Homogeneous And Non-Homogeneous Blends Of Liquid Silicone Rubber
(For Desired Effects)

Daniel T. Laur
President
Laur Silicone, Inc.
4930 S. M-18, Beaverton, MI 48612
Phone 989-435-7400 * Fax 989-435-7707
Email DTLaur@LaurSilicone.com

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Introduction

The concept of blending silicone rubber to intermediate durometers is well known in High Consistency Rubber (HCR). Likewise, the blending of polymers to non-homogeneous mixtures is also well known. With the recent introduction of Easy Cure™ technology, One Part™ LSRs are now available (1) (2) (3) (4). This makes both homogeneous and non-homogeneous blending of liquid silicone rubbers more practical.

Homogeneous blends

The concept of molding simple parts in a semi-automated manner using One Part™ liquid silicone was demonstrated at the ACS Rubber Division show in Columbus, Ohio in 2004 by Laur Silicone (5). This allows less expensive LSR molds and allows for parts that are currently being made with HCR to be switched to LSR. A paper supporting this concept appeared in the January 2005 issue of Rubber World (6).

WABASH MPI Model GL30H-15-X Plunger Style Injection Machine is designed for use in a variety of LIM molding applications, including the use of ONE PART™ liquid silicone. Shown as run with two cavity semi-automatic mold.

Shorter, less automated production cycles of varying parts may require more frequent changing of durometer. This would suggest a need for more flexible materials and delivery systems. These materials and systems are available.

The practice of blending HCRs to intermediate durometers is well known. As early as the 1970s Dow Corning had published technical bulletins telling how to calculate the formulation to achieve intermediate durometers (7). In addition there are data sheets that give intermediate durometers for blends of NPC 40 and 80 (8). The following blend durometers were shown with 2,4-dichlorobenzoylperoxide:

NPC 40	100	75	50	25	0
NPC 80	0	25	50	75	100
Durometer	41	49	62	68	78

While this same procedure has been done with two component LSR materials, the process of doing such a blend has been discouraged because this would require four pumps and up to three static mixers. In addition, off-ratio materials could lead to increased inventory costs.

The introduction of One Part™ LSR has greatly simplified the system requirements for handling LSRs (9). Only one standard LSR pump is required to handle fully compounded materials, or one pump and an additive system if an additive stream is desired. This has freed up the second pump of a standard two-component system, making it available to blend durometers in the same way it was used to blend “A” and “B” components of a two-part system.

Current systems with metering should be able to provide the ratio control necessary to blend to intermediate durometers. Shown below are the results achieved by blending a low and high durometer LSR:

LS7010-30	100	80	60	40	20	0
LS7050-60	0	20	40	60	80	100
Durometer	35	40	45	50	55	60
Tensile, MPa	5.7	5.7	6.6	6.9	6.8	7.0
Elongation, %	485	430	435	385	330	295
Tear, B kN/m	25.9	29.1	36.6	38.7	37.3	37.0
Sp. Gravity	1.09	1.10	1.10	1.11	1.12	1.13

The predictability of blending the One Part™ LSR appears to be comparable to blending HCRs.

Because of the compatibility of the low and high durometer materials, the system can be simply purged to change durometers. The material produced during the purge will cure. However, the durometer will not be predictable until the mixture has stabilized.

The Easy Cure™ system has been shown to be stable for periods greater than one year (9). This eliminates the need to clean or refrigerate the static mixer sections for extended shutdowns. The elimination of the need to purge the mixer should also help reduce off ratio inventory.

As with any manufacturing system, there are choices that should be considered when deciding which approach to use. Some of the considerations are shown below:

	Blended durometer system	**Fully compounded durometer to specification**
System cost	Higher	Lower
Lead times for particular durometer	Short / made in house	Longer/ must be ordered
Test results	Not available for blend	Available with each lot
Material waste	During mixer purge	During pump or pail change
System requirements	Two pumps with metering and static mixer	One pump or air pressure delivery system, no static mixer
Material packaging	Drums or pails	Drums, pails or tubes
Material pricing	Standard One Part™ pricing	Standard One Part™ pricing
Pot life	One year plus	One year plus

Non-Homogeneous Blends

As long as the author can remember there have been non-homogeneous blends of polymers marketed. One of the best examples of this is flooring where un-evenly dispersed colors are added for decorative purposes. The photo below shows an ashtray made in the Dow Corning Fabrication Lab circa 1970. The part was likely made with HCR and shows some of the visual effects that are possible with multicolored parts.

This old concept can be applied to parts made with LSR. While the same could be done with two-component LSR materials, the process has been made simpler with the new One Part™ LSRs.

(Note: The ashtray is on a silicone placemat made from circa 1960.)

The equipment needed to do this will vary with the manufacturing method used. The coasters shown in the picture were made with a simple compression mold in a standard lab press.

The material was pre-weighed onto the molding plate using two caulk guns. The plates were mated to the mold and the parts press cured. The patterns are due to the way in which the two materials were applied to the plate. Both materials are the same durometer.

A trial run was done (at Alba Enterprise, Inc.) on a standard LSR molding machine. In this case the two-pump meter mix system was removed and replaced with a simple air gun tube system. Two tubes with valves were used to control which color was fed into the mold. No static mixer was used. This system uses a standard mixing screw.

The pictures show varying colors as the material fills the mold, and air caulk guns.

To avoid mixing the materials in the screw barrel a modified screw with less mixing might be considered. To achieve more color differentiation a feed system that permits pulsing of the two materials might be considered. Both of these should be practical with One Part™ materials. These materials do not require any additional mixing to overcome any under mixing in the static mixer section.

The non-homogeneous blending of the same durometer for a visual affect is mainly a marketing consideration. It should have little effect on the part's performance in service other than the effects of the knit lines.

The use of materials with different physical properties, e.g. durometer, could be both marketing and performance tools. The picture shows coasters with three colors, which were made with a simple compression mold filled with three different durometers.

This same principle could be modified and used with injection molding equipment. With more precise controls this concept should be useful for co-molding parts with different durometers in a controlled manner.

Footnotes 1-9

(1) Paul Kehl, "Liquid Silicone Rubber", May 2004 Rubber Roller Group Meeting
(2) Paul Kehl, "Heat Cured™ One Part™ Liquid Silicone Rubber", May 2004 International Silicone Conference
(3) Paul Kehl, "Properties and Processing of the Heat Cured One Part™ Liquid Silicone Rubber", October 2004 ACS, Rubber Division Meeting
(4) Paul Kehl, "Next Generation Liquid Silicone Rubber", *Rubber World*, May 2004
(5) Lippincott & Peto, *Rubber & Plastics News*, November 1, 2004, Page 12
(6) James M. Curtis, Mathew J. Guoan, William D. Inman, Jr. & Janice D. Worden, Dow Corning, "Liquid Injection Molding Versus Compression Molding: Effect on LSR Elastomer Mechanical Properties", *Rubber World*, January 2004, Pages 16, 17 & 20
(7) Dow Corning, "Fabricating with Silastic® Silicone Rubber", Form no. 17-053B-79, Page 5
(8) Dow Corning, "Silastic® NPC 40 and 80 Silicone Rubber Products, ©1979 Dow Corning Corporation
(9) Paul Kehl, "One Part™ Liquid Silicone in Conventional High Consistency Silicone Applications", April 2004 International Silicone Conference