# Silicone Molding with Objet Parts

Application Note

Skill level
Time
Cost

## Overview

- Silicone rubber molding is a perfect solution to fill the gap between one-off rapid prototyping and prototype injection molding. Silicone molds produce urethane castings that are used for functional testing, product demonstration and even low volume manufacturing. From rigid and tough to soft and flexible, quality parts can be made in less than a week at a low cost.
- Silicone molds reproduce the tiniest of details thus the quality of the pattern is critical. With PolyJet™ technology, perfect patterns are created and ready for mold-building immediately after they are cleaned. The hours or days previously devoted to sanding, filling and priming patterns is no longer needed. Consequently, PolyJet™ technology expedites the silicone rubber molding process and reduces its cost.
- Rapid prototyping reignited the use of silicone molding. Prior to rapid prototyping, pattern creation took longer than building a rubber mold and casting parts. With rapid prototyping, silicone rubber molding is once again a competitive and attractive solution. PolyJet™ technology further reduces the time, labor and cost of silicone molding, making its use with urethane casting an ideal solution for prototype development and low volume production.
- Silicone molding offers lead times of three to seven days at just one-tenth (or less) of the cost and time of an aluminum tool. Silicone molding is an attractive alternative for producing many injection, compression and rotationally molded plastic parts.
- Silicone molds are capable of reproducing extremely complex geometries and very fine details. Due to the cycle time, cost per piece and tool life, silicone molding is ideally suited for applications producing 1 to 100 parts. However, since the tools are inexpensive and quickly made, the creation of multiple silicone rubber molds to produce larger numbers of parts is a viable option.

## Silicone Rubber Materials

For rapid prototyping, the recommended type of silicone material is two-component addition silicone rubbers that consist of:

- Vinyl base polymer
- SiH base hardener
- Platinum based catalyst

These silicone materials are translucent with very little shrinkage (<0.1%).
Type of chemical reaction: addition

Brands used by our experts:

- **ALPINA Additive Silicone Rubber -** http://alpina-silicone.com/cms/front_content.php?idcat=19
- **EBALTA Silicone for Rapid Prototyping -**

http://www.ebalta.co.uk/products/products_silicones.html

- **Axson -** http://www.axson.com

# The Silicone Molding Process

**Step 1**: Degassing - Insert the silicone A component into the vacuum chamber to remove moisture at 30inHg VAC/ 760mmHg for 15 minutes. If the room is cold, an additional 5 minutes may be needed.

**Figure 1** degassing process

**Step 2**: Create a frame for the silicone rubber pouring - Build a four-sided box with inside dimensions equal to those of the pattern. Any rigid, smooth material can be used, including MDF, finished plywood or a Formica laminate.

**Figure 2** Master model

**Step 3**: Add vents and gating to the pattern -
Venting allows air to exit the tool. Without venting, air pockets will prevent a complete filling of the tool cavity. Vents are made from 1/16 inch (1.6 mm) metal or plastic dowels. Cut the dowels long enough to extend from the pattern surface out through the top of the tool. Attach the vents with cyanoacrylate (super glue) to all high points of the pattern and any areas that are likely to trap air when casting the silicone rubber.

Attach a gate to the part using cyanoacrylate. Make the gate from a 1/4 inch (6.4 mm) rod stock cut to a length which extends from the part surface through the top of the tool. If casting a viscous urethane, use a larger diameter rod.

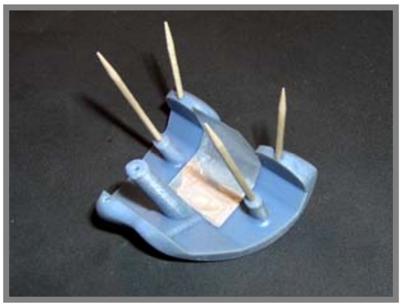


**Figure 3** Attaching the gates

After the tool has cured, remove the gate rod and attach a small paper cup over the gate channel. The cup will be the reservoir for the cast urethane.

