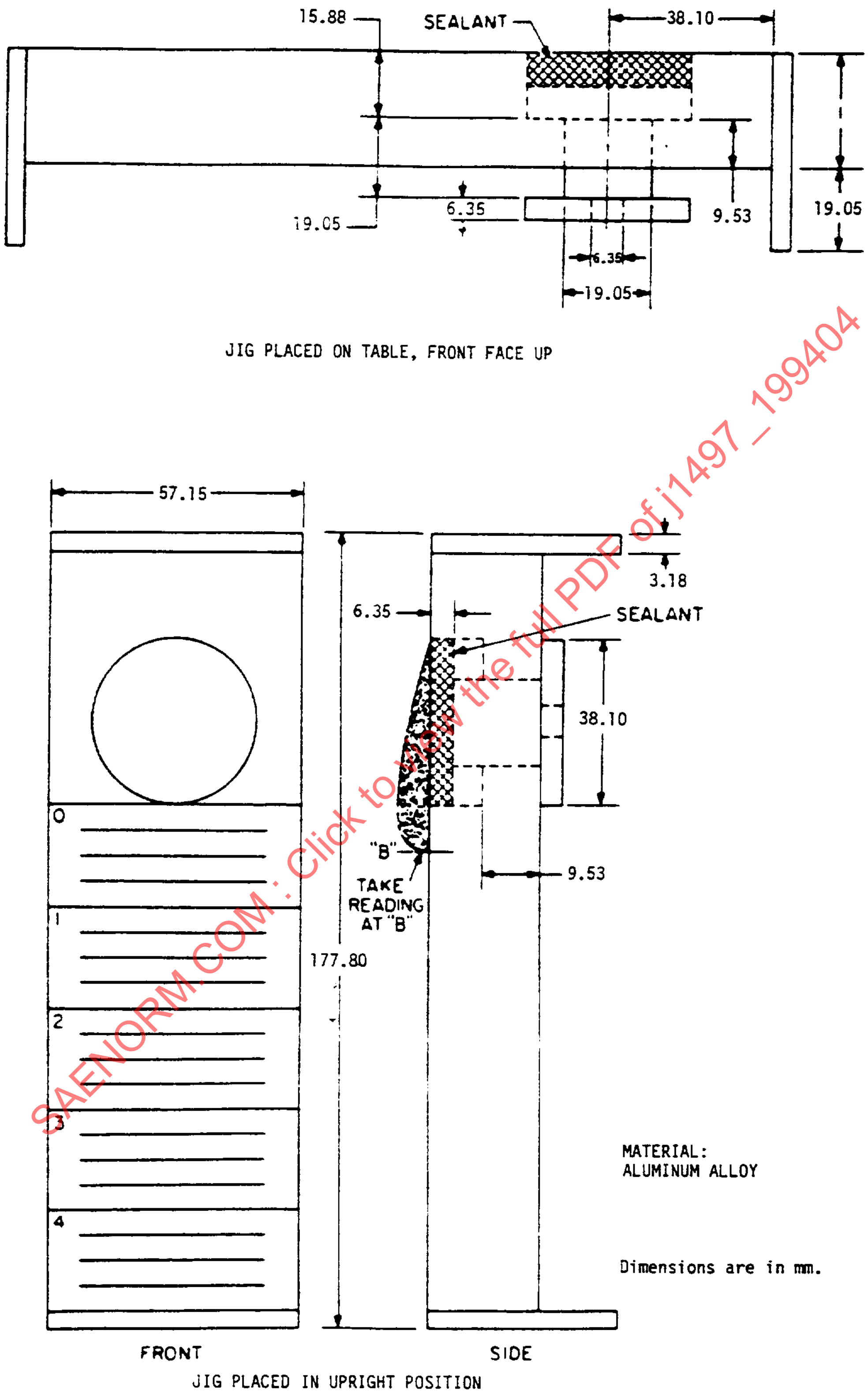


FIGURE 5—FLOW TEST FIXTURE

The flow test shall be when the plunger is advanced to the limit of its forward travel, and the flow measurement shall be taken immediately after the expiration of 3 to 30 min. The flow shall be measured from tangent to the lower edge of the plunger to the farthest point to which flow has occurred. The measurement after the indicated interval shall be considered the initial flow of the silicone compound.

3.1.3.5 Tack Free Time/Cure Rate

3.1.3.5.1 Apparatus

a. Strip of polyethylene film 50.8 × 152.4 × 0.076 mm
b. Spatula or doctor blade
c. Stop Watch

3.1.3.5.2 Procedure

a. Apply the RTV compound from the container.
b. The quantity of compound varies. However, a typical 25.4 mm "Hershey Dot" is the recommendation.
c. With a spatula or doctor blade, spread the compound down the polyethylene film as soon as possible (within 1 min). The shape of an elongated triangle with the initial start area about 3.18 mm thick to a feather ending about 0.127 mm.
d. Beginning at the time the compound is first applied, determine the tack free time by slightly touching the compound with a fingertip at 5 min intervals.
e. The test is completed when the surface is dry to the touch and no compound is transferred to the finger.
f. Typical values are 10 to 30 min at 21.1 °C and 50% RH.

3.1.4 TYPICAL CURED [1] PHYSICAL PROPERTY RANGES

a. Specific Gravity—1.03 --------------- 1.60
b. Hardness, Shore "A"—15 --------------- 60
c. Tensile Strength—1035 --------------- 5520 kPa
d. Elongation, %—100 --------------- 600
e. Low Temp. Flexibility— –45.5 °C
f. Thermal Stability—260°C, Special products—343 °C
g. Fluids and Oil Sealability—(Usage Applications)

Engine Lube Oil
Engine Coolant
Automatic Transmission Fluid
Rear Axle Lubricant

3.1.5 BOND STRENGTH DEVELOPMENT—Most silicone sealants bond to clean surfaces without the aid of primers. A preliminary evaluation should be made to determine acceptable adhesive properties on the substrate used in the specific application. The adhesive bond strength will depend on the joint configuration, material thickness, and surface area. Normally, sufficient strength will develop in one day, with maximum strength after seven days.

