White Paper

Silicon: An Element of Inspiration. An Element of Discovery. An Element of Design. An Element of Dow.

Gasketing Options with Silicones from Dow

Kent Larson, The Dow Chemical Company, USA

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Gasketing Options With Silicones From Dow

Gaskets and seals are used extensively to both contain things inside a system and to keep external environments from affecting closed systems and devices. A wide variety of sealing designs, processes and materials can be used. There are many good – and even many "best" – ways to create a gasket/seal. Some options offer one set of benefits, while another may offer a different set. Often, more than one gasketing option will work. Designers and engineers should review and consider various options to understand the trade-offs and benefits before down-selecting to a single choice.

With this in mind, Dow offers product choices that cover nearly all of the primary options used for gasketing, and we have extensive experience and expertise in every area of the globe to assist customers in making the best choices. This paper is meant to share high-level design options and to inspire ideas. For specific material recommendations for your application, data, etc., please contact your local Dow representative.

To the right are some of the options and trade-offs between benefits and limitations.

Gasket Option	Recommended For:	Not Advised For:
In-place Gasketing (IPG)	• Highest reliability • Uneven surfaces • Wide tolerances • Inconsistent bond line thickness • High joint movement	• Fast throughput/short cycle time • Very difficult surfaces to bond to • Repair or rework
Cure-in-place Gasket (CIPG)	• Fast assembly – pick and place • One surface that may be uneven or of wider tolerances • Repair or rework potential • Moderate joint movement	• Designs with uneven or unreliable clamping pressure • Very difficult surfaces to bond to
Molded-in-place	• Fast assembly – injection or compression molding • Surfaces difficult to bond to • Moderate joint movement • Uneven, inconsistent joint thickness	• Designs with uneven or unreliable clamping pressure (unless with adhesion) • Repair or rework
Precured gG	• Fast assembly – pick and place • Easiest to assemble • Repair and rework	• Wide tolerances or uneven surfaces • Inconsistent bond line thickness • High joint movement • Designs with uneven or unreliable clamping pressure

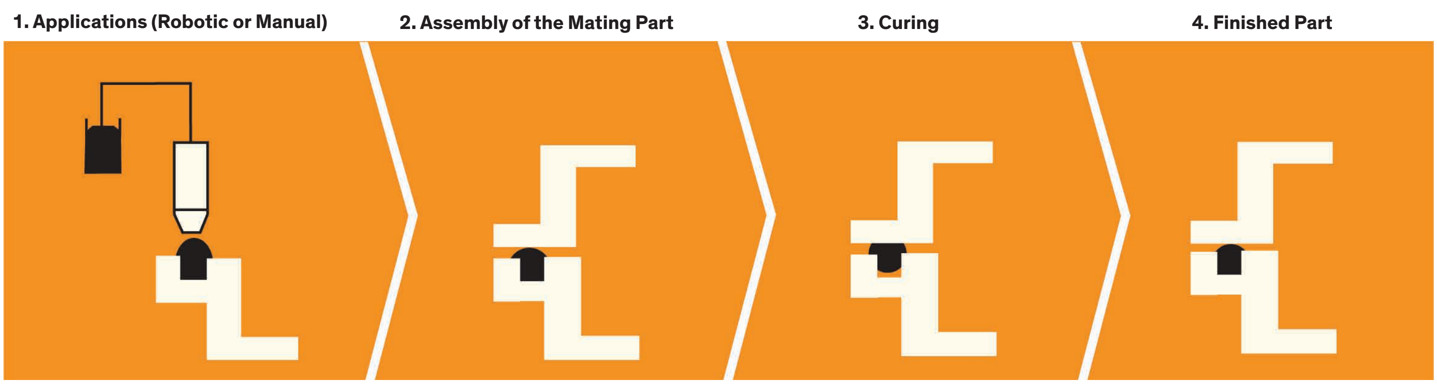
We will explore each of these options in greater detail in the following pages.

1. Adhesion to Both Sides = An Adhesive or Glue, In-place Gasketing (IPG)

This creates a permanent, nonrepairable seal. No compression pressure is needed – no clamps, springs, snaps, etc. The adhesive requires some form of dispense equipment and must be cured for the recommended time and temperature conditions at the time of assembly. Since this adds complication to the assembly process (dispensing and curing), there are potentially more things that could go wrong, such as ensuring good adhesion every time. If everything is done correctly, the option typically provides the most reliable, dependable seal – in large part because the seal does not require uninterrupted compression pressure. Sealing capability is as durable and reliable as the adhesion. This option is particularly well-suited when the bond line or joint thickness is unknown or may vary significantly. Material can be applied around a complete outer edge or to selectively seal noncontinuous gaps. Very rarely are adhesives and sealants modified or customized by subcontractors/assemblers.

