

# High Consistency Silicone Rubber

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## An Introductory Handbook on Fabrication

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## **Introduction to High Consistency Silicone Rubber**

Welcome to a world of creative possibilities.

High consistency silicone rubber (HCR) is an extraordinary two-part silicone compound which is clay-like in its uncured state, allowing it to be formed into a finished product without the need to build complex molds. This material has extremely strong and versatile properties lending itself to durable finished products which perform, in many instances, more favorably than other products within the family of elastomeric silicones.

The two parts of this HCR compound are mixed according to weight in even amounts by sending them repeatedly through a simple but specialized rolling mill. This effectively folds the materials upon itself so as to achieve a homogenous molecular distribution.

The unified mass of material can be rolled into sheets and laid over complex forms to be cured. It can be fashioned from a rolled mass into most any desired shape. It may be prepared with pigments to have virtually any color and be combined with other batches of colored silicone to create designs. It also can be combined with diverse HCR formulations to design appliances with selective performance zones, making it possible to have varied physical properties within a single piece. Moreover, a variety of other materials and components can be incorporated into such creations to make unique complex devices in an economical way.

HCRs have long been used in the extrusion forming of products and in the creation of orthopedic and medical appliances. They play a significant role in prototyping and have many applications to the world of tactile and visual arts.

The inspiration for this handbook has been to serve the prosthetics and orthotics industry. While some of the subject matter may be designed to apply to practitioners, craftsmen from other industries as well will be exposed to the essential principles involved in handling and fabricating with high consistency silicone rubber.

## What is silicone?

Silicone elastomers are compounded using reactive linear chain molecules together with a cross linking agent and mineral fillers to lend favorable mechanical properties such as elasticity, energy absorption, and tear strength. The viscosity and type of the basic linear chain molecule, together with the processing temperature, determine the mechanical behavior of the elastomer produced.

To someone who is new to working with silicone elastomers, the following is a brief outline to clarify the position HCR silicones hold in the range of silicone elastomers.

### Silicone families

One distinguishes typically several classes of silicone rubbers. However, for simplicity, one can think of these in the three following categories, organized by the basic manner of curing. **Addendum “A”** has been compiled to describe the classes of silicone rubber with greater detail to assist with selecting other non- HCR silicone materials for a variety of applications.

1. Condensation curing silicones comes as a one-part system (no mixing required), such as caulking adhesives
2. RTV (room temperature vulcanizing) tin catalyzed or platinum catalyzed (two part)
3. HTV (high temperature vulcanizing) platinum catalyzed (two part)

Platinum catalyzed, and more specifically the HTV or Heat curing silicones have outstanding properties and are superior to conventional organic rubbers for a variety of applications. They have exceptional mechanical strength throughout a wide range of temperatures. They are chemically inert, and stable against oxidizing and ultra violet light degradation. Once cured, there is an absence of residual reactive groups. This property makes it ideal for food, pharmaceutical, and medical applications.

HCRs as a subgroup formulation presently belong to the high temperature vulcanizing (HTV) family of silicones. Though these HCRs are designed for relatively fast heat curing, extended periods of time at room temperature will also allow some curing. However, without critical temperature thresholds being reached, full strength and elastic qualities may remain in question.

## **Laboratory Requirements and Principles**

In the following section you will find a list of equipment often needed in processing HCRs, along with guidelines which will promise success and minimize frustration during fabrication.

### **Temperature control**

Since HCR silicones are heat cured, it is important to respect the role temperature plays in preparation, storing, and processing. Moreover, the ambient environmental temperature affects work life, ease of handling within the work life, and progression of cure. A room temperature of 65F or brisker is recommended for a work life of about 6 hours.

### **Environmental cleanliness**

Of the many conditions that lead to success with this material, cleanliness plays an important role. A clean workspace free of dust and contaminants is vital. Ideally, one should have a dedicated work place with counter space and vices or jigs for holding the work piece. If this work space cannot be devoted, then prior to working with this material, at the very least one should thoroughly clean the space along with work utensils and anything that might touch the work piece in the course of fabrication. Removal of environmental contaminants, particularly organic rubber such as latex gloves, transient oils, or food is essential. Dirt that otherwise would remain on one's hand is quickly transferred to the sticky surface of HCR silicone. It is helpful to have running water nearby for hand washing. A curing oven that is free of blowers (which may stir up dust and particulates) and which operates in a low temperature range is ideal.

### **Dedicated time**

Though time is a relative attribute in any laboratory facility, it should be noted that the forming process of HCR requires time that is dedicated for completion. Allowing for dedicated time as a part of your work plan is an important condition for success. Once the material has been catalyzed by mixing, the clock is ticking. Distractions such as open-ended breaks or phone calls can steal valuable minutes needed in the work life of this material. Once a project is started, returning to the modeling task hours after an interruption may likely require you to start over.

## **Tools and equipment**

The following are a list of tools and equipment that have proven important in fabrication with HCR products by hand.

Digital scale readable to 1/10<sup>th</sup> of a gram

Rolling mill such as the JB Mill (pictured)

Low temperature oven

This is commonly referred to as a drying oven, with temperature control sensitivity between 100F and 200F, or 37C and 93C. Most curing events will take place within this range. The time needed will be significantly influenced by any 10 degree difference.