3.1.6 PACKAGING AND STORAGE—Most sealants are supplied in ready-to-use collapsible aluminum squeeze tubes, caulking cartridges, and in bulk containers 18.9 to 208.2 L.

When stored in the original unopened containers at temperatures less than 27 °C, most sealants offer a shelf life of one year. To prevent curing of the unused portion of an opened container, reseal air tight.

1. Cured 7 days at 25 °C and 50% RH.

Proper rotation of inventory is a recommended practice.

3.1.7 ADVANTAGES AND DISADVANTAGES

3.1.7.1 Advantages

a. Lower cost than preformed gaskets
b. Eliminates need for large and costly gasket inventory
c. One component, therefore, no mixing required
d. Easily pumped on automatic or semi-automatic equipment
e. Ideally suited for robots and automated assembly lines
f. Has capability to fill large gaps
g. Does not flow under its own weight; can be applied to parts in horizontal, vertical, and overhead positions
h. Good adhesion (unprimed) to many metal surfaces
i. Temperature range— –46 to 260 °C
j. Good resistance to outdoor weathering, vibration, moisture, and ozone
k. Good fluid resistance to most oils, lubricants, and coolants.

3.1.7.2 Disadvantages

a. Some RTV silicones generate by-products while curing which can cause corrosion if not properly vented
b. Prolonged contact with uncured sealant can cause irritation to skin and eyes
c. Working time is dependent on temperature and humidity
d. Requires clean mating surfaces
e. Slower cure in low humidity environment
f. Removal of cured sealant difficult when applied to clean surfaces
g. Most sealants cannot be painted
h. Due to the low thickness as clamped, limited ability to follow movement between flanges

3.2 Anaerobic Methacrylate Ester Sealant—The word "anaerobic" is derived from the Greek, meaning life in the absence of air. Hence, anaerobic compounds cure in the absence of air and in the presence of metal or other active surfaces.

Cure rates at room temperatures range anywhere from a few minutes to several hours. Since there are no solvents, the conversion from liquid to solid is virtually 100%, completely filling the voids, surface imperfections, tool marks, and so forth, eliminating all potential leak paths.

There are a variety of sealant types, selection of which depends on the following:

a. Fluid/gas to be sealed
b. System pressure/temperature
c. Surface configuration and finish
d. Flange makeup (rigid/flexible)
e. Number, grade, and size of bolts
f. Disassembly requirements

3.2.1 THE BASIC CHEMISTRY—Anaerobic formed-in-place gaskets cure through a process called "polymerization." These long cross-linked polymer chains are typical of the cured anaerobic products and are indicated chemically in Figure 6.

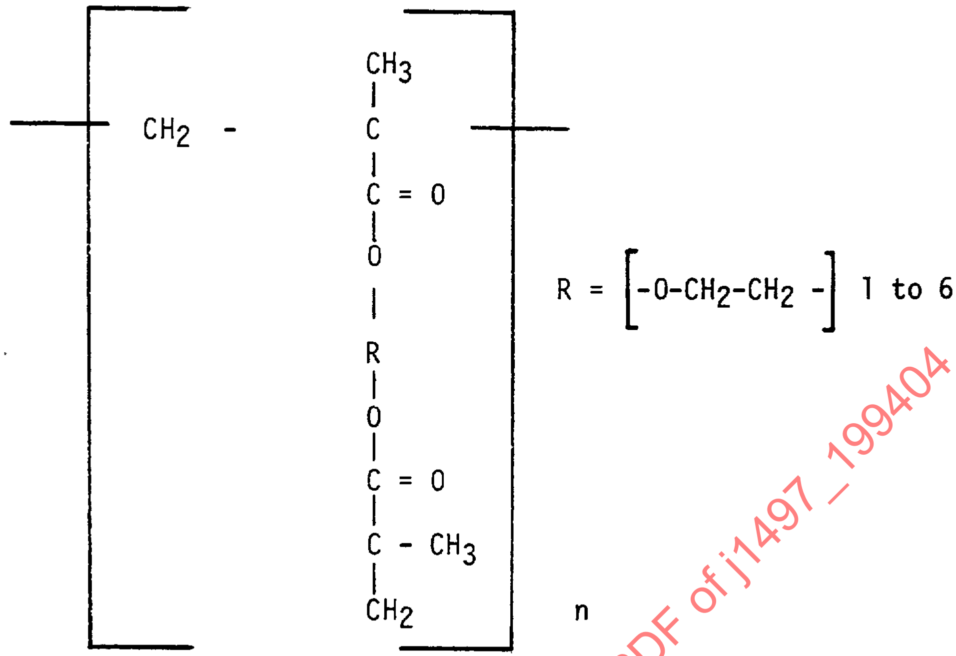


FIGURE 6—CHEMICAL STRUCTURE

3.2.2 UNCURED PROPERTIES

a. Resin (Anaerobic)—Methacrylate Ester
b. Viscosity—As specified by manufacturer
c. Specific Gravity—Approximately 1.1
d. Flashpoint (TCC)—Above 93 °C
e. Toxicity—As specified by manufacturer
f. Shelf Life—One-year minimum

3.2.2.1 Use of Primer or Activators—The cure is affected by the type of metallic surface. Some parts are inactive and may require at least one surface to be activated to insure reliable performance. See Table 2.