Important Material Characteristics:

- **Compression set –** not typically important. No post-cure is required.
- **Elongation –** can be very important for high-movement joints.
- **Modulus –** generally, silicones have low modulus, which allows the adhesive to flex and move easily to reduce joint stress. Generally, lowermodulus products will have superior resistance to peel stresses.
- **Strength –** may not be important if mechanical fasteners are used. If the joint expansion cannot exceed the elongation, it will not break, even if the adhesive's strength is low.
- **Adhesion –** very good adhesion to both surfaces is required.
- **Cure conditions –** some products require heating at temperatures >120°C. Others require days to cure at room temperature – longer if moisture migrating into the bulk of the adhesive in the joint is limited due to small surface area exposed to the atmosphere.
- **Viscosity –** sealing small gaps may require a specific viscosity range to completely fill gaps without overflow.



Product Options:

Hot melts – nearly instant assembly and broadest adhesion, with extremely high elongation capability and no need to cure during assembly. Considerations: 0% cohesive adhesion; can be challenging to use/apply at first.

Suggested products to start with:

- DOWSIL™ EA-4600 LV HM RTV – Melt Viscosity 5-25,000 cps @ 120°C, 60A Hardness
- DOWSIL™ EA-4600 HM RTV Black UV – Melt Viscosity 60,000 cps @ 120°C, 56A Hardness

Moisture cures – typically the lowest cost and easiest to apply. Cure with exposure to moisture in the air and bond well to most substrates. Considerations: very slow cure (days).

Suggested products to start with:

Continuous seals, nonflowable:

- DOWSIL™ 3-0100 Automotive Sealant – 37A Hardness, 455% Elongation
- DOWSIL™ 3-0115 Automotive Sealant – 50A Hardness, 375% Elongation
- DOWSIL™ 3145 RTV MIL-A-46146 Adhesive/ Sealant – 46A Hardness, 625% Elongation

Small gap/spot seals, flowable:

- DOWSIL™ 3140 RTV Coating – 32A Hardness, 420% Elongation, 34,400 cP Viscosity
- DOWSIL™ SE 9120 Clear Adhesive – 24A Hardness, 375% Elongation, 8,125 cP Viscosity
- DOWSIL™ SE 9187 Clear Adhesive – 18A Hardness, 155% Elongation, 1,150 cP Viscosity

Heat cures – fast assembly and easy to apply. Considerations: more selective adhesion and typically must cure at temperatures above 100°C or at or above 125°C.

Suggested products to start with:

- SILASTIC™ RBL 9694-20P – 21A Hardness, 925% Elongation, Compression Set 36%
- SILASTIC™ RBL 9694-30P – 32A Hardness, 820% Elongation, Compression Set 31%

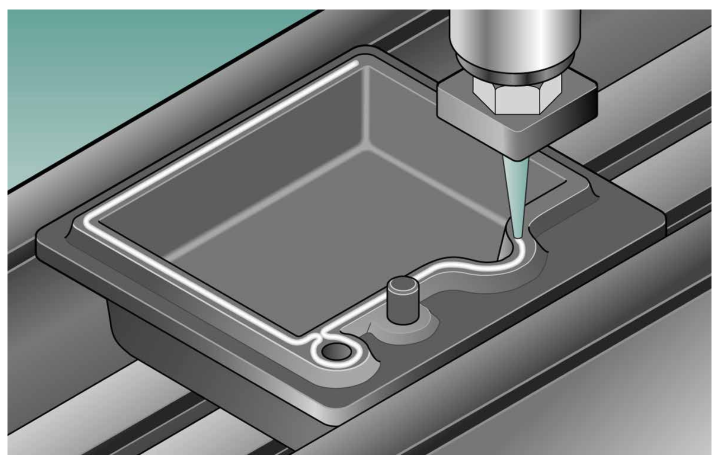
Double-sided tapes – Dow has a wide variety of silicone pressure sensitive adhesives (PSAs) that fabricators can apply to many different tape backings. In tape form, no cure is required and there are no liquids to deal with. Applying is done manually or by pick-and-place reels. Considerations: tapes require a very even, controlled bond line with tight tolerances and smooth surfaces. Foam-based tapes can allow for greater tolerances but at a cost of greatly reduced strength.

Suggested products to start with:

- DOWSIL™ 2013 Adhesive – Solventless, 36 g/mm Adhesion
- DOWSIL™ 7657 Adhesive – Lowest Cure Temp, High Tack, 35 g/mm Adhesion

HCR or LSR – a molding operation could be done. Priming would be required on all substrates to achieve adhesion. Selective-adhesion LSRs are being commercialized. Considerations: requires excellent adhesion with a primer, and this option is not common.

