

# Casting and Molding Primer

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# Design Sources

## Existing

We already have an item we'd like to replicate.

## 3D Printed / Machined

We have a design that was created with an expensive, time consuming process or medium; or a medium that isn't suitable for real-world use. For example printing in plastic, then casting in metal.

## Sculpted

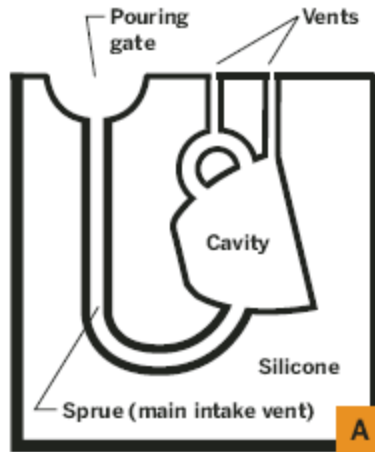
Parts can be created by sculpting cheap, flexible materials like clay, polystyrene, or wood. Small pieces can also be glued together to create larger, more cohesive finished projects. Sometimes these source materials require a coating, such as clear spray acrylic, to make them suitable for moldmaking.

# Molds

## Two Part Mold

The process of object replication starts with the creation of a mold. First we need a mold box to contain the mold material and our object when we do the pour. You'll want to create a mold with at least one half inch of space between the wall of your mold and the extents of your objects. This should increase as the size of your mold increases. This will help prevent the mold from deforming under the weight of the casting resin when poured.

Your object will most likely need extra parts to allow for venting and what's called an underpour. Underpour fills the mold through a sprue (a pathway for our casting material) and fills the object space from the bottom up. This works best for complex shapes to eliminate dead spaces where air will collect.



Source: Make Magazine Volume 8

These extra cavities can be made from pretty much anything; clay or straws are good materials. Vents and pouring cavities can be attached to your object with glue to make a good seal. These parts will have to be trimmed off the final product, but will make much better casts. You'll want to mold your design in an inverted fashion. This will allow the vents and pouring cavities to support the object inside the mold box. Additional supports can be added in the form of extra vents.

You'll want to find a plane on your object where the mold will be split into its two separate parts. This placement should be based on the shape of your object. Keep in mind, there will be a small seam at this point which will have to be finished on the the final product.

Once your mold cures, you can remove the mold from its box, split the mold carefully with an Xacto knife or similar and remove the original object. The mold is then stuck back together in the mold box and a casting can be made by pouring into the empty spaces left by our object.

## One Part Mold

A one part mold is a much simpler method for replicating parts, but it requires a part with one flat surface and very little, if any changes in the x and y dimensions. Our part will have to be removed straight out of the mold without splitting it, so this method isn't suitable for complex shapes.

## Rotational Mold

If you want to create a hollow casting, you can pour your casting material into your mold, seal it and rotate the mold constantly on both axes. This will coat the inside evenly, leaving you with a hollow copy.