TABLE 2—ACTIVE AND INACTIVE SURFACES

Active Surfaces	Inactive Surfaces
Steel	Zinc
Iron	Pure Aluminum
Copper	Stainless Steel
Brass	Cadmium
Manganese	Magnesium
Bronze	Bright Platings
Nickel	Anodized Surfaces
Commercial Aluminum	Passivated Surfaces
	Titanium

3.2.2.2 Gaps Over 0.25 mm Up To 1.27 mm—For these gaps, primer must be used. Partial cure is obtained in 4 h and full cure in 48 h.

3.2.2.3 *Heat Cure*—Heat cures can be used to overcome gaps or inactive surfaces as follows in Table 3:

TABLE 3—CURE TIME VERSUS GAP SIZE USING HEAT AT 120 °C

Gap	Cure Time Required 120 °C
0.51 to 0.76 mm	2 h
1.27 mm	3 h

3.2.3 TYPICAL CURED PROPERTIES

a. Resin—Flexible Methacrylate Polymer
b. Temperature Range—Continuous –53 to 149 °C operation for sealability
c. Percent Elongation—Approximately 30%
d. Tensile Shear Strength—3.4 to 6.9 MPa at 0.50 mm film thickness

3.2.3.1 *Method for Preparation of Bubble Free Films of Gasketing Products*

3.2.3.1.1 Test Apparatus

a. 152.4 x 152.4 mm plate glass panes
b. 0.76 mm thick sheet polyethylene
c. 2% solution of lecithin in 1,1,1,-trichloroethane
d. Lab centrifuge
e. 10 mL disposable syringes or equivalent
f. Cotton swabs
g. 8 x #1 Hargrave clamps or equivalent

3.2.3.1.2 Preparation

a. Using cotton swabs, coat one side of two glass panes with an even coating of lecithin solution. Allow all solvent to flash off.
b. Cut 0.76 mm thick polyethylene to produce a 152.4 x 152.4 x 12.7 mm square edging. This provides a 0.76 mm gap while also preventing excessive material run out.
c. Heat seal the bottom of a Luer lock tip so that the syringe becomes leakproof. This may be accomplished by heating the tip with a lighter or other convenient flame source and crimping with a pair of needle nose pliers.
d. Fill sealed syringe with gasketing material and place in lab centrifuge. Centrifuge at high speed for at least 10 min and check material for air content. Continue to centrifuge until all air is dissipated.

3.2.3.1.3 Assembly

a. If primer curing, apply recommended primer to both lecithin-coated surfaces of the glass panes. Allow all solvent to flash off.
b. Place 152.4 x 152.4 x 12.7 mm polyethylene square edging along edges of one glass pane.
c. Cut off the centrifuged syringe with a razor blade as close to the bottom of the syringe as possible so that the largest diameter opening is obtained.
d. Using the syringe plunger, slowly push the gasketing material out onto the center of the polyethylene-edged glass pane to form a contour-free mound. The amount of material needed to produce the desired film can vary depending on the gasketing product used. In general, four centrifuged syringes of material is a good starting point.
e. Place the remaining glass pane, coated side down, gently onto the mound of gasketing material taking care to ensure that air entrapment is avoided.

f. Press down slowly until the top glass pane contacts the polyethylene edging on the bottom pane while ensuring that the gasketing material has wetted the surface.
g. Clamp the glass panes with even spacing all around the material and allow to cure. If primer-cured, a minimum of 24 h at room temperature is required. If a heat cure is desired, a minimum cure of 2 to 4 h at 93.3 °C is recommended.

3.2.3.1.4 Disassembly

a. Place the edge of a razor blade or putty knife between the polyethylene edging and glass pane.
b. Slowly, run the edge of the sharp tool around the perimeter of the film and separate the glass from the cured film.

3.2.3.2 Typical Environmental Resistance—Hot Strength and Heat Aging tests were started after 24 h cure at room temperature. Figures 7 and 8 depict the test results.

NOTE—Test method ASTM D 1002 with sandblasted steel lap shears.