Suggested product to start with:



HCR:

- SILASTIC™ DY-32-541 U Silicone Rubber– 30A Hardness, 360% Elongation, Compression Set 5%

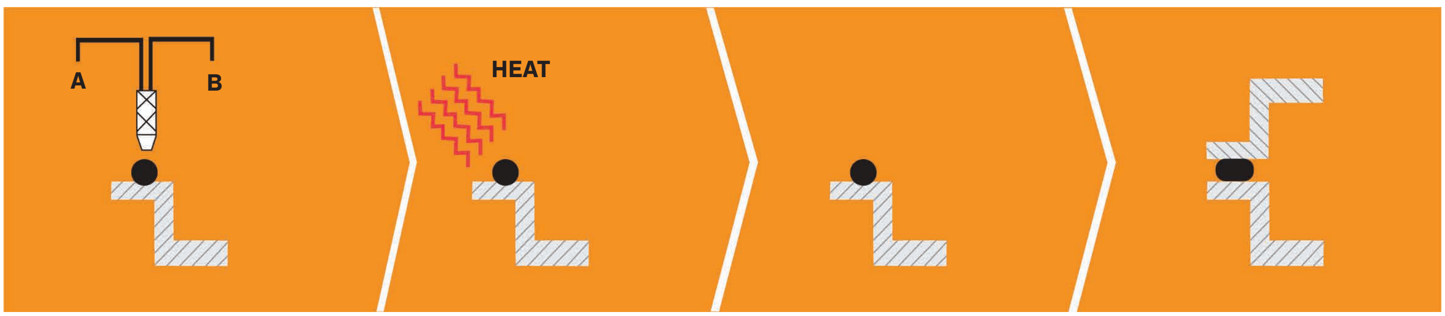
LSR:

- XIAMETER™ RBL-2004-20 to -75 – Range of Hardness, 400-900% Elongation, Compression Set 16-28%

2. Adhesion to One Side = Cure-in-place Gasket (CIPG)

A material is applied and cured with adequate adhesion to one surface, often months in advance of the final assembly. At assembly, no dispensing, molding or curing is needed, but clamping pressure is required to seal to the other surface. Since adhesion is only to one surface, the joint is easily opened and the seal is repairable. Complications of dispensing/curing can be done elsewhere from final assembly but still have same potential for things to go wrong to the bonded side. The sealing capability is only as good as the clamping pressure reliability. Once assembled, adhesion does not typically matter – the clamping pressure is what creates the seal. Adhesion, therefore, is predominantly for preassembly handling. Less total compression pressure may be required since the compression seal is on just one side. Material can be applied in a channel (often best to maximize compression seal), but this is not required. Uneven bonding surface is acceptable, but compression seal mating surface cannot vary greatly. Compression of 25% or more typically is required for a good seal. The more uneven the bond line gap, the greater the compression required. Foams can be used for very high compressions but offer less sealing force. Joints cannot move or flex more than the minimum compression pressure required to ensure a good seal. This option tends to be more serviceable (disassemble and reassemble) but may still have some adhesion to both surfaces after a prolonged time. Very rarely are products modified or customized by subcontractors/ assemblers.

1. Applications | **2. Curing with Heat** | **3. Transport** | **4. Assembly**



Robotically Applied | Typically Cured within 5-10 Min | Part Ready for Next Action

Important Material Characteristics:

- **Compression set** – can be very important. Post-curing typically is not possible.
- **Elongation** – can be very important for high-movement joints.
- **Modulus** – may be less important, but helps to determine the stiffness of the joint.
- **Strength** – may be important, especially for higher-hardness/ modulus materials.
- **Adhesion** – good adhesion to one surface is required.
- **Hardness** – the lower the durometer hardness, the less pressure will be required to achieve the recommended compression required for good sealing. The higher the durometer, the stiffer the joint will be = less movement once assembled.
- **Cure condition**s – some products require heating at temperatures >120°C. Others require days to cure at room temperature.

Product Options:

Moisture cures – see "Moisture cures" in section 1 (page 4).

Heat cures – require low compression set; see "Heat cures" in section 1 (page 4).

Curable foams – these require low heat to cure, and they allow for (and require) greater joint compression.
Considerations: higher compression set; much weaker; more complicated process.

Suggested Product to Start With:

- SILASTIC™ 3-8186 Thixotropic Foam – 140% Elongation, 23°C Compression Set 3%

Single-sided PSA tape – could work here, but with the same limitations as previously described (see "Double-sided tapes" in section 1 [page 4]).

HCR or LSR – see "HCR or LSR" in section 1 (page 4); could be done in a molding operation with one substrate primed to get adhesion. This is not a common option.

