

# Rivets and How They are Installed

by Laurence Claus

In April of 1912, the “unsinkable” luxury liner Titanic would set out on her maiden voyage, only to collide within several days with an iceberg and sink in the freezing waters of the north Atlantic. The sinking of the Titanic would become, perhaps, the most iconic of all modern maritime accidents, and one that has been memorialized with multiple documentaries and blockbuster films such as James Cameron’s 1997 adaptation of the disaster.

For many years it was believed that the iceberg tore a long gash in the Titanic’s hull. Exploration and analysis of the ship and its parts, however, seem to suggest a different story. The one that emerges is of substandard iron rivets, already functioning at their margins, overstressed during the collision, breaking, and allowing hull plates to separate and seawater to flood inside.

Certainly there were many factors in-play, but, yes it seems likely that the rivets failed, dooming the “unsinkable” Titanic to catastrophic failure and so many of its passenger and crew to a watery grave.

As this story illustrates, rivets can and do play an exceptionally important role in the life and function of the products and structures in which they are used. Although other technologies have replaced many of the early uses of rivets, such as holding together ships and other large iron and steel structures, rivets are still an integral part of the manufacturing and assembly landscape and are, in fact, imperative in certain manufacturing industries such as aerospace and automotive.

This article will explore the different styles of rivets and some of the equipment used to install them.

## Types of Rivets:

Traditional rivets can be separated into four basic categories. These are solid, tubular, semi-tubular, and blind rivets. With the exception of blind rivets, the category names pretty well describe the basic part geometry. Solid rivets are solid cylinders, tubular rivets have a hole extending the entire length of the part, and semi-tubular rivets are a combination of the two, with a hole only extending a fraction of the length of the part. In each case the rivet must be constrained on both ends and the unformed end is provided with some sort of force to upset it. This results in that end “mushrooming” or flattening out and sandwiching the clamped material in-between. It is important that the installation generates enough compression in the joint to hold it together and prevent undesirable looseness of either the joint or the rivet. This was especially important during the time that rivets were used to hold ships like the Titanic together, as a loose rivet could result in a leak in the hull. In fact, skilled riveters were highly sought after and amongst one of the best paying jobs in the shipyard.

Blind rivets describe a variety of rivets that require one-sided access only. These rivets are designed with at least two parts, a tubular body and a mandrel. A special tool grips the mandrel which either pulls into or on the rivet body causing it to deform or upset without any contact with a die or anvil. The mandrel is designed to break off once the joint has been pulled tightly together.

Although these are the four traditional categories of rivets, in recent years other items have been developed to address specific needs or applications. Examples of a couple of these products include the Rivet Nut and the Self-Piercing Rivet

(SPR). In recent years, SPRs have become especially popular in certain industries and have become a favored use with automotive OEMs in attaching lightweight components such as aluminum together.



## Solid Rivets:

Solid rivets are by no means new technology. In fact, solid rivets have been found in items discovered in archeological sites dating back three or four thousand years. Conceptually a solid rivet’s function is relatively simple. It is placed through pilot holes in the material being joined and struck or pressed so that the un-formed end is upset or flattened out, effectively sandwiching the captured material between the two upset

ends. Whether this is accomplished manually or with the assistance of a rivet setting tool, the process requires contact (and thus access) to both sides of the rivet. The rivet, in addition to upsetting the un-formed end, may also “fill” in the center so that any looseness between the rivet body and the clamped material’s pilot hole is filled up. Since many rivets are operating in an environment where the loading is in shear, this is particularly advantageous as it completely fills the joint and makes it seem like one homogenous item.

Solid rivets can be found in many different materials; aluminum, steel, iron, stainless steel, brass, copper, and others. Perhaps the most common materials are aluminum and steel. Additionally solid rivets range from diameters that are very tiny to almost two inches. Naturally, the larger the diameter or stronger the material, the more consideration a designer must use regarding how it is actually assembled.