Clean counter space

Teflon work surface (non-stick oven liner)

Vacuum system

Nylon fabric hose

Clear plastic bags

Gnurled hand tools

Spatula

Pinwheel

Pigments

Cyclohexane solvent

Refrigerator

Plaster of Paris

Poly vinyl alcohol solution PVA

Polyester Parfilm (separating spray film) Price- Driscoll's Ultra 4 is available from

[www.factor2.com](http://www.factor2.com)

## **Manual Handling and Techniques**

### **Project planning considerations**

HCRs come in five different durometer formulations: 20, 35 , 50, 65 , and 80 shore A. The design requirements on any given project will dictate what durometer formulation is chosen for use. Furthermore, these formulations can be joined, seamed, or overlaid together to create whole pieces with varying performance properties throughout. They fuse (literally cross link molecularly) together so that there is seldom concern that they will come apart due to a physical dissimilarity. The following is a brief description of their individual characteristics:

Shore 25 A is the softest and the most elastic of the HCRs. In its uncured state there is some slumping of this material at room temperature if it is expected to stand up in tall or thick sections under its own weight. The initial presence of heat encourages the slumping as well.

Shore 35 A is most commonly used as it possesses good elongation and is very strong when finished. Uncured, it exhibits minimal slumping characteristics, but may need some structural support while curing.

Shore 50 has working characteristics similar to shore 35.

Shore 65 A is approximately as firm as an automobile tire in its cured state. It has no slumping characteristic during forming, and it has low elongation once cured. The initial mixing process is difficult because the material wants to behave in a crumbling manner before it is kneaded forcefully into a cohesive mass. Material fresh from the manufacturer may not behave in this crumbling manner. Crumbling by itself does not mean the product has gone bad.

Shore 80 A is rather hard and, while still technically rubber, it begins to take on a more plastic feel once cured. This is often chosen for finished internal structural reasons. This material, like Shore 65 A, crumbles during the initial conditioning before it becomes cohesive.

The higher shore HCRs may require separate preliminary conditioning with respect to the A and B components. This is especially true when they have been stored for a while. A practical approach to getting the material to be cohesive is to put the individually weighed

amounts into freezer type Ziplock bags. The crumbly mass can then be worked through the bag with a heavy rolling pin or mallet without scattering it.

For artists, armatures may be called for especially when using the lower shore rubber. In the prosthetics industry, HCRs are most often laid over plaster casts, which more than adequately support the material until it has been fully cured.

## **Pigmenting**

Careful selection of pigments is important. It is advisable to use concentrated pigments suspended in non-functional\* silicone oil. Concentrated pigment will minimize the amount of free or molecularly unbound oil molecules in the future silicone matrix. Excessive free oils may curtail future adhesiveness, change the rheology during the work life, and in extreme situations demonstrate oil migration within the final product. While functional silicone oils may be more desirable for other applications, in the world of HCR silicone creations they will speed up the reaction time and dramatically shorten work time.

**\*Note:** *A compound is “functional” when it contains significant amounts of free chemical bonds available for chemical reactions to occur.*

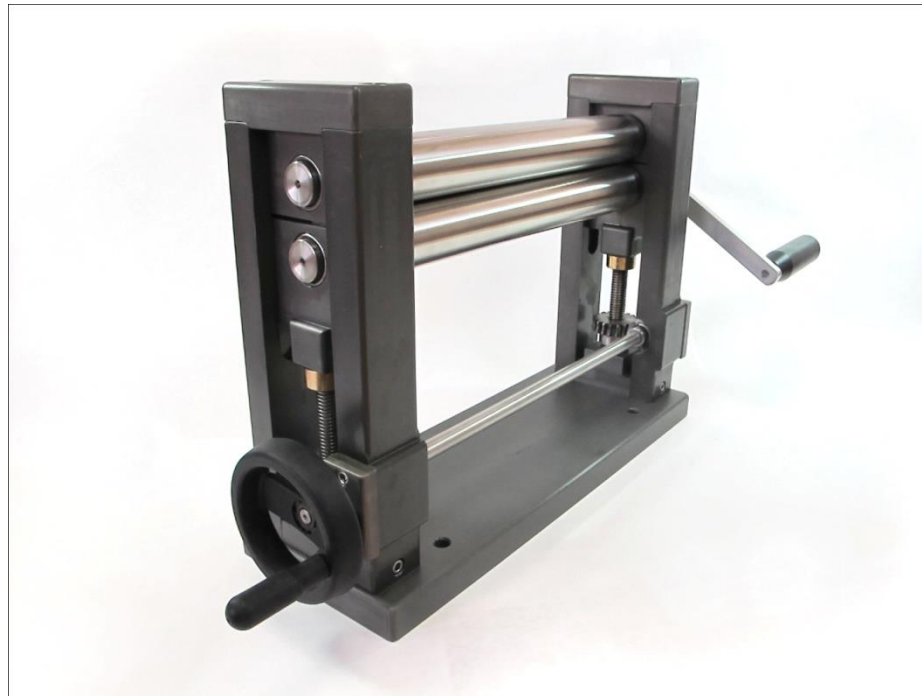
*Important: Any desired colors should be pre-mixed and then added to the A component just prior to mixing with the B component.* Adding non-functional oils days before use will alter the working performance. If, for the sake of preparedness or precision, you need to prepare the color in the A component in advance of your work, put it in the refrigerator wrapped in cellophane until ready to use. In the author’s experience, certain oils added to the B component (presumably the side retaining the catalyst) leads to unilateral curing of the B component. (Depending on the pigment maker this may be seen in the reverse with the A side unduly affected, so inquire for HCR compatibility with the manufacturer.)

*Using pigments with non-silicone oils should be approached with caution.* Dry pigments are viable but may produce an occasional intense grain of color. If grainy color qualities are desired, then chopped fibers or flocking are often used. These should not be relied upon, however, to opacify the silicone as the bulk requirement to do so is high.



### **Milling and catalyzing**

A calendar mill has three functions. The first is to ensure a homogeneous mixture of the A and B parts, which starts the reaction process. The second function is to reduce or eliminate the presence of bubbles in the material. The third function is to prepare the particular batch into either a sheet or a sausage- like roll for application. The manner in which one receives material from the mill determines whether the form will be a sheet or a sausage-like roll. Sheets are generally laid over a plaster form and seamed together by hand to create thin walled elastic or flexible structures; rolls are used as the beginning blocks for massed forms.