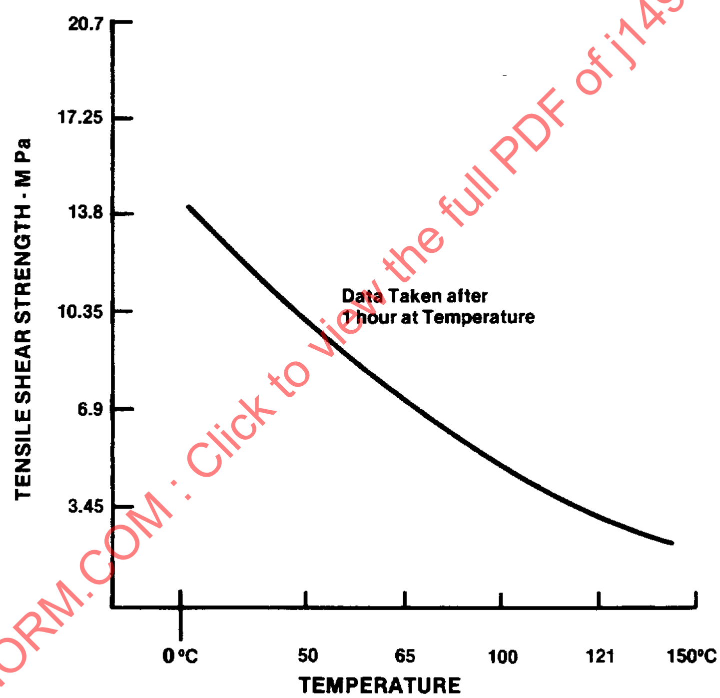


FIGURE 7—HOT STRENGTH

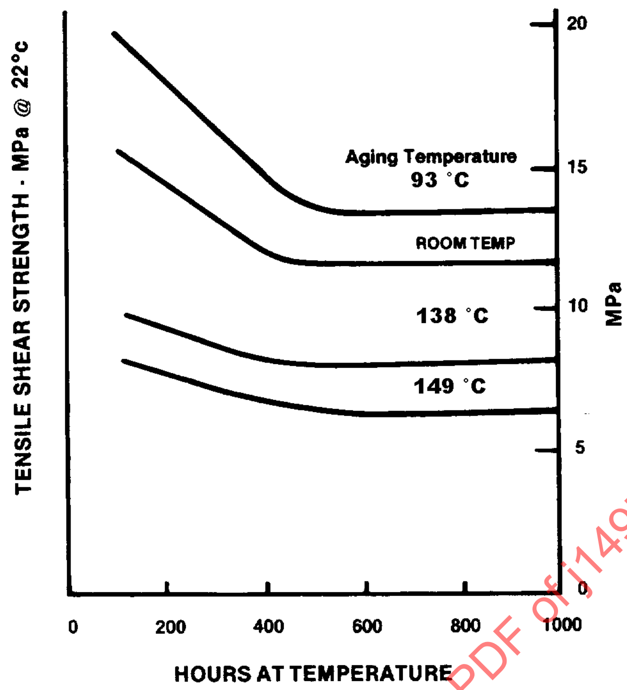


FIGURE 8—HEAT AGING

3.2.3.3 *Solvent Resistance*—Cured sections of material were weighed, measured for hardness, and then submerged in various solvents for 15 days at 86.7 °C. Changes in weight and hardness are given in Table 4:

TABLE 4—WEIGHT CHANGE AND HARDNESS CHANGE AFTER SUBMERSION IN VARIOUS SOLVENTS

Solvent	% Weight Change	Shore "A" Hardness Before	Shore "A" Hardness After
Water	+60%	90	90
10W30 Motor Oil	0%	90	90
Isopropyl Alcohol	+25%	90	82
Unleaded Gasoline (1)	+31%	92	86
Toluene	+38%	90	86
1,1,1 Trichloroethane	+50%	91	72
Phosphate Ester Oil	+46%	90	87

1. Test at room temperature.

3.2.4 USE AND APPLICATION—Material can be used to seal rough or nonmachined surfaces and precut gaskets. To obtain best results, contaminants such as grease, heavy oils, and dirt *must* be removed with adequate solvent. Material can eliminate some gaskets 0.76 mm or less thick and can be used to coat hard or soft cut gaskets to obtain good reliability. It remains flexible when not used over 121 °C and will maintain static seals up to 149 °C.

3.2.4.1 *Application Techniques—Manual*—Material is an easily workable tacky gel which can be extruded onto one side of a flange surface from a tube or caulking cartridge. Breaks in the bead are easily repaired by manipulation. Small parts can be covered adequately by pressing them into a saturated polyester urethane sponge or by roll coating them with a short nap roller.

3.2.4.1.1 Screen Printing—The material responds well to screen printing techniques. Complex shapes can be coated in seconds with precise control of material quantity and placement.

Excess material can be cleaned by wiping with recommended solvent. Material on hands can be cleaned with waterless mechanics' hand soap followed by soap and water.

3.2.4.2 Warning—EYE IRRITANT. MAY IRRITATE SENSITIVE SKIN—Contains acrylic acid and methacrylic ester. In case of eye contact, flush with water for 15 min. Get medical attention. Wash after skin contact. *KEEP AWAY FROM CHILDREN.*

3.2.5 STORAGE CONDITIONS—Store material in original containers. Maintain at 20 °C ± 11 °C storage temperature. When kept under these conditions, a one-year shelf life can be expected. Material removed from containers may be contaminated during use. *Do Not Return This Material To Original Containers*.

3.2.6 ADVANTAGES AND DISADVANTAGES

3.2.6.1 Advantages

a. Reduces cut gasket inventories
b. Reduces machining operations
c. Eliminates costly retorquing operations
d. Single component system eliminates mixing
e. No waste from cure in open containers
f. No migration; can be applied to vertical surfaces
g. Seals surface imperfections
h. Eliminates gasket compression set and bolt loosening
i. Seals most common industrial fluids
j. No cracking or shrinkage during cure
k. Easily applied on automatic or semi-automatic equipment
l. Long open time after application
m. Good adhesion to most metal surfaces
n. Good vibration and shock resistance

3.2.6.2 Disadvantages

a. Requires use between closely-fitted surfaces; does not have large gap filling ability
b. Requires handling care to insure full flange coverage upon assembly
c. Prolonged contact may cause slight skin irritations
d. Not recommended for use on flexible joints
e. Requires at least one active surface

4. Engineering, Design, and In-Process Handling

4.1 Material Selection—A desirable feature in production is to use chemically compatible cure system sealants. This eliminates the need for purging the pumps and feed lines when switching from one supplier's material to another.

Consult with the sealant manufacturer to determine the effects of mixing materials.

4.2 Operating Temperature

4.2.1 RTV—Generally, RTVs can be used from –46 to 260 °C continuously and intermittently to 316 °C. Special products are available for intermittent use to 343 °C.

4.2.2 ANAEROBICS—Generally, anaerobics are available for use from 54 to 140 °C continuously and intermittently to 177 °C. Special products are available for intermittent use to 232 °C. Refer to manufacturer's recommendations for individual applications.

4.3 Operating Pressures—Pressure tolerance is dependent upon several conditions: time, joint width, gap clamp load, and other factors.

Figures 9 and 10 show typical gap and pressure data.

Confirming tests should be conducted using actual parts for each particular application.