Once assembled, coat all surfaces with mold release. Since mold release selection depends on the type of silicone rubber, refer to the manufacturer's recommendations.

**Figure 4** Positioning the master model in the frame

**Step 4**: Use a black permanent marker to mark the parting line of the master model. This will make it easier to see where to cut the mold after the silcone has hardened.

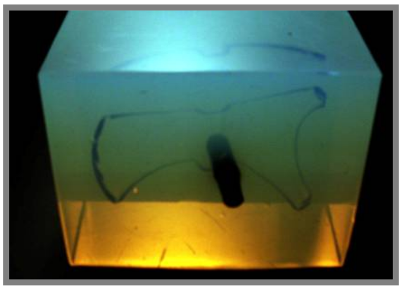


**Figure 5** Parting line visible through The silicon model

**Step 5**: Position the master model in the frame. The master model should be in the air to allow the silicone rubber to flow under it.

**Step 6**: Mixing the silicone **ALPINA Additive Silicone Rubber** with the hardener -

- Silicone A component Köraform A42 – 90%
- Silicone B components: Köraform A41/42 BL and A 42BW together – 10%

| Adjusting the pot life: **BW** | **BL** | **Pot Life** |
|---|---|---|
| 10% | 0% | 60 min |
| 7% | 3% | 135 min |
| 3% | 7% | 270 min |
| 0% | 10% | 300 min |

**Step 7**: Second degassing – Place the mixed silicone rubber in the vacuum chamber until all of the bubbles created by the chemical reaction have collapsed, approximately 5-10 minutes.

**Step 8**: Pour the mixed silicone rubber into the prepared frame. Please note, the liquid silicone rubber is poured in the corner of the frame to allow a smooth flow around the master model.

**Step 9**: A third degassing process is possible after the silicone rubber has been poured into the frame. (This is not mandatory as all the bubbles created during the pouring action will float to the surface during curing.)

**Step 10**: After curing the silicone rubber, remove the frame and cut the mold using a dissector knife along the parting line. In the picture, special tweezers are being used to aid in the cutting process.


**Figure 6** ALPINA Additive Silicone Rubber with the hardener

**Figure 7** Pouring the mixed silicone rubber

**Figure 8** Cutting the mold using a dissector knife

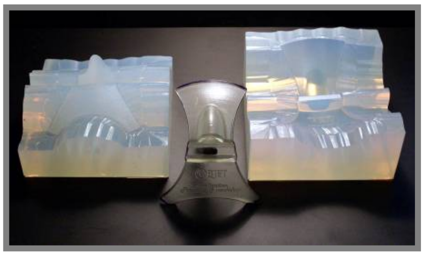


**Figure 9** Master model and silicone mold

**Step 11**: Separate the master pattern from the silicone mold. The mold is ready for casting.

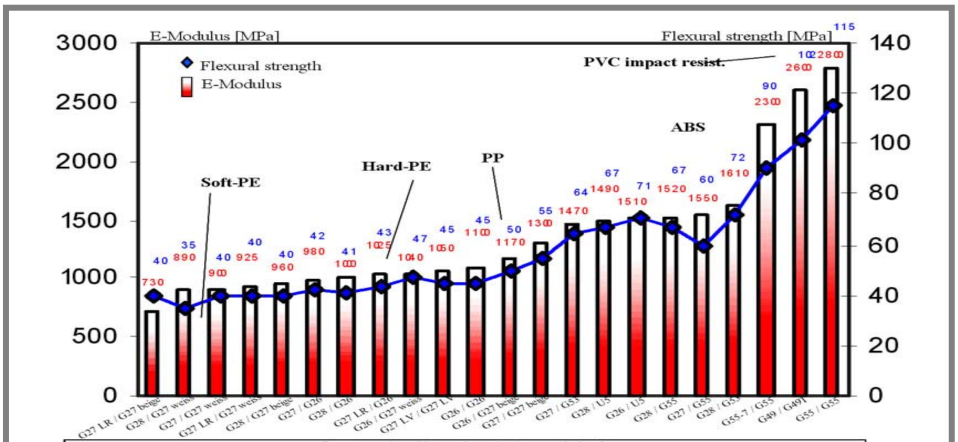
# Choosing the Casting Material and Method

Urethanes may be gravity casted, vacuum casted, pressure casted or injected. The determining factors are: available equipment, the material's pot life and the difficulty in filling the tool.