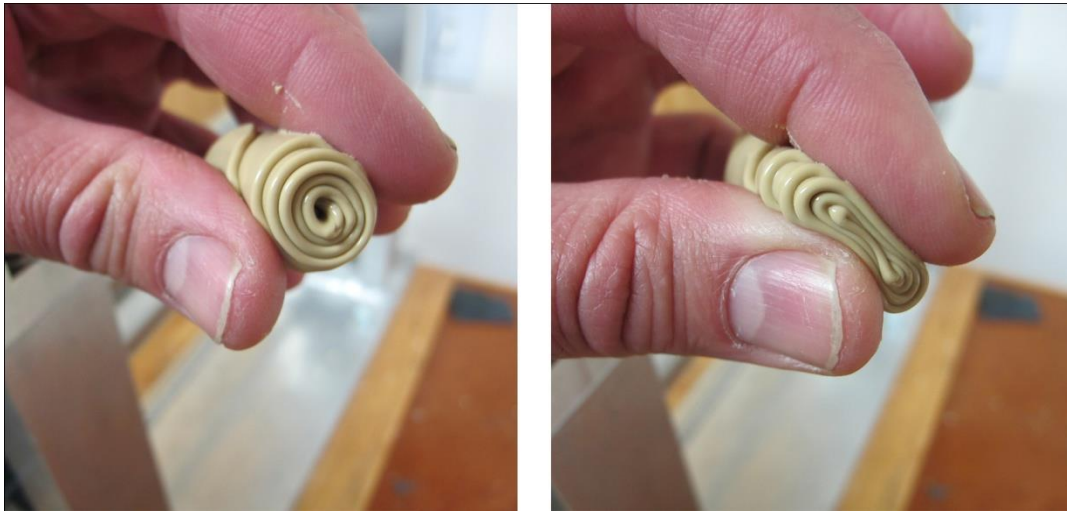
## Milling technique

One of the objectives during milling among the aforementioned functions, is to prepare an essentially bubble free product. To accomplish this, set the aperture between the rollers at 1/8" or 3mm. Begin sending a thick twisted cord of equal parts of A and B through the mill. If you are using a hand cranked mill you will receive the material on the far side of the rollers with your free hand. Capture the leading edge of the material with your finger tips and begin to roll the material back onto itself as it advances out of the rollers. The material may preferentially stick to either the top or bottom roller as it comes out. You will gently stroke the forming silicone roll in the opposite direction of the rollers to build a roll that grows with every subsequent rotation.



This first completed pass of material through the mill is likely to look disorderly and irregular. Send the sausage through lengthwise from one end to the other for your next pass. With each subsequent pass you should notice the material looking more bubble free and the sausage roll to be increasingly orderly. You will notice the ends of the roll will have dimpled or tubular openings. In order to prevent pinching these ends shut and trapping a bubble inside, either fold the sausage in half and feed it through from its middle, or press the material directionally on one end so as to drive the air out of the open end, sealing it in the process. Introduce this end into the rollers for the next pass. You will repeat this action every time you send the material through. If you are working with clear material, with a

little practice you will notice a fairly clear roll. To further purge air from the mass, begin progressively reducing the aperture width of the rollers for several more passes.



*How many passes until catalyzed?* The answer is more than ten, and less than twenty. Technically, the size of the roll along with the number of layered rolls determines the amount of mixing with every pass. A small mass with few revolutions is going to need more passes than a large roll with many revolutions since the number of folds occurring in such a pass is many more. Remember, within this non-liquid substance one is trying to effectively produce uniform mixing on a molecular scale. The number of folds necessary to attain that amazingly small scale is hard to conceive of but maybe not as many as one might assume. To put this in perspective theoretically, if you could fold a piece of paper in half ten times you would produce 1024 layers.

You will notice with much mixing that the internal friction taking place within the material will cause it to become warm or even very warm. Be aware that such warming is accelerating the cure time and reducing your work time. There is a balance between feeling secure that your materials will reach full properties later and the foreknowledge that you can complete your task in an unhurried manner.

## **Forming**

As stated earlier, the material ready for forming can be produced into a roll prior to forming thick sectioned pieces or into sheets which are likely to be laid over another form for support while curing. The preparation and methodology employed when making thin sectioned pieces warrants special discussion.

As a brief introduction, in the field of prosthetics and orthotics it is routine to form appliances over plaster casts. In that connection, HCR silicone sheets will be laid over a cast and seamed and formed into place. Subsequently, a nylon fabric hose is donned over the fashioned piece along with an outer plastic bag. The air is removed from the interior of the bag by vacuum to secure the silicone to the cast and to create a more or less uniform surface to the formed rubber.

Conventional casting plaster can be used as well as gypsum type dental stones. Casts should be dry and sealed. It is recommended that one seals the casts with a thin coat of PVA solution.

The purpose of the PVA is to secure the plaster's surface of dust or particulates that would become embedded or bonded to the inner surface of your creation. Accomplishing this objective while still maintaining a surface that is permeable to gas under vacuum is crucial. Thin coats seem to allow some gas permeability without allowing the silicone to embed into the porous surface of dry plaster. It needs to be acknowledged that PVA concentrations in solution will vary considerably and that there may be other ways of preparing the surface such as with polishing wax. So, the reader is urged to recognize the importance of the underlying principles in whatever materials choices that are made. HCRs will stick to PVA tenaciously when cured together so additional spray separators are helpful. Should the HCR become welded to the PVA, soaking the plaster with water will allow it to release from the inside of a cured rubber appliance.

