How Connectors are Manufactured

Connectors consist of two major components: terminals and housings. Distinct processes manufacture each part. As you know, there are endless terminal and housing designs. Many variations of manufacturing processes create them. However, this article profiles the main processes used to create typical connectors of stamped metal contacts and molded plastic housings.

**Housing Molding**

The molding process turns raw plastic, usually in the form of granules or pellets, into connector housings. The housings are molded from a variety of materials commonly known as plastics or resins. Technically, these plastics are called organic polymers. The chemical and electrical properties of polymers make them ideal for connector housings because they are:

- Light weight
- Corrosion resistant
- Good dielectric (insulating) properties
- Easily fabricated

Sophisticated, computer-controlled molding machines (shown at left) heat and melt the plastic, then force or inject it into a mold under pressure. The molten plastic cools in the mold and is ejected as a finished housing. The process seems simple, but it requires great precision in pressure, timing, and temperature to produce consistent mechanical and cosmetic quality across the many variations of connector housings.

![Molding machine diagram](image)

INJECTION MOLDING PROCESS OVERVIEW

- **A** Plastic granules or pellets are poured into a hopper or feed mechanism.
- **B** The hopper feeds the plastic into a heated barrel. A screw mechanism forces the melted plastic into a nozzle (C) for injection into the mold (D).
- **C** Once the plastic reaches the proper temperature, it is injected, or shot, under tremendous pressure, through a nozzle into the mold.
- **D** The mold, shown open here, is closed during injection. One side is stationary, and the other side moves to close and open. The molding machine clamps the mold at a pressure of between 45 and 120 tons.
- **E** After the part cools in the mold (a few seconds), an eject mechanism forces it out of the mold and into a storage system. The plastic in the channels that feed the mold is also ejected. A portion of it is reclaimed in a process called regrind, and is reused.
Terminal Stamping
Stamping converts raw metal into terminals and pins. Stamping begins with a flat metal strip. Part of the metal becomes a carrier strip on which the metal feeds into a sequence of extremely precise stamping, cutting, and forming operations that produce a terminal.

Terminals are made from several types of base metals such as brass and copper. Brass terminals have good spring, strength and electrical properties and are the least expensive metal by weight. They are typically a 70/30 mixture of copper and zinc. Copper alloy terminals are made from high strength modified copper and have good thermal and electrical capabilities. They are mainly used in automotive applications and resist softening in high temperatures, like under-hood applications.

Stamping requires two main types of equipment - a stamping die and a stamping press.

Stamping Dies do the cutting and forming as the carrier strip feeds through. A typical terminal requires 200 to 1,200 die operations, with each operation executed by part of the die and one stroke of the press.

Stamping Press supplies the force the die uses to make terminals. They are rated in the 18-30 ton range and execute over 1,000 strokes per minute.

Stamping is a four-step process:

Prepare The Die
The die is mounted into a stamping press. The press supplies the pressure, but the die does the actual work of cutting and forming.

Feed The Metal
Strip metal is fed into the stamping machine and die. The metal may be plated or unplated.

Cut and Form
Parts advance through the die on the carrier strip. Through a progression of small cutting and forming operations, the metal becomes the terminal design.

Collection
Finally, the completed terminals are removed from their carrier strip and dropped into storage bins (shown above). Or, they may be wound onto reels for feeding into a subsequent process, such as plating or assembly.
Terminal Plating

Few metals satisfy all mechanical, electrical and cost requirements of connectors. For example, terminal base metals like brass and copper stamp and form well, have good strength, spring and formability, but they are not ideal in corrosion resistance. To overcome their deficiencies, terminals are plated with other metals that excel in those connector requirement areas. Plating often uses metals like nickel, tin or gold. Gold is the most corrosion resistant, however it is also the most expensive. To reduce plating cost, some terminals are plated in gold on the contact areas only, and the rest of the terminal might be plated in nickel and or tin.

Terminal Plating Metals:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Tin</td>
<td>Overall excellent terminal finish</td>
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<tr>
<td></td>
<td>Most widely used plating material</td>
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<tr>
<td></td>
<td>Low cost</td>
</tr>
<tr>
<td></td>
<td>Excellent conductivity</td>
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<tr>
<td></td>
<td>Excellent solderability</td>
</tr>
<tr>
<td></td>
<td>Low corrosion resistance</td>
</tr>
<tr>
<td>Gold</td>
<td>Excellent corrosion resistance</td>
</tr>
<tr>
<td></td>
<td>Excellent solderability</td>
</tr>
<tr>
<td></td>
<td>Soft, but cobalt or nickel are added to harden</td>
</tr>
<tr>
<td></td>
<td>High cost</td>
</tr>
<tr>
<td></td>
<td>Selective plating reduces cost</td>
</tr>
<tr>
<td>Nickel</td>
<td>Typically used as underplating (see description at right)</td>
</tr>
<tr>
<td></td>
<td>Minimizes adverse reactions between base and plating materials</td>
</tr>
<tr>
<td></td>
<td>Improves adhesion and solderability</td>
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Underplating Two metals may have undesirable molecular interactions or not bond well. For example, gold tends to diffuse into copper and brass into tin. Underplating places a thin barrier of a non-reactive metal such as nickel, between them.

Plating is an electro-chemical process that has three main steps:

**PRE-TREATMENT**

Pre-treatment prepares the parts for plating. It includes several processing steps for cleaning and de-burring the contacts. For example, a step called activation dips parts in acid to remove oxide film and lightly scale surface for better plating metal bonding.

**ELECTRO-PLATING**

Electroplating deposits the plating material on the substrate. It uses electric current to generate a molecular attraction and bonding between the base terminal metal and plating metal in a chemical solution.

**POST-TREATMENT**

Post-treatment includes rinsing, cleaning, sealing neutralizing and drying the parts after plating. 100% of the plating chemistry must be removed from the plated parts.
Connector Assembly
Depending on the type of connector, production volume, time-to-market, and other factors, there are four different assembly methods that are generally used for connectors.

Assembly Methods:

Manual Assembly
Used for low volume production, samples, prototypes, and to meet the quick time-to-market requirement of some new products.

Semi-Automated Assembly
Combines bench-top tools and one or more manual operations such as feeding parts and pressing a foot pedal.

Flexible Assembly
Excels at tooling various products with quick changeovers. Time-to-market demands usually drive this approach. Flexible assembly lines typically serve lower production volumes that require flexible and fast reconfiguration.

Fully Automatic Assembly
Produces high output of one product family. The line can be quickly retooled for small changes like circuit count. This approach strives to maximize production rate by focusing on one product of huge quantities.

Post Processing
Includes operations such as ink-jet markings, bending terminals and inspection. Molding, stamping, plating and assembly each have their own inspection process. Production lines typically have machine vision inspection that captures an image of a part and compares it to a picture of an ideal part. Out of tolerance parts are rejected.

Contact Dereelers
Feed terminals on reels into the assembly process.

Housing Feed
Sends and orients housings into tracks for advancing through assembly.

Terminal Insertion
Uses stitchers or gang insertion machines to place terminals. Stitchers insert terminals or pins one at a time in an action that resembles a sewing machine. It loads as many as 400 terminals per minute. Gang Insertion loads multiple terminals in each insertion cycle. Although the machine runs slower, on average the insertion rate is 8 times faster than a stitcher.

Packaging
Places assembled parts into chosen packaging medium.