Solid rivets require the already formed head to be held tightly in-place while the un-formed end (known as the point) is pressed into shape. In former times this was accomplished by a rivet setting team that included a “heater” usually young boys that would heat the rivets up, a “holder-up” who would place the hot rivet in the pilot hole and hold it in place, and two “bashers” who would take turns striking the head with a hammer until the point was formed and the joint properly closed up. As the rivet cooled it would contract which acted to further pull and hold the joint together. This work was extremely difficult and the quality of the joint would depend on the skill and speed of the riveting team.

For this reason, manual riveting would be replaced with machines and tools that could engage the process faster and provide better quality results. Today these operations are accomplished using riveting hammers or rivet squeezers. A riveting hammer normally requires two individuals. One individual acts in a capacity similar to the original “holder-up” and uses a tool called a Bucking Bar to hold the formed end of the rivet. The other individual operates the pneumatic riveting hammer, which strikes the end with many blows in a very short period of time, and quickly forms the point. These tools come in several varieties and weigh anywhere from several pounds to almost ten pounds. Although today’s tools are designed to be as ergonomically friendly as possible, manually operating such a tool all day long can be exhausting. This method is used on steel rivets



up to about a quarter of an inch in diameter and larger for softer materials.

Smaller rivets can be assembled using rivet squeezers. These tools usually have “dies” located at either end of a C-shape yoke. A pneumatic cylinder or cylinders squeezes the rivet between the dies on the yoke forcing the unformed end to deform into the desired point shape.

Large rivets are upset in a similar fashion but using larger tooling and pneumatic cylinders. The sturdiness and weight of this equipment usually means that either the part is shuttled into a floor standing press or transported to the part via some form of crane or robot.

### **Tubular and Semi Tubular Rivets:**

Since the part of the rivet that is being upset is partially hollow, the force required to upset (or in this case flare out) the point is significantly lower than what is needed with a solid rivet. In most cases these types of rivets do not have the design expectations to carry load like a solid rivet. For this reason, these types of rivets are often used in high volume but non-structural applications.

Conceptually the process of installing is similar to a solid rivet. One side has a preformed head and the second side must be upset. Since the end to be upset is mostly hollow, the force required to do so is comparatively minimal. For this reason, setting tools for these types of rivets usually rely on a single, powerful impact from the tool. This blow is sufficient to upset or flare the end over and set the rivet.

### **Blind Rivets:**

Often one of the biggest challenges to engineers designing a new assembly process occurs when access to the back side is either very limited or nonexistent. This immediately eliminates a wide range of fastening options such as the three discussed above, since they require access to both sides of the joint. For these instances, fortunately blind fasteners are available today. These products are aptly named because the installation is made from the front side only and are designed to upset or deform beneath what is visible to the installer. Thus they are called “blind” because the fastening mechanism is occurring outside the sight of the installer.

Today there are a wide variety of blind fastener types spanning the performance spectrum from light duty all the way to heavy duty. These products generally have at least two components, a hollow body and a mandrel. The hollow body may take many different shapes and head styles from raised truss heads to recessed countersunk styles. Materials may also vary from steel, stainless steel, and aluminum, but all remain relatively “soft” so that they may be easily deformed. Most of these products have a mandrel with a bulb on the end. In most cases, a special installation tool will grip the mandrel and pull it upward. This action applies tension to the joint, compressing and holding it together. At the same time the bulb will either get pulled a small distance into the hollow body expanding it to create the rivet point or the bulb will compress the end of the rivet body and form a flange for the rivet point. In either case, just like a solid or tubular rivet, the rivet body will form a point

larger than the pilot hole it was pressed through, thus providing retention of the joint.

There are three body style variations, filled, semi filled, and hollow. With the filled style, the mandrel is designed to fracture flush with the top of the head. This variety provides the greatest shear strength of the three since the hollow cavity is completely filled with the mandrel. The semi-filled variety fractures below the line of the head so that only a small portion of the mandrel is actually retained. The hollow variety does not retain any of the mandrel so that it is hollow throughout. This variant is the lightest in weight but does sacrifice strength relative to the filled and semi-filled varieties.