When forming a silicone sheet over plaster, one must keep in mind that bubbles or air pockets can form beneath the sheet wherever it has not made full contact with the plaster form. The best way to mitigate this problem is to have a methodical way of laying down the sheet, working the material directionally to drive out air trapped beneath. Vacuuming the material down over a semi-porous cast also helps, as does ventilating through the thickness of the silicone with a medical type pinwheel prior to vacuum bagging. \*

The next section will take the reader through a tutorial for making a basic silicone liner or socket.



\* The use of a metal pinwheel tool to ventilate the surface of the silicone with many tiny holes will allow bubbles to be vacuumed to the outer surface.

## **Procedure for Producing a Prosthetic Rubber Socket or Liner**

The ensuing sections describe a particular task commonly applicable to the fabrication of prosthetics and medical appliances. Creative minds from different backgrounds will readily recognize other applications for these techniques.

### **Preparing the stone or plaster cast**

Ideally, the plaster form should be dry. Dryness produces gas permeability within the cast that protects against the formation of bubbles on the inner surfaces of the liner.

Permeability is a prerequisite for a common vacuum method that will be applied to help draw out inner surface bubbles. Furthermore, the expansion of gases when heated in the oven also contributes to the problem of inner surface bubbles. Permeability allows localized or entrapped air to find an escape.

Porosity in the surface, while helpful, can also produce adhesion when the time comes to demold. Therefore, it is important to have a plan for easy demolding. While there may be more than one approach, one proven method is to coat the plaster surfaces that will be touching silicone with a thin coat of PVA (polyvinyl alcohol) solution. One coat seems to soak into the plaster, still leaving a fairly porous surface. To ascertain whether the surface is still permeable, it should have a slightly shiny egg shell like appearance. A completely shiny surface would suggest a failure to establish gas permeability. HCR bonds tenaciously to PVA. Therefore, an additional spray of Polyester Parfilm will ensure easy demolding. If the HCR bonds strongly to the PVA on the cast, soaking the cast in water will soften the PVA enough to release.

Prepare pigment and catalyze the HCR silicone according to the descriptions in the previous section.

### **Laying the silicone on the form**

Once the silicone is prepared, roll it into a sheet with the desired thickness and sufficient size to cover as much of the form in one pass as you dare. Drape this onto the cast. You will be working in a systematic manner to bring the silicone sheet in full contact with the form without entrapping air below the surface. Folds must be trimmed close to the cast and the seams worked directionally with a gnurled rod to send out trapped air from under the sheet. Similarly, the entire surface should be worked over carefully to drive out small entrapped air bubbles to the open margins. Seams are best made by butting edges against each other and working the material together until the seam is uniform and invisible.

One may need to tailor specific shapes to accommodate as yet uncovered but intended areas of the form.

When you have completed covering the desired area and all the liner material is in place, cover the liner with a nylon fabric hose followed by a thin plastic bag. The sheer nylon hose serves to allow the air to escape the surface evenly. Evacuate the air from within the bag with a strong vacuum pump. This helps to create a uniform surface. Further work the material within the vacuumed bag if you notice surface irregularities. Also, after the bag has been removed it can be effective to smooth or contour the surface with the nylon fabric hose still in place.

Carefully separate the nylon hose from the silicone. Trim the edges with a spatula or a tightly pulled thread. You are ready for oven curing.

### **Oven curing**

Now that the product has been shaped and the form of the future appliance has been established, it is time to change the phase of this kneadable material to fully rubber by means of **time** and **heat**. It is important to respect the role of these two variables in successful oven curing.

While the silicone will respond to elevated temperature readily enough, rapidly curing the material may cause gas expansion wherever it may be hiding in small pockets, thus causing the formation of unwanted and unsightly blisters. Allowing the material to cure first at a lower temperature over a longer time period, to the point where its resiliency as rubber is attained, will minimize the expansion of hot gas. Later when the material has reached much of its resilient property, post curing at a higher temperature will advance it to achieving its full-strength properties.

One conservative approach recommended for a newly formed appliance is to put the piece in the oven at a low temperature, such as 110 degrees Fahrenheit, for eight hours or overnight. After 8 hours, progressively bring the temperature up until you reach about 185 degrees. An hour or two at 185 degrees or higher will bring the material to full cure.

If one wishes to cure the rubber rapidly with no concern for bubble formation, it will cure within minutes at temperatures above 200 degrees. Depending on the cross-sectional thickness of the material, one can expect some variation of time until fully cured.

Temperatures higher than 250 degrees run the risk of scorching or altering careful choices made in pigmenting.

## **Demolding and finishing**

If sufficient care was taken to prepare the cast's surface, then removal of the rubber should be easily achieved by peeling. From time to time one may have to deal with adhesion. Soaking will soften the PVA sealer. Also, a long- and slow-time dependent pulling approach is better than pure force.

Once removed, if the internal surface feels slippery, it is due to attached PVA residue. This must be scrubbed off with lots of water. Your skill and understanding of this material will be known by how flawless the interior surface of your liner is. Small bubbles may be buffed or sanded out as can the meniscus-like edges of very shallow blisters. Larger undesirable pockets can sometimes be filled with the same material and then re-cured. In principle, if the product that was made is relatively new, adding additional material will form a bond that for most purposes is quite strong, although its final bond strength may not theoretically be as strong as the surrounding rubber.

Trimming is accomplished with sharp knives such as razor blades. The silicone may be sanded with high RPMs using greater or equal to 100 grit. Also, 3M makes an abrasive wheel available from *Factor 2* that is effective at buffing edges.

