Forming
Hot-dip galvanized sheet can be formed almost as readily as uncoated cold rolled sheet. It can be formed in a variety of ways, from simple rollforming and brake pressing to complex and intricate stamping.

As with uncoated steel sheet, factors other than metallurgical designation (CS, FS, DDS, etc.) of the base sheet enter into the successful forming of galvanized sheet. The galvanized coating exhibits frictional characteristics that are different from those of uncoated steel. Thus, lubricants, die materials and other elements of fabrication must be compatible with the coating to optimize productivity. In stamping and forming operations, it is advantageous to use dies that are harder and smoother than would be used for the same uncoated steel sheet. When proper attention has been given to forming parameters, hot-dip galvanized sheet is essentially as formable as cold rolled sheet that possesses similar ductility.

Joining

Soldering
Soldering is an established method for joining galvanized sheet or attaching solderable items to galvanized coatings. Galvanized sheet can be readily soldered with many types of conventional solders and fluxes. Lead/tin solder alloys are typically used. Flux residues should be removed after soldering to prevent corrosive damage to the zinc coating.

Welding
Galvanized sheet can be readily welded by the same methods used to weld cold rolled sheet. For example, spot welding is readily performed, but
caution must be applied to avoid more rapid deterioration of the spot-welding electrodes. For metal-arc welding and other high temperature welding methods, precautions must be taken to avoid porosity and cracking of the weld that can be caused by penetration of zinc into the weld pool.

Zinc has a much lower melting point (787°F) than steel and a lower boiling point (about 1600°F). During welding, zinc vapor burns in the air to produce dense, white zinc oxide fumes. These fumes need to be adequately vented. Specific precautions are given in ANSI Publication Z49.1 Safety in Welding and Cutting. The thicker the zinc coating, the more fumes are generated. In general, resistance welding is preferred for joining galvanized sheet products because it results in less fuming than other types of welding.

**Electric Resistance Welding**

**Spot Welding**
Because the galvanized coating has a lower surface contact resistance than bare steel, welding conditions for galvanized sheet will differ somewhat from those used for welding hot rolled or cold rolled sheet. Generally, higher electrode forces and higher welding currents and/or longer weld-cycle times are required to produce the same fused-zone diameter in galvanized sheet as achieved with uncoated sheet.

Zinc pickup on the electrodes during spot welding can cause fairly rapid electrode wear, so that only several thousand welds can be made before electrode dressing. To minimize zinc pickup, the electrodes should be kept as cool as possible by utilizing water cooling and controlling the rate of welding. The use of copper alloy, truncated-cone-shaped electrodes is preferred for spot welding galvanized sheet. Dome-type electrodes also may be used when electrode alignment is a problem.
For all galvanized products, extremely high welding current is to be avoided, because excessive heating tends to cause expulsion of the zinc coating under the electrodes. The optimum setting of the welding parameters must be determined by trial and are dependent on the specific application and sheet characteristics such as thickness or coating weight.

**Seam Welding**
Conventional seam welding equipment can be used for welding lap joints made with galvanized steel sheet. Seam welding of galvanized steel sheet can be considered to be continuous spot welding; the guidelines for spot welding should be followed for seam welding. To produce acceptable welds, the procedures used for cold rolled sheet should be modified toward slightly narrower electrode width, higher electrode force, higher welding current and slightly lower welding speed.

**Restoration of Weld Areas**
When good appearance and maximum corrosion resistance are desired in the weld area, oxides and fluxes from the welding operation should be removed by sand blasting, wire brushing or grinding. Satisfactory recoating methods are soldering, metal spraying or application of metallic-pigmented paints.

**Fastening**
From a mechanical standpoint, any style of fastener suitable for use with sheet metal can be used to join galvanized sheet to itself or to other materials, provided the fastener design is appropriate for the structural requirements of the application. The list of acceptable fasteners includes common ones like nuts and bolts, screws and rivets, and special types like clamp fasteners, clips and blind screws.

The fastener material should be selected carefully. First, the fastener should possess the same or greater corrosion resistance as the galvanized sheet to ensure that the fastener life does not contribute to premature failure of the fabricated part.
Second, the fastener material should be compatible with the coating; that is, it should be selected to avoid accelerated corrosion that, at times, can occur between certain types of dissimilar metals. Suitable materials include nylon or other plastics, stainless steels and carbon steel fasteners with thick zinc alloy heads. Galvanized or other plated fasteners also are suitable, but the coating must be thick enough so that the corrosion resistance is at least equal to the corrosion resistance of the galvanized sheet.

Fasteners made of lead or copper dramatically accelerate the corrosion of the zinc when an electrolyte is present. These materials set up an electrolytic cell, and the zinc coating sacrifices itself to protect the fasteners. Therefore, these fasteners must be avoided.

**Adhesive Bonding**

Adhesive bonding is a viable technique for joining coated steel sheet to either other coated or uncoated sheet as well as to other materials. The growing use of adhesive bonding in industries such as the automotive industry clearly demonstrates the reliability and durability of this fastening method.

Adhesive bonding is an excellent method of joining dissimilar steel sheet products. It does not alter the properties of the steel or its coating. It provides uniform stress distribution and can be applied to reduce vibration and noise. Adhesive bonding can serve to enhance product design, so that mechanical fasteners and/or welding can be avoided. It can function as a moisture sealant. Also, it increases the range of material choices and material combinations available to the product designer.

Two important conditions are necessary for proper use of adhesive bonding: (1) the load on the bonded area should be evenly distributed; (2) the joint should be stressed mainly in a shear mode; peel and cleavage forces should be minimal.

Two types of adhesives, thermosets and thermoplastics, are widely used
to join steel sheet. Thermoset adhesives generally possess high shear strength, rigidity and durability, and are capable of supporting a wide range of specified design loads. They include acrylics, epoxies, and urethanes. Thermoplastic adhesives generally are tough and ductile, and are excellent for energy-absorbing applications.

**Sealants**

Sealants are often used between overlapping areas of steel sheet to form watertight joints and to achieve superior environmental durability. Neutral-cure silicone rubber sealants are recommended for use with galvanized sheet. These materials need no primer. They are flexible and noncorrosive as well as resistant to heat, cold, water and ultraviolet rays.

Other types of sealants, like butyl rubber and styrene butadiene rubber, may also be used successfully. For more information about sealants for specific applications, consult a sealant manufacturer.

**Painting**

U. S. Steel Galvanized Sheet can be readily painted either before or after fabrication. When painted in coil form, the product is called prepainted sheet. Paint provides obvious aesthetic effects as well as increased corrosion protection. Increased corrosion protection is a major attribute of painted galvanized sheet. The paint film provides substantial improvement by shielding the zinc coating from acid rain and other corrosion-accelerating contaminants in the environment.

Selection of a pretreatment that provides an adherent bond between the zinc coating and the paint is vitally important for correct application of painted galvanized sheet. One of the keys to good performance of painted galvanized sheet is the selection and use of a primer designed for galvanized surfaces.

Items made from galvanized sheet should be thoroughly cleaned and dried prior to application of the pretreatment. The most common type of pretreatment is zinc phosphate. Other pretreatments can be used, but they
should have a proven performance record for use on galvanized sheet.

Many types of paint can be used on galvanized sheet. The choice depends on the ultimate service requirements of the product. For example, some types are formulated to maximize the resistance to fading and chalking. Others provide good flexibility for use with prepainted sheets. To maximize the performance of painted galvanized sheet, it is highly recommended that users consult with paint suppliers to obtain maximum performance.