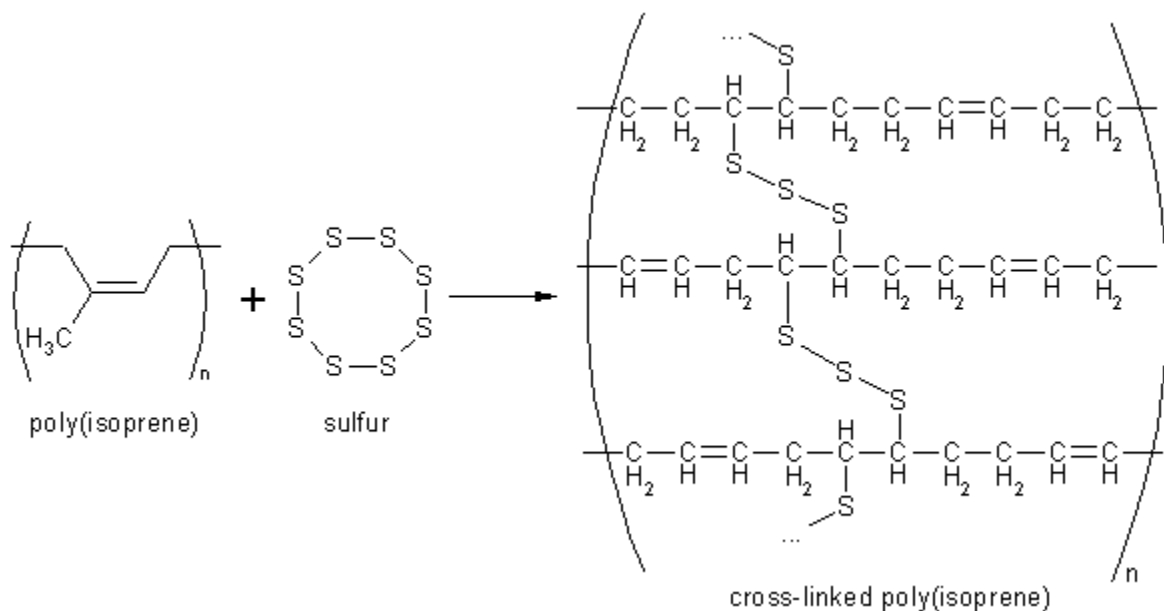
# Materials

## Polymers

A monomer is either an atom or a small molecule that can bind to monomers of the same type to form a chain. When monomers are chained by the addition of a catalyst, a polymer is formed. These polymer chains can have 10,000 molecules or more and can be on the order of tens of feet long depending on the properties of the monomers -- in just ONE molecule.

## Crosslinking

Crosslinking is what Charles Goodyear used when he created Vulcanized rubber. Natural rubber is a simple mixture of polymer chains. These chains move around when natural rubber gets warm and turns the rubber into a gooey mess. What Goodyear did was add a crosslinker to the rubber, creating an elastomer. Adding sulfur under heat crosslinks individual rubber polymers together to form a massive mesh of polymers. This crosslinking turns the mass of polymers into what amounts to one giant molecule. These structured polymers give us what we know as synthetic rubber its stability and rigidity at normal temperatures.



**Note:** *Isoprene is the monomer of natural rubber.*

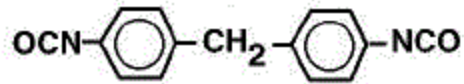
**Source:** Wikipedia

## Polyurethane Resin

Polyurethane resins are two part systems. Monomers, plasticizers, surfactants and crosslinkers are stored separate from the catalyst. When combined, the catalyst starts a chain reaction of polymerization and crosslinking that hardens the mixture into a plastic or rubber

compound.

### **Polyurethane MDI monomer (diphenylmethane diisocyanate)**



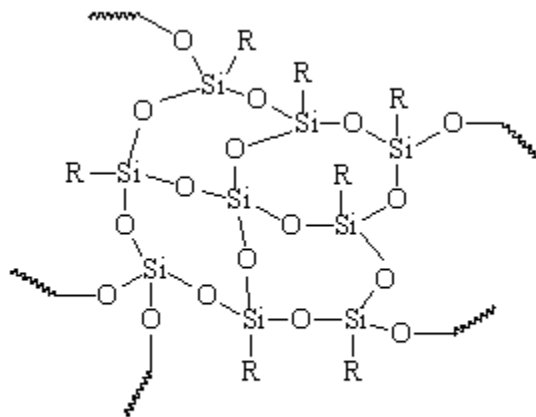
Source: Wikipedia

By varying the plasticizers or surfactants, we change the elasticity. By varying the catalyst, we change how fast our polymer will cure. These variations are from product to product and are made clear in the product specifications.

### **Silicone Resin**

Room Temperature Vulcanizing (RTV-2 in this case) silicone works similarly to polyurethane, as it is a two part system, but silicone monomers have silicon and oxygen alternating backbones instead of carbon backbones. The monomers form a cage-like structure and give the final product stretchy and non-stick properties.

### **Silicone Polymer (polysiloxane)**



R = Me, OH, H

Source: Wikipedia

### **Alginate**

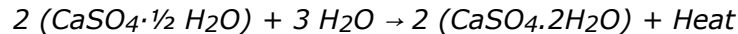
Alginate is very similar to silicone rubber, but is skin safe and best for making molds of body parts (known as lifecasting). It is expensive.

## Plasters

Plaster usually refers to gypsum plaster, called Plaster of Paris. When water is added, the more soluble form of calcium sulfate returns to the relatively insoluble form, and heat is produced.

While Plaster of Paris is suitable for a number of mold and casting applications, it is not safe for body parts.

### Formula for Plaster of Paris



You could be burned. Plaster of Paris contains crystalline silica and in its powdered form, it can easily be inhaled. Exposure to airborne crystalline silica can cause lung damage and is a known carcinogen.

## Wax

Wax can be used as a sculpted source material or intermediate casting material, where the wax can be melted out through vents in the mold material to prevent having to split the mold open

# Material Properties

## Hardness

Hardness in this context is related to rigidity and durability.

One can measure hardness with a Shore durometer. This method has several scales, each with a number 0 - 100, higher is harder. The most common being A for rubbers and D for hard plastics. You'll find the same types of resins will be offered in different hardness levels. The hardness you choose will vary by application.

*Rubber band - 25A*

*Car tire - 75A*

*Hard hat - 75D*

## Viscosity

Viscosity deals with the "thickness" of the materials we're working with. This is commonly measured in centipoise, abbreviated cP or cps.