Your creative project is ready for service. One final note on the care of this silicone: Silicone is known to draw in some oils so your clients need to be advised to use water-based products that come in contact with the appliance. Imbibed oils may make the material swell to a minor degree. It makes gluing for repairs impossible and in some instances can alter the color appearance of the material.

## **Conclusion**

The above instruction and information is intended to spare the novice working with HCR a lengthy, perhaps painful learning curve. It is meant to transmit an essential working understanding of a truly wonderful material. For the artist and prosthetist alike, enjoying early success with HCR will lead to enduring, creative, and ingenious use for a myriad of endeavors.

(The following section has been adapted from the article “Of Rubber and Resin” published in O&P Edge magazine August 2018)

**Create a socket with a strong seamless connection between HCR silicone rubber and hard resin laminate.**



To conjoin materials as dissimilar in their respective properties as elastic rubber and rigid laminate resin is rightly questionable from an engineering standpoint. Yet with a certain fabrication approach, along with a sound mechanical transitional connection, an apparently seamless, durable transition from resin to rubber is achievable. The following section outlines methods and design for the successful creation of durable sockets made of rubber and resin.

To date, our practice has only focused on upper extremity applications. However, this experience opens a rich territory of new socket and appliance designs for the orthotic and prosthetic industry. Moreover, when one realizes that products with such a combination of materials are relatively easy to produce, such applications may gain wide-spread acceptance.

This article proposes to demonstrate how to create a hybrid socket with conventional hard laminated resin along with HCR rubber.

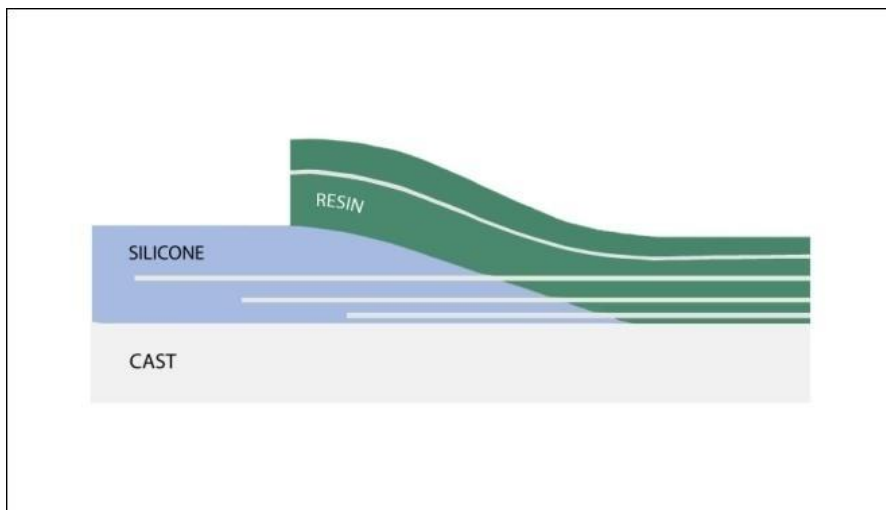
Epoxy-acrylic resin and silicone by themselves share no great promise for chemical bonding. Therefore, one must rely on the mechanics of a third, very strong fabric material: Spectralon™. This fabric is incorporated into the lap type joint which can withstand the high local stress associated with unavoidable bending at the joint. The spectra fabric has a progressively terraced insertion into the rubber to distribute forces acting across the joint over a large area.



Resin, wicking into these strata, penetrates somewhat into the interior of the rubber at these layers to enhance the mechanical connection.

HCR Rubber is used because of its extraordinary strength. A variety of durometer formulations are available which all can be simply formed into precise shapes.

With the exception of the calendering device and the HCR silicone, all of the materials needed are readily available and common in prosthetic fabrication. It is presumed in this section that knowledge of fabric and resin laminations is widely understood and information easily available so that no procedural commentary will be made in this following section pertaining to those techniques.

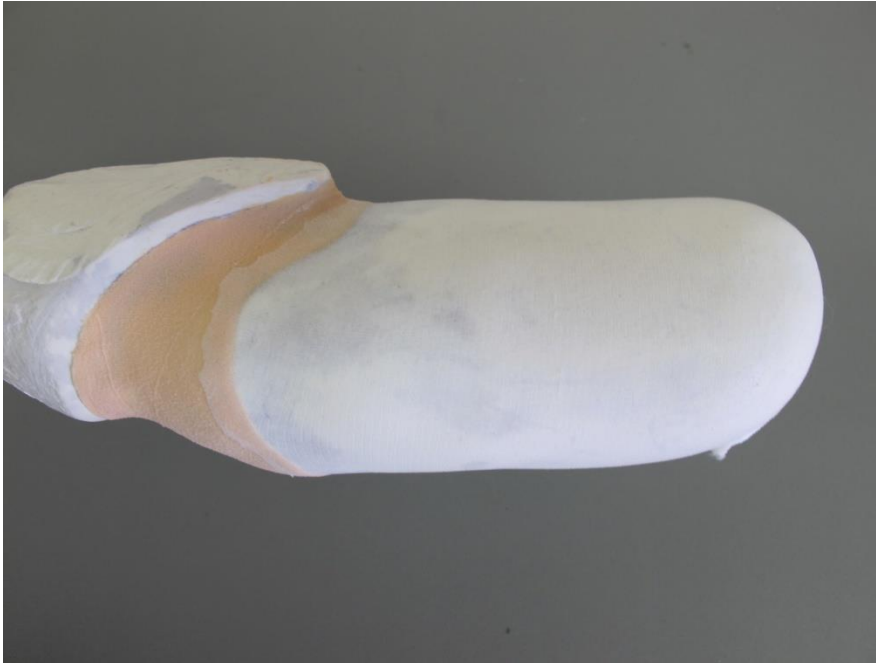


**Figure 1.** Create a lap type joint where the fabrics of the lamination extend into the interior of the rubber in a terraced manner.

