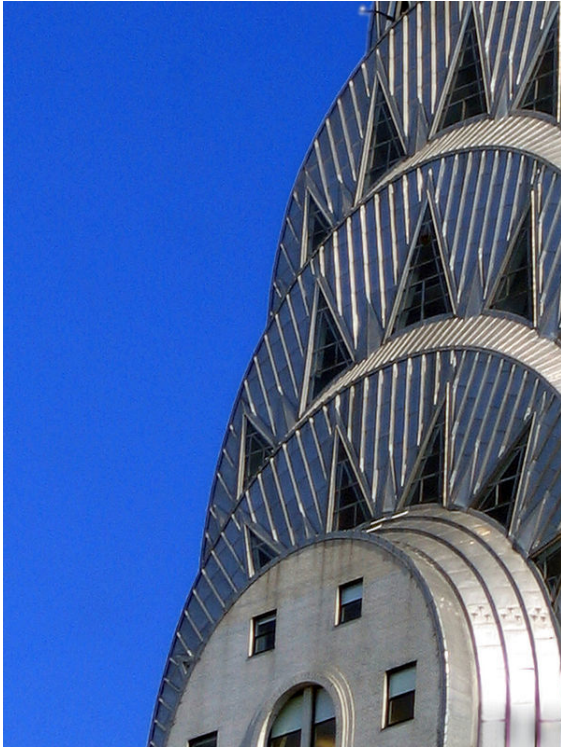
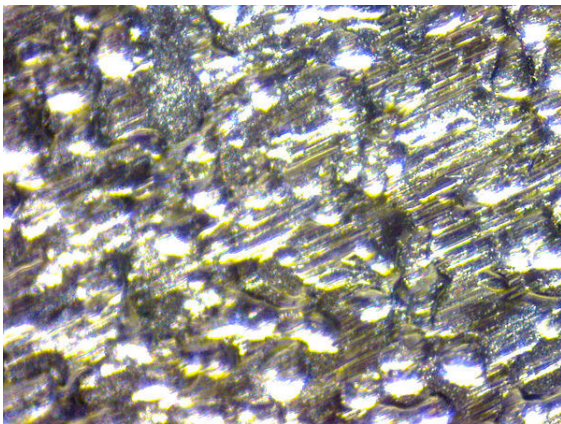


# Sheet metal



*Sheets of Nirosta stainless steel cover the Chrysler Building*



*Microscopic close-up of mild steel sheet metal.*

**Sheet metal** is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Countless everyday objects are constructed with sheet metal. Thicknesses can vary significantly; extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

Sheet metal is available in flat pieces or coiled strips. The coils are formed by running a continuous sheet of metal through a **roll slitter**.

The thickness of sheet metal is in the USA commonly specified by a traditional, non-linear measure known as its **gauge**. The larger the gauge number, the thinner the metal. Commonly used steel sheet metal ranges from 30 gauge to about 7 gauge. Gauge differs between ferrous (iron based) metals and nonferrous metals such as aluminum or copper; copper thickness, for example is measured in ounces (and represents the thickness of 1 ounce of copper rolled out to an area of 1 square foot). In the rest of the world the sheet metal thickness is given in millimeters.

There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium. For decorative uses, important sheet metals include silver, gold, and platinum (platinum sheet metal is also utilized as a catalyst.)

Sheet metal is used for car bodies, airplane wings, medical tables, roofs for buildings (architecture) and many other applications. Sheet metal of iron and other materials with high magnetic permeability, also known as laminated steel cores, has applications in transformers and electric machines. Historically, an important use of sheet metal was in plate armor worn by cavalry, and sheet metal continues to have many decorative uses, including in horse tack. Sheet metal workers are also known as “tin bashers” (or “tin knockers”), a name derived from the hammering of panel seams when installing tin roofs.<sup>[1][2]</sup>

## 1 Materials

### 1.1 Stainless steel

Grade 304 is the most common of the three grades. It offers good corrosion resistance while maintaining formability and weldability. Available finishes are #2B, #3, and #4. Grade 303 is not available in sheet form.<sup>[3]</sup>

Grade 316 possesses more corrosion resistance and strength at elevated temperatures than 304. It is commonly used for pumps, valves, chemical equipment, and marine applications. Available finishes are #2B, #3, and #4.<sup>[3]</sup>

Grade 410 is a heat treatable stainless steel, but it has a lower corrosion resistance than the other grades. It is

commonly used in cutlery. The only available finish is dull.<sup>[3]</sup>

Grade 430 is popular grade, low cost alternative to serie 300's grades. Used when high corrosion resistance is not a primary criteria. Common grade for appliance products, often with a brushed finish.