Gravity casting is simply pouring urethane into the tool cavity without vacuum or pressure assistance. In vacuum casting, the tool is filled and an ample supply of urethane is poured into a reservoir created by the gate cup. The tool is then placed in a vacuum chamber. The evacuation of air draws the urethane into the tool. A similar process is used for pressure casting with the main difference being that the chamber is pressurized to force the urethane into the tool cavity.

- When the cavity is difficult to fill, try injecting the urethane using a large syringe or a caulking gun.

# Fast Cast Resins




Prototype- and moulding-casting resins (processed by hand)

| Resin | G27LR | G28 | G27 | G27LR | G28 | G27 | G28 | G27LR | G26 | G27LV | G26 | G26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardener | G27 bei | G27 we | G27 we | G27 we | G27 be | G26 | G26 | G26 | G27 we | G27LV | G26 | G27 be |
| Mixing ratio p.b.w. | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 | 100 100 |
| Potlife [min] | 4,5 | 6,5 | 2,3 | 4,5 | 6,5 | 2,3 | 7,5 | 4,5 | 2,5 | 2,3 | 4,5 | 2,7 |
| Shore hardness D | 70 | 68 | 70 | 70 | 69 | 70 | 68 | 71 | 71 | 70 | 70 | 72 |
| E-modulus [MPa] | 730 | 890 | 900 | 925 | 960 | 980 | 1000 | 1025 | 1040 | 1060 | 1100 | 1170 |
| Flexural strength [MPa] | 40 | 35 | 40 | 40 | 40 | 42 | 41 | 43 | 47 | 45 | 45 | 50 |
| Impact resistance [kJ/m²] | 40 | 41 | 60 | 69 | 28 | 50 | 19 | 36 | 31 | 23 | 30 | 27 |

| Resin | G27 | G27 | G28 | G26 | G28 | G27 | G28 | G55-7 | G49 | G55 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hardener | G27 be | G53 | U5 | U5 | G55 | G55 | G53 | G55 | G49T | G55 |
| Mixing ratio p.b.w. | 100 100 | 100 75 | 100 70 | 100 70 | 100 80 | 100 80 | 100 75 | 90 100 | 100 24 | 80 100 |
| Potlife [min] | 2,3 | 1,2 | 4 | 1,6 | 5,3 | 1,5 | 5 | 4 | 25 | 4 |
| Shore hardness D | 70 | 77 | 79 | 71 | 78 | 75 | 79 | 82 | 82 | 84 |
| E-modulus [MPa] | 1300 | 1470 | 1490 | 1510 | 1520 | 1550 | 1610 | 2300 | 2600 | 2800 |
| Flexural strength [MPa] | 55 | 64 | 67 | 71 | 67 | 60 | 72 | 90 | 102 | 115 |
| Impact resistance [kJ/m²] | 22 | 19 | 24 | 24 | 30 | 50 | 25 | >100 | 27 | >100 |

**Diagram 1** Prototype and molding-casting resins (processed by hand)

- The average pot lives of fast cast resins are between 6-10 minutes, making them ideal for vacuum casting.
- Fast cast resins can simulate injection moldable materials. In the table above, the E modulus and Felxural strength values are shown along with those of injected molded plastic with similar properties.
- For example, if you require a material close to ABS, mix the G55-7 with the G55 in a mixing ratio of 9/10. This will give you a pot life of 4 minutes.
- Note: Fast cast resins have a longer pot life than RIM materials. During the pot life, fast cast resins heat to high temperatures (around 100C°) which damage the silicone mold. When using this kind of resin, only 30-

35 parts can be casted from one silicone mold. To produce more parts, a new silicone mold is needed.