Let us begin with making the rubber part of the joint first. For this a very smooth dry cast is desired. The outline of areas which are intended to be made of rubber are drawn on the cast. The cast is then coated with a modest coat of PVA solution and when dry it is lightly sprayed with Polyester Parfilm. HCR silicone is clay like so that it can be rolled into thin sheets and placed onto the cast within the lines of the outline. Care should be taken to produce orderly marginal boundaries. Care should also be taken to prevent bubble entrapment beneath the silicone. The PVA coating should still allow gas permeability through the cast under vacuum so that through the technique of bagging and evacuating air at high vacuum, small entrapped air bubbles will be drawn out from the interior surface of the silicone that is in contact with the cast.



**Figure 2.** High Consistency Rubber is clay like and can be laid up in sheets.



**Figure 3.** Fabric can be wetted into the rubber by subjecting it to vacuum inside of a plastic bag.

Next, one dons a sheer nylon hose over the cast, pulling it snugly to overlap the silicone margin. This nylon hose will be tacked into the silicone and trimmed to have a  $\frac{1}{4}$ " overlap. A second nylon hose and then a thin plastic bag such as a produce bag will be applied for the purpose of generating a vacuum. After a strong steady vacuum, the bag along with the second nylon is removed and discarded. The second nylon ensures that under vacuum the first nylon is neatly drawn down and wetted into the silicone. This first nylon which runs out of the silicone margin is designed to give the future lamination a nice interior surface and secure the edge of the rubber against the lamination, however fine that transitional edge may be.



**Figure 4.** Fabric is layered between sheets of silicone.

A thin layer of silicone is laid over the trimmed edge of the nylon leaving approximately 1/8" of the original 1/4 "margin still exposed. This second layer of silicone can be perforated with a pinwheel prior to vacuum bagging to draw out bubbles that may have become entrapped between layers.

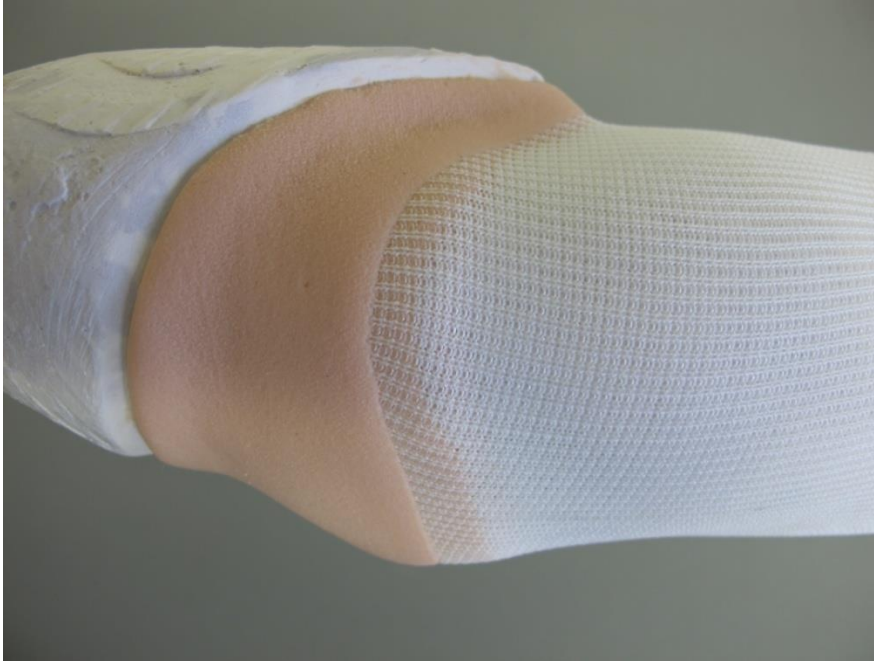


**Figure 5.** The second layer of silicone before subjecting it to vacuum

The process of embedding and sandwiching fabric into the silicone may be repeated two more times using spectra hose. Each fabric layer should overlap the previous reaching further into the rubber form to produce the terraced entry of fabric into the rubber form.



**Figure 6.** Spectra fabric half embedded



**Figure 7.** Spectra fabric layered and embedded

When sculpting of the rubber to the final form is completed, the cast along with rubber and fabric is placed in an oven for curing. Oven curing occurs first at low temperatures to prevent the expansion and appearance of hidden bubbles. This is done at temperatures below 110F for many hours until the material has rubber like properties. Post curing at temperatures at 190F will bring the rubber to its full elastic strength properties without harming the fabric fibers. At least one hour is recommended at this temperature.



**Figure 8.** Cutting strips are added after the rubber brim is cured.

The rubber fabric creation can be separated from the cast but left on the cast for the creation of a removable cutting strip made of HCR. Use PVA solution or Parfilm on the cured rubber before applying the uncured rubber strip to ensure later separation of the two. Cure the strip in place in the oven. This strip will allow one to cut the lamination along a defined line after the lamination is complete. It is helpful to add one or two strips lengthwise to aid in removing the extra overlying lamination. A cast saw can scar the underlying rubber.



**Figure 9.** Additional fabric layup to suit.

The rubber/ fabric assembly is now ready for removal from the cast entirely. Prepare the cast for lamination with an internal PVA bag. Don the assembly again and add additional laminating fabrics to suit. Complete the lamination by conventional means.