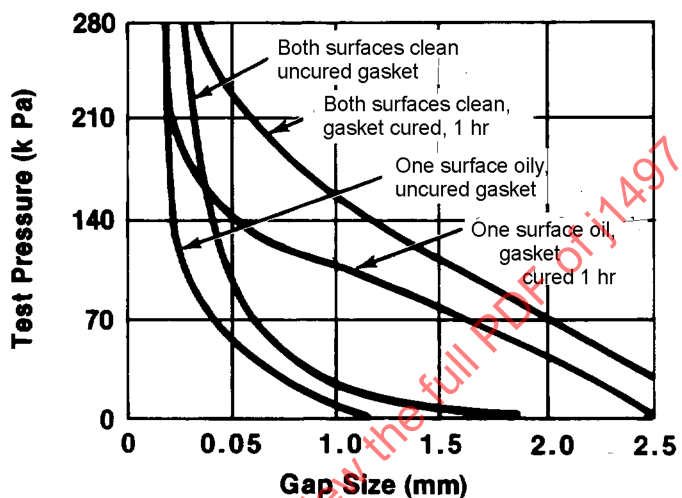


FIGURE 9—TYPICAL RTV GAP VERSUS PRESSURE

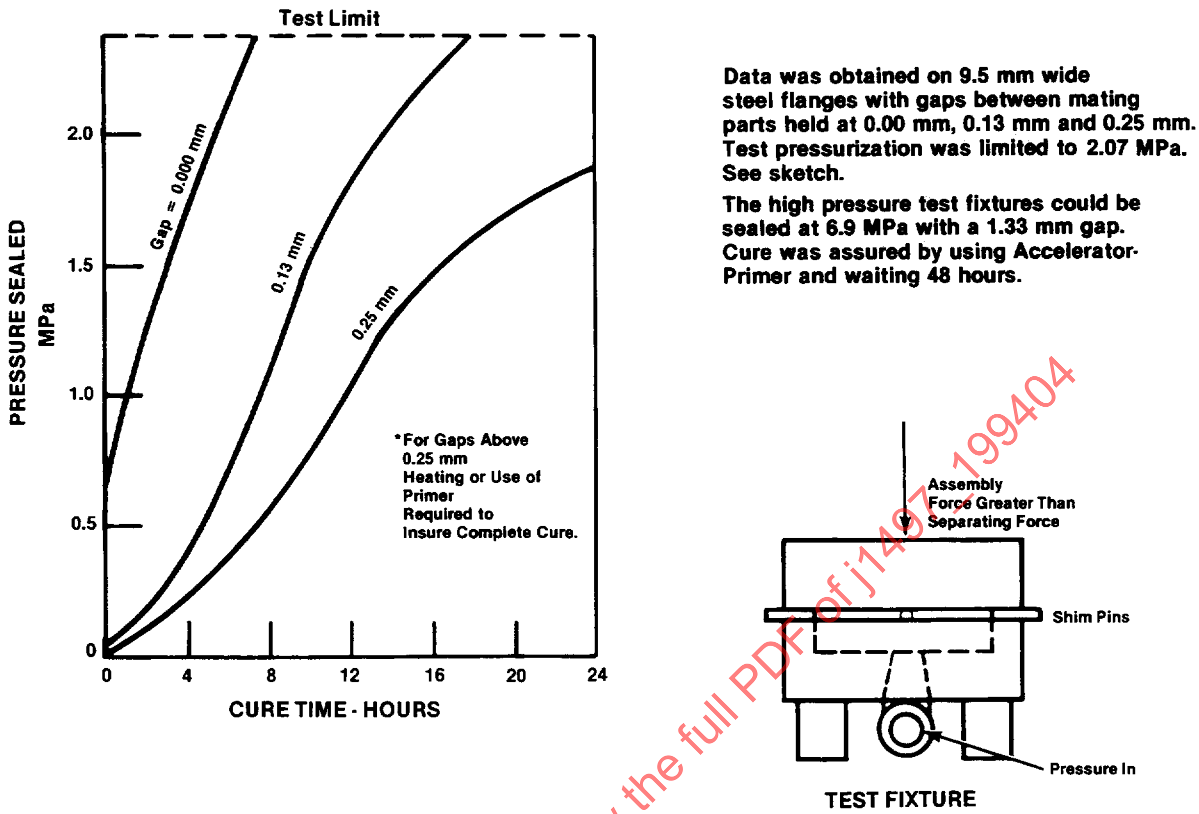


FIGURE 10—TYPICAL ANAEROBIC GAP VERSUS PRESSURE

4.4 Fluids to be Sealed—The sealant must be resistant to the fluids to be sealed. Refer to manufacturer for recommendations.

4.5 Design

4.5.1 THERMAL EXPANSION—Differential expansion of mating flanges is very critical. The sealant must be capable of tolerating the relative movement while maintaining seal integrity. This can be accommodated through proper selection of sealant, gap thickness, and flange material.

4.5.2 GAP THICKNESS—RTV can generally accommodate gaps up to 2.5 mm. Anaerobic sealants can accommodate gaps to 0.25 mm. The use of primer allows larger gaps. Gap thickness is affected by cure time and pressures encountered during assembly and operation.

4.5.3 FLANGE SURFACE—To assure efficient sealing, design parameters such as flatness and surface finish must be defined and specified to keep mating parts under control.

4.5.4 FASTENERS—In joints where there is excessive relative movement due to pressure or expansion, bolt spacing and clamp load are important in maintaining proper gap.

The joint integrity should not allow gap increase during "in process" testing or during operation.

Do not allow sealant into blind holes as hydrostatic lock may occur, resulting in false torque readings (low clamp load).

4.5.5 MINIMUM SEALING WIDTH—Generally, the minimum sealing width for (A) is 5 mm and for (B), 3 mm (see Figure 11). Wider flanges are strongly recommended.