A variety of these fasteners exist that, instead of having a smooth or lightly grooved mandrel, actually have a threaded mandrel and a nut above the fastener body. These utilize the mechanical advantage of screw threads to generate the tension and load necessary to deflect the body, form the point, and separate the mandrel. By using the mechanical advantage of the screw threads, these designs can offer high strength varieties and achieve high joint tension.

Just as there are many styles of these fasteners, so too are there many styles of installation equipment. One can pick-up a manual rivet gun at the local hardware store which resembles a pair of pliers. These simple tools grip the mandrel of the blind rivet leaving the rivet body exposed. The installer can then push the rivet body through previously prepared pilot holes and begin to squeeze the handles together. This allows the tool to grab the mandrel and pull it into the body, expanding it. The installer continues to actuate the handles in this fashion until the body is fully expanded and the mandrel breaks off. The broken mandrel slips out of the tool, making it possible to start the process again.

Manufacturers who must assemble many of these joints each day will likely utilize pneumatic or electric tools that perform this same function but without much effort from the installer. The tools are generally lightweight and portable. They may be pistol grip or in-line, and although usually small and portable, in certain situations where ergonomics is a concern may be equipped with support arms and tool balancers.

### Self-Piercing Rivets:

Relative newcomers, Self-Piercing Rivets were designed as an alternative to spot welded joints. These rivets are either semi-tubular or split rivet design and will pierce the upper sheet or sheets and flare out in the lowest sheet creating a strong joint. They are especially advantageous for joining materials that are either difficult or impossible to join using a spot weld, such as a mixed material joint (for example, aluminum and steel or composite and aluminum).

Self-Piercing Rivets require two sided access as there is an upper part of the tool to push the rivet through the material stacks and a lower “die” which determines how the rivet will upset or flare in the lower sheet. This installation tool is normally integral with a C-frame and mounted in a stand-alone assembly station or on a manufacturing robot.

### Rivet Nuts:

This unique product is essentially a blind threaded insert. Unlike blind rivets that pull together and hold multiple layers, Rivet Nuts usually are attached only to a single layer. They have an internal thread which allows them to act as a threaded insert and are a convenient way to create a threaded joint in a thin sheet component that otherwise is difficult because of size, geometry, or fabrication method to obtain a threaded joint at that location.

Installation of Rivet Nuts is similar to the installation of blind rivets. The Rivet Nut will possess an upset collar or head, an unthreaded section, and a threaded section. The Rivet Nut is threaded into a mandrel on a special tool. The tool spins the mandrel so that it begins to collapse the unthreaded section and pull it up tightly against the bottom of the sheet. Once it is firmly in-place, the mandrel disengages leaving the Rivet Nut ready for the installation of a screw.

Like blind rivet installation tools, Rivet Nut installation tools are generally light and portable so that they can be easily manipulated by the installer. However, they may also be integrated into a stand-alone station or onto a robot arm.

### Orbital Forming:

In some instances, an assembly may be rather delicate and unable to withstand the forces exerted by an impact riveting process. In these instances, Orbital Forming may be just the right answer. Orbital Forming can be used on either solid or semi tubular rivets, and just about any material that is feasible for riveting.

In Orbital Forming, a slightly off-angle head (or horn) rotates over the part progressively moving the material into the desired shape. This motion exerts significantly less force on the end being upset and so is advantageous when impact riveting may be too extreme.

Orbital Forming requires special tooling and equipment. Normally a special, stand-alone machine is required.

### Summary:

Rivet technology has advanced a great deal since the beginning of the twentieth century. Today there are many varieties of rivets for a multitude of different applications. And in the same vein, each of these different rivets has a multitude of different installation tools. Anyone that is considering using rivets during assembly has many options worthy of consideration. ■