*Water - 1 cP*

*Olive Oil - 80 cP*

*Corn syrup - 1,400 cP*

*Honey - 2,000 - 10,000 cP*

Considerations for choosing the proper viscosity of a material center mainly around detail and air. The more viscous the working material is, the less apt the material will be to fill in small areas and allow air to escape. In general, thinner is better.

## **Pot Life**

This is the time you have after mixing your materials before it "sets up". You must get your stirring and pour done before this period ends.

## **Demold Time**

This is the time between when you finish your pour and when you can safely separate the mold from the casting or source. At this point your product is not likely at its final hardness and will take a few more hours to cure fully. Usually, the warmer the casting is, the faster it will cure. In fact, some materials are designed to be heat cured.

$$24 \text{ cu. in. / lb.} * 2 \text{ lb.} = 48 \text{ cu. in.}$$

## **Mix Methods**

The majority of the compounds used to create molds and castings, with obvious exceptions being wax and metals, are two part systems.

*By Volume - Graduated container*  
*By Weight - Scale*

Why is the mixing so important? If we have too much of any compound, we have free molecules floating around which are trapped by, but do not add structurally the final product. The same happens if we fail to mix thoroughly. Mixing allows every molecule to come into proximity to its counterpart in the mixture.

When mixing it's important to mix deliberately, for at least 1 minute, increasing the time depending on the volume of material. Scrape the sides of the mixing container, as any unmixed material on the side will pour off with it. Careful! Most two part systems are EXOTHERMIC. They will get hot and hotter with more material. Play it smart with your mixing containers.

## **Tint**

Tints are used to color your final castings. Tints can be liquid concentrate or powder. Each tint is very specific to the product you're using and you need to read the instructions carefully to prevent creating problems in the curing process of your casting.

## **Specific Volume**

The specific volume allows you to figure out how much material, by weight, will fill a given volume, expressed usually in cubic inches per pound. If your material has a specific volume

of 24 cu. in. / lb. and you have 2 lbs of material, you can create a mold or casting with a volume of 48 cu. in.

## Estimating quantities

For a shape which is box-like, a simple estimation of the quantity of material required would be length times width times height. This value would be cubic something, cubic inches if you use inches to measure. This can be converted into other volumetric units common to liquids like gallons, or liters.

$$4.25 \text{ in.} \times 3.25 \text{ in.} \times 0.5 \text{ in.} \sim 7 \text{ cu. in.}$$

$$7 \text{ cu. in.} \sim 115 \text{ milliliters}$$

For a highly irregular shape, fill a container with water until overflowing. Put another container underneath that to catch the overflow, then place your object into the container of water. Weigh the overflowed water on a scale.

Using the weight of water, since it has a known specific volume, we can calculate the absolute volume of the overflow.

$$\text{Specific volume of water at } 70F \sim 0.016 \text{ cu. ft. / lb. or } 27.648 \text{ cu. in. / lb.}$$

$$27.648 * 0.25 \text{ lb. of water} \sim 7 \text{ cu. in. or } 115 \text{ milliliters}$$

We can do the same with our materials. If we have x pounds of casting materials, we can multiply that by the specific volume of casting or mold material.

$$0.5 \text{ lb. of mixed resin} * 25.9 \text{ cu. in. / lb.} = 12.95 \text{ cu. in.}$$

## Cost

The entry point for a silicone rubber and urethane plastic kit with Smooth-On is \$50 for about 6lbs of material in total.

*Silicone rubber costs about \$100-150/gallon.*

*Urethane plastic costs about \$60-80/gallon.*

Smaller quantities are usually available. Proper estimation for your project will help you get the best value for your money, but these chemicals have a pretty short shelf life once opened. Count on your materials only lasting 1-2 months once opened.

## Brands

*Smooth-On*

<http://www.smooth-on.com/>

*Alumilite*

<http://www.alumilite.com/>

*TAP Plastics*

<http://www.tapplastics.com/>

## **Pouring**

### **Air**

Air is the enemy. Air will stick to small crevices in your work. Pouring carefully can help prevent trapped air bubbles. When pouring a one part mold, you'll want to pour away from your object to the bottom of the container and allow the mold material to rise naturally around the object. This will allow air to escape. Additionally, you'll want to shake or vibrate both molds and castings before they start to set. This will shake loose trapped air and allow it to rise out. In the case of two part molds, underpouring and proper venting should allow air to escape, but shaking out air will still be beneficial.

### **Vibration**

Vibration can come from tables or appliances designed specifically for removing air from liquids, or makeshift systems can be used. For example, you can leave your project on a running clothes dryer.