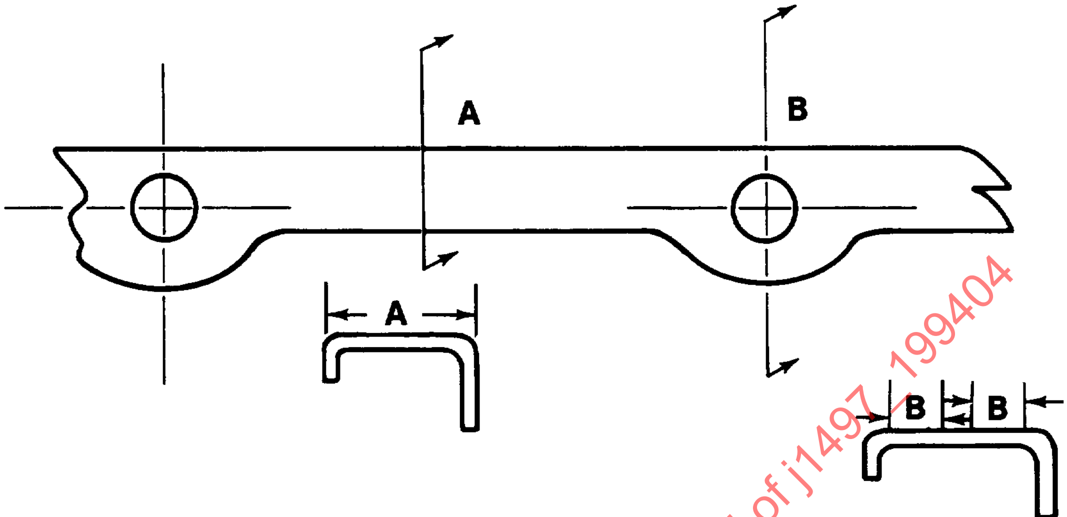


FIGURE 11—MINIMUM SEALING WIDTH

4.5.6 FLANGE DESIGN—Since liquid gaskets depend on flange adhesion to seal, the joint must be designed so the sealant does not fail in shear or adhesion. The thickness of sealant must be sufficient to accommodate movement induced by vibration, impact, and differential thermal expansion (see Figures 12, 13, and 14 for examples).

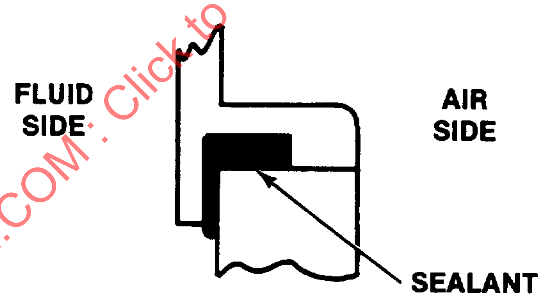


FIGURE 12—SHIELDED STEP FLANGE

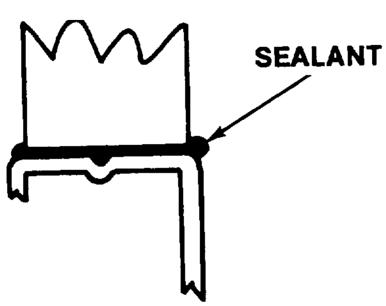


FIGURE 13—GROOVED FLANGE

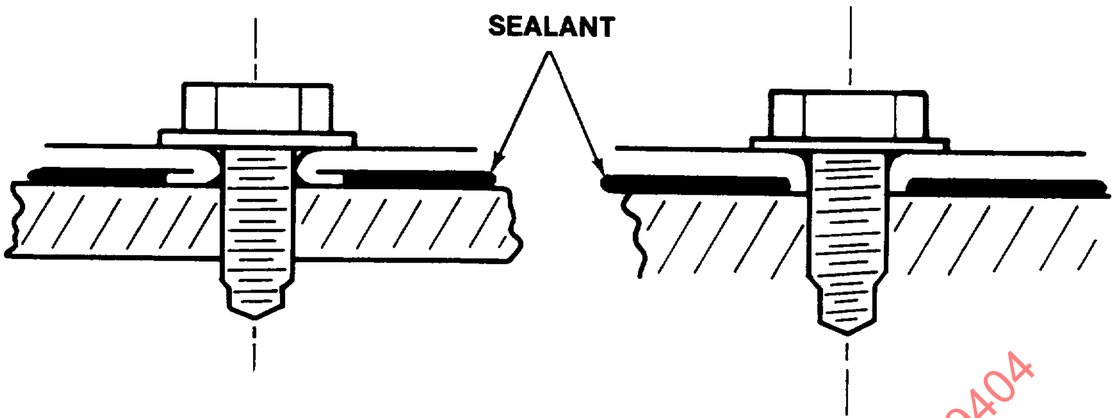


FIGURE 14—GAPPED FLANGE

4.5.7 BEAD SIZE—Increasing the bead size may increase the pressure capability of a joint, but too large a bead may decrease pressure capability. This is due to the effect of cure time when using RTV.

Establishing minimum bead size requires experimentation during the initial development and during an assembly plant trial. Table 5 shows the length of bead versus the bead size diameter that will result when using 28 cc of silicone sealant material.

Figure 15 can be used as a guide for selecting the proper bead diameter for various joint widths and gap sizes for RTV. Figure 16 shows anaerobic recommendations. The gap in this instance is due to inherent out-of-flat of the mating flanges.