# RIM

## 1. Overview

Reaction injection molding (RIM) is similar to injection molding except thermosetting polymers are used. Thermosetting polymers cause a curing reaction to occur within the mold. The two parts of the polymer are mixed together and the mixture is then injected into the mold under high pressure using an impinging mixer. The mixture is allowed to sit in the mold long enough for it to expand and cure.

## 2. Advantages:

Reaction injection molding produces strong, flexible, lightweight parts which can easily be painted. It also has quick cycle times as compared to typical vacuum cast materials.


**Figure 10** RIM machine
http://www.dekumed.de/E/PRODUCTS/e_unidos100.html

Note: Wearing rubber gloves is imperative when working with RIM materials

## 3. The Molding Process:

- RIM machines have two separate containers: one holds the resin and the other holds the hardener; both containers have a separate pump. The pumps push the materials into the mixing head. The mixing ratio can be adjusted by adjusting the pumps' volume.
- On the front of the mixing head is a "static mixer." The static mixer combines the RIM resin with the hardener.
- The static mixer is inserted into the mold and then injects the material into the mold within seconds.
- For example, Dekumed's UNIDOS100 RIM machine can fill one liter of mixed material in 60 seconds. If a larger volume of mixed material is needed, larger RIM machines exist.

## 4. RIM Materials Selection:

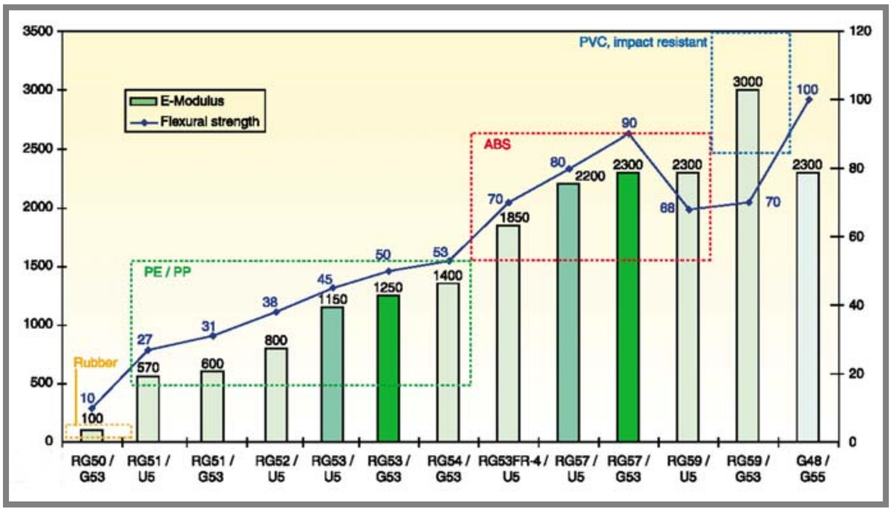



**Diagram 2** Selection of RIM materials

| Injection molding materials / RIM materials: Resin A | Hardener B | Density ISO 1183 g/cm³ | E-modulus ISO 178 MPa | Flexural strenght ISO 178 MPa | Tensile strenght ISO 527 MPa | Elongation at break ISO 527 % | Impact resistance ISO 179 kJ/m² | HDT ISO 75B °C |
|---|---|---|---|---|---|---|---|---|
| RG50 | G53 | 1,1 | - | - | 5 | 200 | - | - |
| LDPE | | 0,92 | 400 | 10 | 10 | 400 | n.t. | 40 |
| RG51-HS | G53 | 1,15 | 450 | 20 | 25 | 150 | 75 | 65 |
| RG51 | U5 | 1,2 | 570 | 27 | 34 | 70 | 36 | 110 |
| RG51 | G53 | 1,2 | 600 | 31 | 34 | 100 | 40 | 62 |
| RG52 | G53 | 1,2 | 800 | 38 | 30 | 60 | 42 | 72 |
| HDPE | | 0,95 | 1200 | 23 | 30 | 500 | n.t. | 60 |
| RG53 | U5 | 1,2 | 1300 | 54 | 38 | 20 | 50 | 120 |
| RG53 | G53 | 1,2 | 1400 | 58 | 38 | 25 | 60 | 110 |