3. Molded-in-place

This is typically the mainstay of liquid silicone rubber. LSRs can be applied with low-pressure injection molding or compression molding that has well-defined channels to hold the LSR. Adhesion can come from the LSR (selective adhesion = sticks to part but not to mold) or from primers but may not be required. If adhesion is used on both sides, this becomes nearly the same as in-place gasketing (see page 3), but molded instead of dispensed. If adhesion is not used, some form of constant compression pressure is required, and the joints cannot move or flex to an extent that it compromises the minimum compression pressure required to ensure a good seal. If primer is applied just to one side, this becomes nearly the same as cure-in-place gaskets (see page 5). For higher-pressure compression molding, high-consistency rubber (HCR) can be used. These typically are peroxide-cured but also can be addition cure. Both require high heat for rapid cycle times. This option requires molding equipment at time of assembly and is a very common design choice. It is somewhat complicated, like in-place gasketing (see page 3), and often requires considerable expertise by the molder. Molders can – and often do – custom-compound the rubber, especially for HCRs, since the cure catalyst must be milled in just before use. Molding works well with varying bond lines/gaps but requires a channel to contain the material.

Elongation can be very important for high-movement joints if adhesion is used. If adhesion is desired, primers can achieve bonding to many surfaces.

Important Material Characteristics:

- **Compression set –** can be very important. Post-curing may not be possible.
- **Elongation –** can be very important for high-movement joints.
- **Modulus –** may not be highly important, but helps to determine the stiffness of the joint.
- **Strength –** may be important, especially for higher-hardness/modulus materials.
- **Hardness –** the lower the durometer hardness, the less pressure will be required to achieve the recommended compression required for good sealing. The higher the durometer, the stiffer the joint will be = less movement once assembled.
- **Cure conditions –** most products require heating at temperatures >120°C.

Product Options:

Heat cures – same as previously mentioned (see "Heat cures" in section 1 [page 4]), but will require lowest compression set.

HCR or LSR – same as previously mentioned (see "HCR or LSR" in section 1 [page 4]). Lower-hardness rubbers will tend to be more stress-relieving, which can be important for adhesion. We have active work advancing in selective adhesion and lower cure temperatures.

4. Precured Gaskets

These can be LSRs, but they more commonly are HCRs. No dispensing, molding or curing is required at assembly. The gasket must be carefully placed and aligned either manually or robotically. Compression is essential for sealing, and it must remain above a minimum value throughout the life of the device. Compression set is very important, and most materials used for these types of gaskets have very good compression set resistance and sealing force retention for a given amount of compression. Foams can be used for higher compression/ greater variability of gap size, but the sealing force is much less. Users have minimal control – they specify the gasket, but quality is only controlled by the specification. This option usually is the lowest-cost. Since sealing is only as good as the constant compression pressure, this is the least forgiving of part tolerance. Joints cannot move or flex more than the minimum compression pressure required to ensure a good seal. Seal material must be relatively strong with medium elongation).

Important Material Characteristics:

- **Compression set** – very important; post-curing is commonly used to minimize.
- **Elongation** – may not be as important as with other options.
- **Modulus** – lower in importance, but helps to determine the stiffness of the joint.
- **Strength** – may be important, as the gasket must hold up to considerable handling and stress during assembly.
- **Hardness** – the lower the durometer hardness, the less pressure will be required to achieve the recommended compression required for good sealing. The higher the durometer, the stiffer the joint will be = less movement once assembled.
- **Cure conditions** – requires heating at temperatures >120°C in most cases. Post-cures can be considerably hotter and for several hours.
- **Securing the gasket in place** – in some designs, it may be desired to hold the gasket in position during assembly processes without fixturing, or the compression of the gasket may be limited. In those circumstances, an adhesive may be used to minimize gasket movement. PSAs can be used for low-strength holding (which can allow easy repositioning or rework), or a strong adhesive may be chosen. Adhesives should have durable and robust adhesion to the gasket and sealing surface and have somewhat similar modulus, elongation and thermal expansion characteristics as the gasket.

Product Options:

HCR – the most common choice for adequate properties at the most cost-effective price; same as previously mentioned (see "HCR or LSR" in section 1 [page 4]).

LSR – not as common of an option; same product recommendations as previously mentioned (see "HCR or LSR" in section 1 [page 4]). Thermoplastic Elastomers – uncommon, but have been used in this way; same as previously mentioned (see "Thermoplastic Elastomers" in section 3 [page 6]).

Adhesives – for fixturing during manufacturing and limiting movement in use. Durable bonding to cured silicones is best accomplished with select moisture-cure silicones and silicone hot-melt adhesives. The hot-melt adhesives offer much faster cycle times since they have nearly instant adhesion strength once dispensed, while moisture cures can take days to cure.

Suggested Products to Start With:

- DOWSIL™ EA-4600 LV HM RTV – Melt Viscosity 60,000 cps at 120°C, 56A Hardness
- DOWSIL™ 3145 RTV MIL-A-46146 Adhesive/Sealant – 46A Hardness, 625% Elongation

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