## 1.2 Aluminium

Aluminum is also a popular metal used in sheet metal due to its flexibility, wide range of options, cost effectiveness, and other properties.<sup>[4]</sup> The four most common aluminium grades available as sheet metal are 1100-H14, 3003-H14, 5052-H32, and 6061-T6.<sup>[3][5]</sup>

Grade 1100-H14 is commercially pure aluminium, highly chemical and weather resistant. It is ductile enough for deep drawing and weldable, but has low strength. It is commonly used in chemical processing equipment, light reflectors, and jewelry.<sup>[3]</sup>

Grade 3003-H14 is stronger than 1100, while maintaining the same formability and low cost. It is corrosion resistant and weldable. It is often used in stampings, spun and drawn parts, mail boxes, cabinets, tanks, and fan blades.<sup>[3]</sup>

Grade 5052-H32 is much stronger than 3003 while still maintaining good formability. It maintains high corrosion resistance and weldability. Common applications include electronic chassis, tanks, and pressure vessels.<sup>[3]</sup>

Grade 6061-T6 is a common heat-treated structural aluminium alloy. It is weldable, corrosion resistant, and stronger than 5052, but not as formable. It loses some of its strength when welded.<sup>[3]</sup> It is used in modern aircraft structures.<sup>[6]</sup>

## 2 Gauge

Use of Gauge to designate sheet metal thickness is discouraged by numerous international standards organizations. For Example, ASTM states in specification ASTM A480-10a "The use of gage number is discouraged as being an archaic term of limited usefulness not having general agreement on meaning."<sup>[7]</sup>

Manufacturers' Standard Gauge for Sheet Steel is based on an average weight of 41.82 lb (18.96 kg) per square foot per inch thick.<sup>[8]</sup> Gauge is defined differently for ferrous (iron-based) and non-ferrous metals (e.g., aluminium and brass).

### 2.1 Tolerances

During the rolling process the rollers bow slightly, which results in the sheets being thinner on the edges.<sup>[3]</sup> The tolerances in the table and attachments reflect current man-

ufacturing practices and commercial standards and are not representative of the Manufacturer's Standard Gauge, which has no inherent tolerances.

## 3 Forming processes

### 3.1 Bending

Main article: [Bending](#)

The equation for estimating the maximum bending force is,

$$F_{Max} = k \frac{TLt^2}{W}$$

where  $k$  is a factor taking into account several parameters including friction.  $T$  is the ultimate tensile strength of the metal.  $L$  and  $t$  are the length and thickness of the sheet metal, respectively. The variable  $W$  is the open width of a V-die or wiping die.

### 3.2 Curling

Main article: [Curling](#)

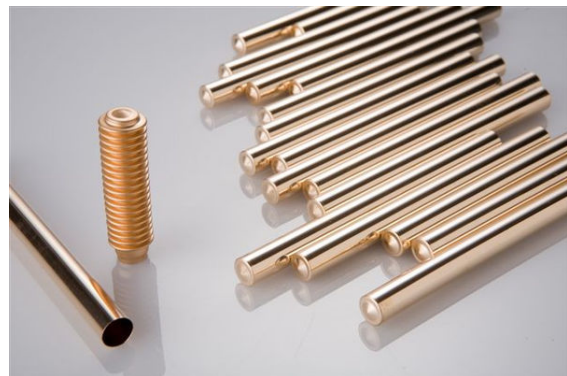
### 3.3 Decambering

Main article: [Decambering](#)

### 3.4 Deep drawing

Main article: [Deep drawing](#)

Drawing is a forming process in which the metal is



Example of deep drawn part

stretched over a form or die.<sup>[14]</sup> In deep drawing the depth of the part being made is more than half its diameter. Deep drawing is used for making automotive fuel tanks,

kitchen sinks, two-piece aluminum cans, etc. Deep drawing is generally done in multiple steps called draw reductions. The greater the depth the more reductions are required. Deep drawing may also be accomplished with fewer reductions by heating the workpiece, for example in sink manufacture.

In many cases, material is rolled at the mill in both directions to aid in deep drawing. This leads to a more uniform grain structure which limits tearing and is referred to as “draw quality” material.

### 3.5 Expanding

Main article: [Expanded sheet metal](#)

Expanding is a process of cutting or stamping slits in alternating pattern much like the stretcher bond in [brickwork](#) and then stretching the sheet open in accordion-like fashion. It is used in applications where air and water flow are desired as well as when light weight is desired at cost of a solid flat surface. A similar process is used in other materials such as paper to create a low cost packing paper with better supportive properties than flat paper alone.

### 3.6 Hemming and seaming

Main article: [Hemming and seaming](#)  
Main article: [Automotive Hemming](#)

Hemming is a process of folding the edge of sheet metal onto itself to reinforce that edge.