| RG54 | U5 | 1,2 | 1400 | 53 | 44 | 12 | 75 | 115 |
| PP homopolymer | | 0,9 | 1400 | 37 | 30 | 150 | 10 | 55 |
| RG53-Fibre | U5 | 1,2 | 1730 | 55 | 35 | 11 | 48 | 63 |
| kPVC | | 1,4 | 2000 | - | 62 | 30 | 5 | 70 |
| HIPS | | 1,03 | 2000 | 55 | 30 | 40 | 8 | 78 |
| RG53-FR-4 | U5 | 1,27 | 2200 | 70 | 45 | 5 | 35 | 110 |
| RG57 | U5 | 1,2 | 2200 | 80 | 45 | 13 | 65 | 125 |
| PA6 | | 1,13 | 2200 | 100 | 80 | 50 | 25 | 80 |
| RG57 | G53 | 1,2 | 2300 | 90 | 54 | 9 | 100 | - |
| RG59 | U5 | 1,8 | 2300 | 68 | 46 | - | 29 | 65 |
| PC | | 1,2 | 2400 | 85 | 63 | 6 | 64 | 128 |
| EP | | 1,25 | 2400 | - | 50 | 3 | 4 | 230 |
| ABS | | 1,06 | 2500 | 75 | 50 | 40 | 22 | 95 |
| PA66 | | 1,13 | 2800 | 120 | 100 | 50 | 12 | 77 |
| RG59 | G53 | 1,8 | 3000 | 70 | 45 | 4 | 30 | 60 |
| PET | | 1,3 | 3100 | - | 80 | 4 | 3 | 65 |
| PMMA | | 1,18 | 3200 | - | 64 | 3 | 2 | 85 |
| PS | | 1,04 | 3500 | 95 | 50 | 3 | 2 | 80 |
| UP | | 1,25 | 3500 | 100 | 50 | 2 | 3 | 80 |
| PP+35%GF | | 1,15 | 4000 | - | 90 | 3 | 10 | 148 |
| PA66+30%GF | | 1,37 | 5900 | 145 | 135 | 5 | 24 | 215 |
| PC+30%GF | | 1,43 | 6700 | 145 | 144 | 4 | 10 | 145 |

**Figure 11**
Illustrated above: a final part (black) and its master model. Information and photos courtesy of Varinex/ Hungary.

**Diagram 3** Selection of RIM materials compared to end product materials

| Biresin® Low pressure RIM-systems | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resin A-polyol Biresin® | RG50 | RG51 | | RG52 | RG53 | | RG54 | RG53 FR-4 | RG57 | | RG59 | | G48 |
| Hardener B-isocyanate Biresin® | G53 | U5 | G53 | G53 | U5 | G53 | U5 | U5 | U5 | G53 | U5 | G53 | - |
| Mixing ratio pbw Resin / Hardener | 100 / 18 | 100 / 64 | 100 / 70 | 100 / 64 | 100 / 75 | 100 / 80 | 100 / 70 | 100 / 50 | 100 / 80 | 100 / 90 | 100 / 28 | 100 / 30 | - |
| Potlife [sek] | 100 | 50 | 50 | 60 | 55 | 55 | 55 | 40 | 40 | 50 | 60 | 60 | 45-60min |
| Demoulding time [min] | 15 | > 10 | > 10 | > 10 | > 10 | > 10 | > 10 | > 8 | > 10 | > 10 | > 10 | > 10 | - |

**Diagram 4** Technical data on RIM materials

# Disclaimer

Objet Geometries Ltd. is not responsible for misuse of our products or their use in conjunction with unsafe or improperly maintained equipment or for uses other than intended as specified in this application note.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