**Figure 10.** Removal

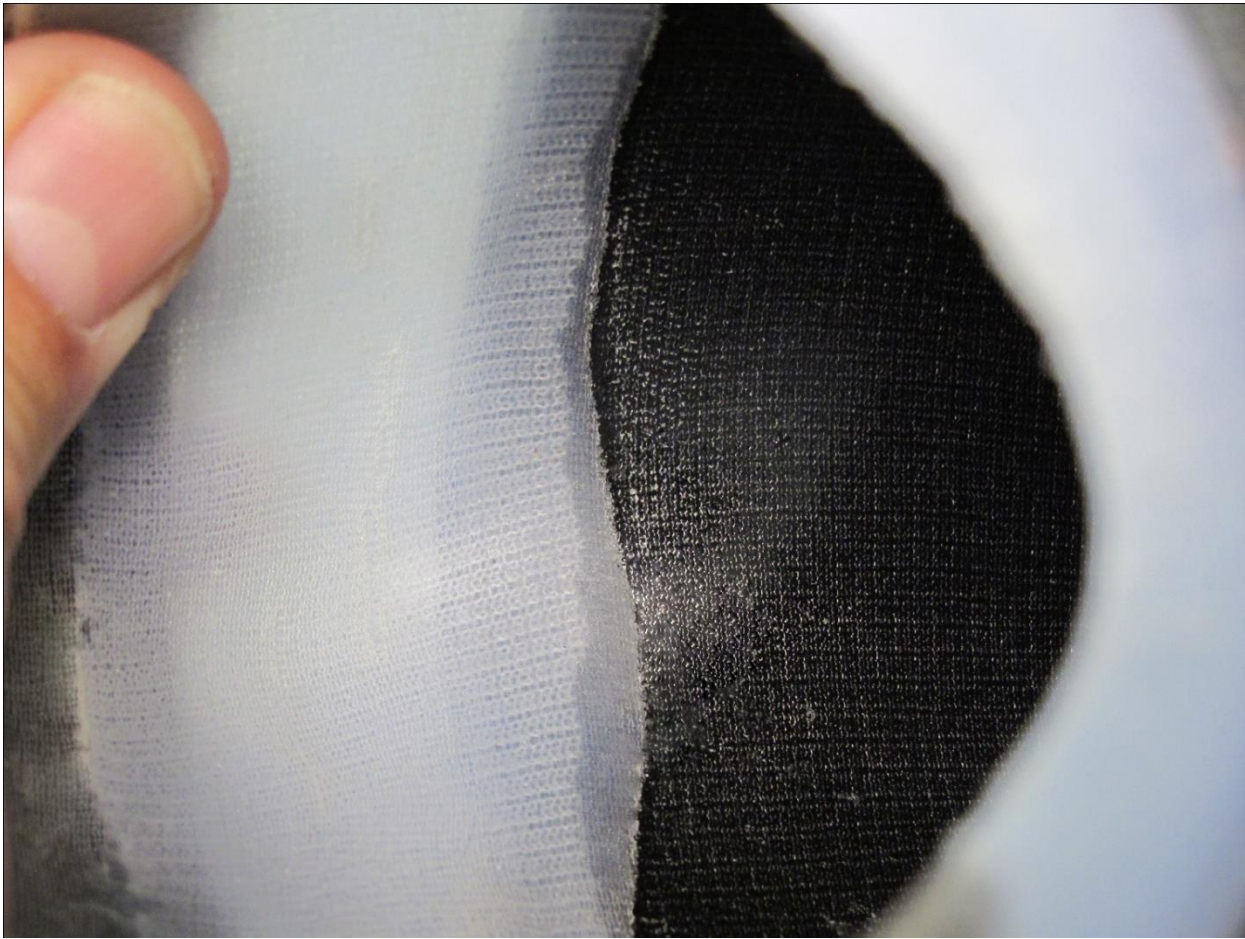
Trimming is done along the aforementioned cutting strips. Glass and carbon fiber dust can be driven into the rubber resulting in an itchy product if sufficient care is not taken. Files and emery boards can be used to finish the edge where high speed tools may throw fibers into the exposed rubber.



**Figure 11.** The transition should feel seamless.

When done correctly, one can expect a completely smooth interior transition from one material to the next. Furthermore, by sending the resin through the fabric into the rubber terraces, there may be an

unseen level of mechanical penetration (a blending transitional zone below the surfaces) which accounts for the unexpected strength of such a joint.

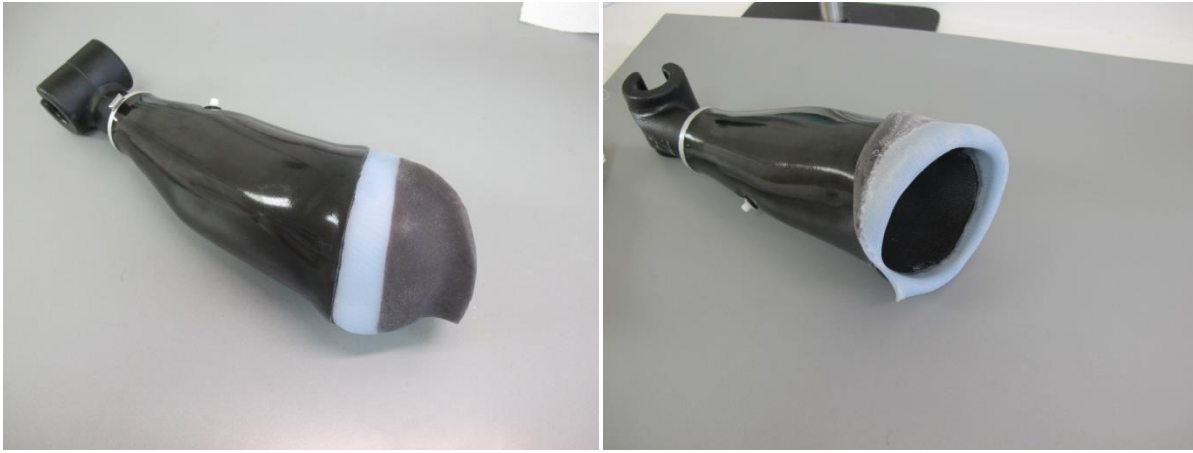


**Figure 12.**

*Clear rubber was used to show how resin has penetrated along the fabric layers into the rubber form.*

Sockets of this sort, in contrast to the flexible thermoplastic socket with a rigid external frame, prove to be far lighter and less bulky. Another reason to think of this design approach as desirable is that elastic brims, as opposed to merely flexible brims, follow the patient's movement and can produce a suction suspension seal. Rubber also offers the prosthetist the freedom to create aggressive super-condylar features that are compliant, comfortable to adjacent bony landmarks, and permit easy donning.