TABLE 5—LINEAR MM OF GASKET PER 28 CC OF SILICONE SEALANT

Bead Size Diameter	Length
0.79 mm	(57.58×10^3 mm)
1.57 mm	(14.48×10^3 mm)
2.36 mm	(6.38×10^3 mm)
3.18 mm	(3.58×10^3 mm)
4.76 mm	(1.60×10^3 mm)

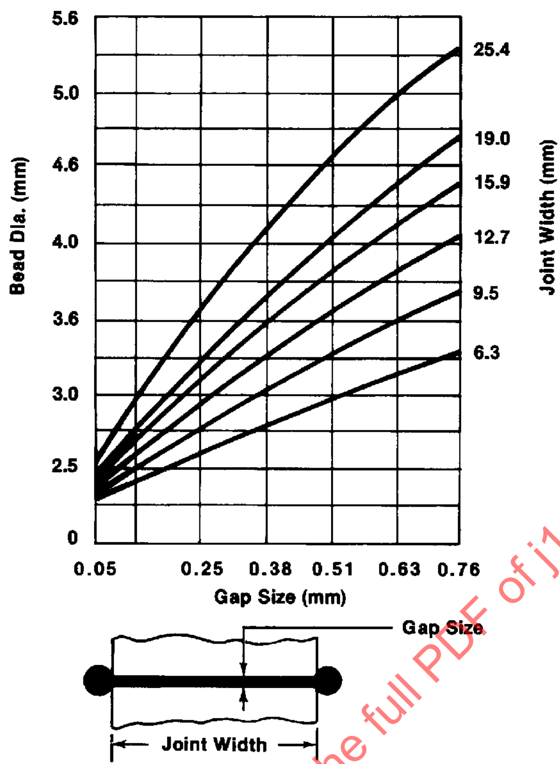


FIGURE 15—RTV BEAD SIZE

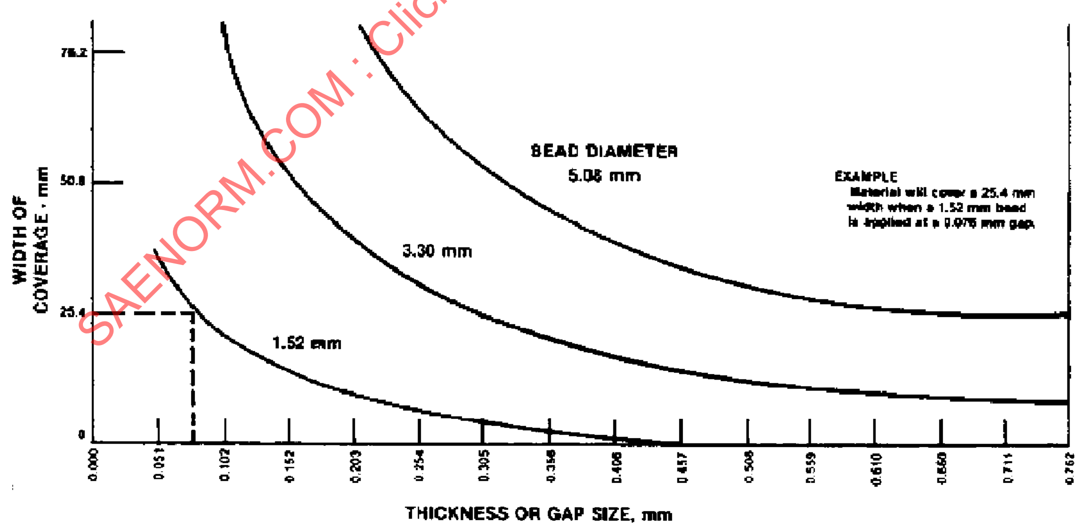


FIGURE 16—ANAEROBIC SEALER BEAD SIZE

4.5.8 Functional Operation—The type of functional operation is an influencing factor in the design of the flange.

4.5.8.1 Types of Operation Include

a. Vibration—such as 4-cylinder engines where high vibration forces are encountered.
b. Impact—such as an oil pan that may encounter a curb or parking lot bumper.
c. Structural—where the entire housing acts as a structural member. In this case, forces are transmitted through the inspection covers or oil pan.

4.6 Manufacturing Process Requirements

4.6.1 Application Equipment Systems

4.6.1.1 Screen Printing—This method uses a mesh screen containing the sealant pattern. The screen is placed on top of the work piece and the sealant is extruded through the mesh onto the work piece. This system is best for anaerobics.

4.6.1.2 Roller Coating—The sealant (usually anaerobic) is applied to a roller. The work piece is then rolled, leaving a thin film of sealant across the work piece.

4.6.1.3 Caulking Gun/Cartridges—This method is commonly used in the field and where the work piece is too large to be removed.

4.6.1.4 Tubes/Cartridges—This method is used where very small amounts of sealant are to be used. Figure 17 depicts the recommendations for dispensing from a tube or cartridge.

4.6.2 Motion Methods Of Dispensing

4.6.2.1 Template Follower—This system uses a template contoured to match the bead pattern. The follower traces the template while the extrusion nozzle dispenses the sealant onto the work piece.

4.6.2.2 Pantograph—This equipment is similar to the template follower in that a template or pattern is tracked. The motion mechanism consists of four light rigid bars joined in parallelogram form. This method is generally used for manual, low volume applications.

4.6.2.3 Cam Follower—This system rotates a profiled cam to generate each desired axis of motion.

4.6.2.4 Phototrace—This system uses a master pattern that is followed by an electric eye mounted on the traverse mechanism.

4.6.2.5 Numerical Control—These machines are controlled by a computer type memory system in which the desired pattern is programmed.

4.6.2.6 Circle Generator—This equipment is similar to a turntable to generate circles.

4.6.2.7 Magnetic Follower—This system utilizes a magnet to follow a steel ribbon of the desired sealant pattern.

4.6.2.8 Table 6 depicts the equipment parameters associated with various methods of sealant dispensing.

Recommendations for Hand Dispensing One-Component RTV Silicone Sealants

Applications in which RTV silicone sealants are dispensed by hand frequently require that the material be dispensed into a crack as a seal, into a corner as a fillet, or onto one of the mating surfaces of two parts to be joined, either as a bond or as a formed-in-place gasket.