**Figure 13.** Here is one of many potential new designs showing a reflected brim as a donning strategy.

## Addendum A

1. Condensation Curing silicones come as a one-part system (no mixing required), such as caulking adhesives, also referred to as acetic acid cure because the odor of acetic acid is emitted during the curing process. There are both food grade and medical grade of one-part condensation cure silicone elastomers.
2. Room Temperature Vulcanizing (RTV)- tin curing (two part) catalyst systems are typically referred to as tin-based systems. Tin-based elastomers generally exhibit shrinkage while curing and will show higher shrinkage over time. Tin-based elastomers have limited library life (length of time a mold will last). Tin-cure systems are generally used for mold making, and not in the fabrication of medical devices.
3. Room Temperature Vulcanizing platinum curing (RTV) also known as addition cure system. Platinum silicones are usually either 10:1 mix ratio or can also be a 1:1 mix ratio by weight. Curing takes place through a chemical reaction that leaves no residual byproduct or unreacted material. This means that there is virtually no shrinkage amounting to .1% or less, making it a great choice for precision parts. This silicone likes heat when curing. For every 10 degrees above 70F one can reduce the cure time in half. So, in an oven at 140F, 24-hour cure silicone should be ready in less than 20 minutes. Platinum Silicones are subject to surface inhibition caused by “poisonous” substrates like, tin, sulfur, oil-based clay, double-sided adhesives, latex and some synthetic rubber.
4. Liquid Silicone Rubber (LSR), Systems are typically two-part 100% solids, pure dimethyl silicone elastomers, engineered for optimum performance in liquid injection molding (LIM) processes for high clarity, high strength molded parts. Liquid Silicone Rubber (LSR) is a pumpable, colorless, translucent paste. When A and B components are mixed together in equal portions by weight, the paste will cure to a tough, optically clear elastomer via platinum catalyzed addition-cure chemistry. Addition cure no solvent, mix ratio 1:1, long working time.
5. High Temperature Vulcanizing (HTV) are usually platinum curing (two part) mixed 1:1 by weight. These will not cure completely at room temperatures. Among these are HCRs known as mill-able silicone elastomers that can be extruded continuously to for a desired size and shape before heat curing. HCR elastomers are supplied in a thick clay-like consistency. HCR elastomers will exhibit the highest physical properties of all silicones, and typically are more abrasion resistant for all applications.

## **Addendum B**

### **AVERAGE TYPICAL PROPERTIES COMPARISON BY CLASSIFICATION**

RTV Shore 30A: Tear 100 ppi: low viscosity. Room Temperature Vulcanizing (Curing)

Typically, 10:1 by weight.

LSR Shore 30A: Tear 170 ppi: high viscosity, Liquid Silicone Rubber: Heat Cure 100 C typical

Typically, 1:1 by weight.

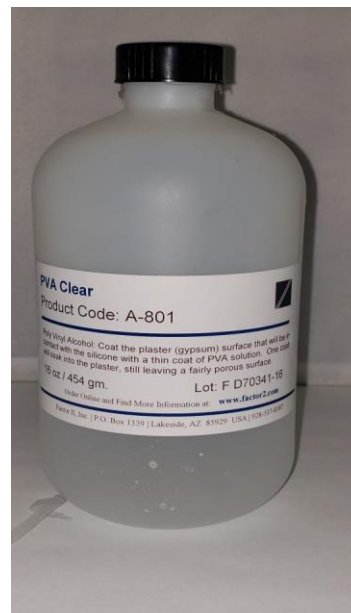
HCR Shore 30A: Tear 220 ppi: Clay like structure, Heat Cure 100 C

Standard. 1:1 by weight.



## A-801

PVA Clear in a Poly Vinyl Alcohol: Used to coat plaster or gypsum surface that will be in contact with silicone. With one thin coat of PVA it will soak into the plaster still leaving a fairly porous surface.



## A-840 CCH Solvent

**Cyclohexane** is a cycloalkane with the molecular formula  $C_6H_{12}$ . CCH is a color-less, flammable liquid with a distinctive detergent-like odor, reminiscent of cleaning products. CCH is a relatively volatile hydrocarbon boiling point of 80.7C.



## Equipment SC-1000

### Digital Scale



## Pigments

I-100 BL Black

I-100W White

I-100Y Yellow

I-100R Red

I-100B Blue

I-100F Flesh

I-100MM Hazelnut)

Mason's Magic



## Pigments

FI-SK01 Buff (Caucasian)

FI-SK19 Mocha Afro American)

FI-SK49 Almond (Hispanic)



## Tools

### **D-317**

HCR Pinwheel tool used for ventilating and de-airing HCR Silicone High Consistency Silicone Rubber.



### **AL-627**

Large Stainless-Steel Cement Spatulas



### **A-805 Roller Protectant**

Roller Protectant is a blend of silicone fluids, formulated specifically to protect the rollers of a 2 roll mill. Recommend Cleaning rollers with A-840 CCH solvent, and misting A-805 onto the rollers of the mill.