When RTV silicone sealant is dispensed by hand into a crack or into a corner as a fillet, the preferred technique is to cut the nozzle at an angle and push the material ahead of the nozzle. Tooling the material, if desired, must be performed immediately.

If the RTV silicone sealant is dispensed as a formed-in-place gasket, or in any application where a uniform bead is required, the following technique is recommended:

1 Cut the nozzle tip off so that the nozzle diameter is equal to the desired bead diameter.

2 Adjust the dispensing rate to a very slow speed of the bead to approximately ½ in. per second if you are using an air-operated gun.

3 Place the nozzle tip against the work surface and begin dispensing the bead. (Step A.)

4 As the bead begins to extrude, raise the nozzle approximately 1 in. to 1½ in. above the work piece so that the bead hangs from the tip of the nozzle like a rubber hose. The thixotropic characteristic of the material prevents the bead from breaking providing a certain amount of slack or drape is maintained. This slack will allow small erratic movements of the nozzle due to normal shakiness of the hand without affecting the location of the bead. (Step B.)

5 Continue to extrude the bead from the nozzle with nozzle tip raised above the part, but concentrate on the exact point where the draped bead contacts the surface. (Step C.)

6 When the bead pattern is near completion, judge the distance to complete the bead as slightly less than the distance at which you are holding the nozzle above the part, and stop extruding the bead. Complete the pattern with the remainder of the bead draped from the top of the nozzle. (Step D.)

7 A slight wipe of the nozzle tip against the surface breaks the bead neatly from the nozzle tip.

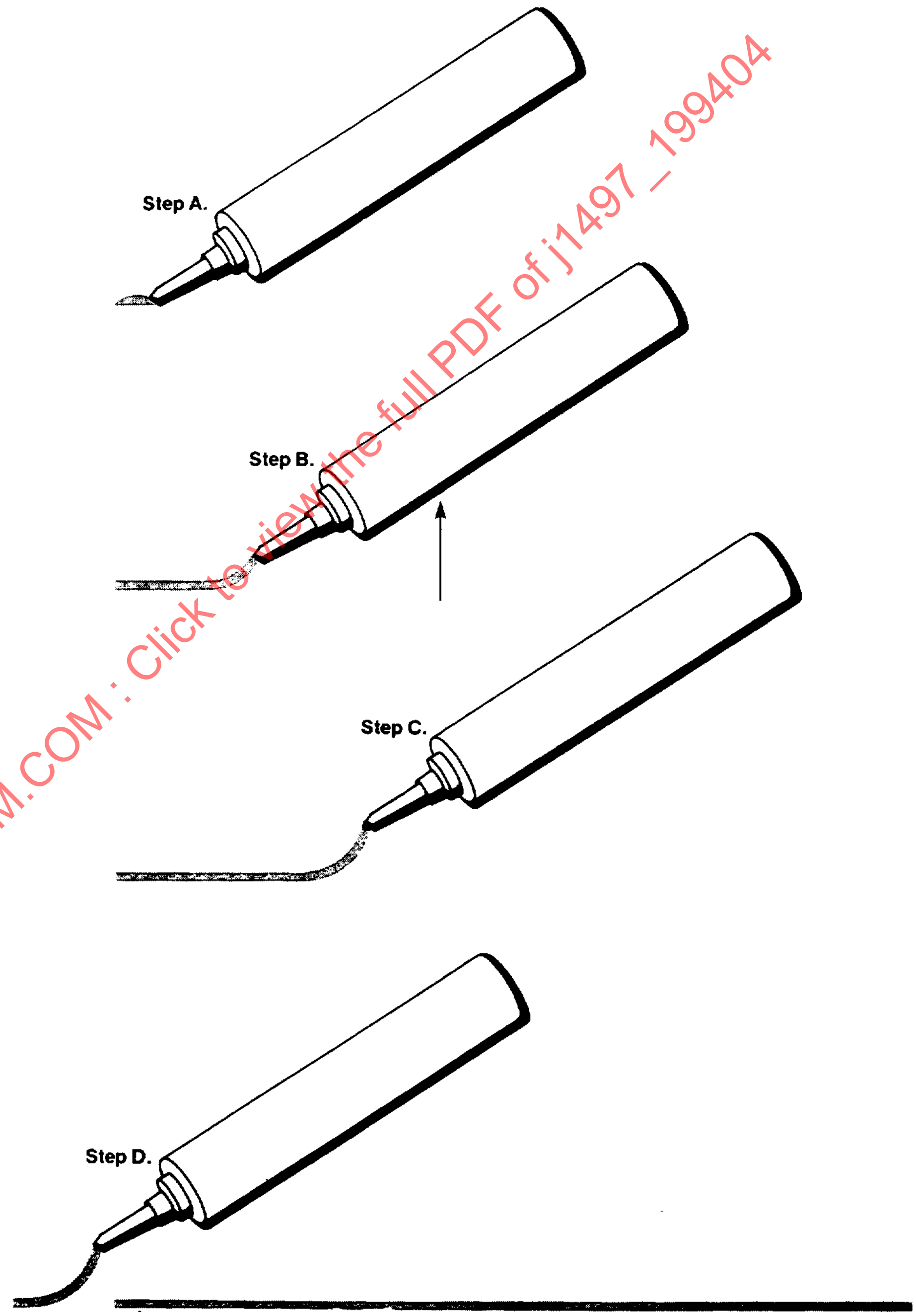


FIGURE 17—RECOMMENDATIONS FOR HAND DISPENSING ONE-COMPONENT RTV SILICON SEALANTS