Seaming is a process of folding two sheets of metal together to form a joint.

### 3.7 Hydroforming

Main article: [Hydroforming](#)

Hydroforming is a process that is analogous to deep drawing, in that the part is formed by stretching the [blank](#) over a stationary die. The force required to do so is generated by the direct application of extremely high [hydrostatic pressure](#) to the workpiece or to a bladder that is in contact with the workpiece, rather than by the movable part of a die in a mechanical or hydraulic press. Unlike deep drawing, hydroforming usually does not involve draw reductions—the piece is formed in a single step.

### 3.8 Incremental sheet forming

Main article: [Incremental sheet forming](#)

## 3.9 Ironing

Main article: [Ironing](#)

### 3.10 Laser cutting

Main article: [Laser cutting](#)

Sheet metal can be cut in various ways, from hand tools called [tin snips](#) up to very large powered shears. With the advances in technology, sheet metal cutting has turned to computers for precise cutting. Many sheet metal cutting operations are based on computer numerically controlled (CNC) laser cutting or multi-tool CNC punch press.

CNC laser involves moving a lens assembly carrying a beam of laser light over the surface of the metal. Oxygen, nitrogen or air is fed through the same nozzle from which the laser beam exits. The metal is heated and burnt by the laser beam, cutting the metal sheet. The quality of the edge can be mirror smooth and a precision of around 0.1 mm (0.0039 in) can be obtained. Cutting speeds on thin 1.2 mm (0.047 in) sheet can be as high as 25 m (82 ft) a minute. Most of the laser cutting systems use a CO2 based laser source with a wavelength of around 10  $\mu\text{m}$ ; some more recent systems use a YAG based laser with a wavelength of around 1  $\mu\text{m}$ .

### 3.11 Photochemical machining

Main article: [Photochemical machining](#)

Photochemical machining, also known as photo etching, is a tightly controlled corrosion process which is used to produce complex metal parts from sheet metal with very fine detail. The photo etching process involves photo sensitive polymer being applied to a raw metal sheet. Using CAD designed photo-tools as stencils, the metal is exposed to UV light to leave a design pattern, which is developed and etched from the metal sheet.

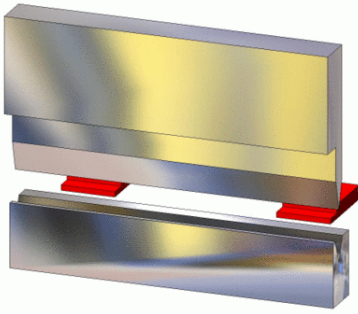
### 3.12 Perforating

Main article: [Perforating](#)

Perforating is a cutting process that punches multiple small holes close together in a flat workpiece. Perforated sheet metal is used to make a wide variety of surface cutting tools, such as the [surform](#).

### 3.13 Press brake forming

This is a form of bending used to produce long, thin sheet metal parts. The machine that bends the metal is called



*Forming metal on a pressbrake*

a **press brake**. The lower part of the press contains a V-shaped groove called the die. The upper part of the press contains a punch that presses the sheet metal down into the v-shaped die, causing it to bend.<sup>[15]</sup> There are several techniques used, but the most common modern method is “air bending”. Here, the die has a sharper angle than the required bend (typically 85 degrees for a 90 degree bend) and the upper tool is precisely controlled in its stroke to push the metal down the required amount to bend it through 90 degrees. Typically, a general purpose machine has an available bending force of around 25 tonnes per metre of length. The opening width of the lower die is typically 8 to 10 times the thickness of the metal to be bent (for example, 5 mm material could be bent in a 40 mm die). The inner radius of the bend formed in the metal is determined not by the radius of the upper tool, but by the lower die width. Typically, the inner radius is equal to 1/6 of the V-width used in the forming process.

The press usually has some sort of **back gauge** to position depth of the bend along the workpiece. The backgauge can be computer controlled to allow the operator to make a series of bends in a component to a high degree of accuracy. Simple machines control only the backstop, more advanced machines control the position and angle of the stop, its height and the position of the two reference pegs used to locate the material. The machine can also record the exact position and pressure required for each bending operation to allow the operator to achieve a perfect 90 degree bend across a variety of operations on the part.

### 3.14 Punching

Main article: [Punching](#)

Punching is performed by placing the sheet of metal stock between a punch and a die mounted in a press. The punch and die are made of hardened steel and are the same shape. The punch is sized to be a very close fit in the die. The press pushes the punch against and into the die with enough force to cut a hole in the stock. In some cases

the punch and die “nest” together to create a depression in the stock. In **progressive stamping** a coil of stock is fed into a long die/punch set with many stages. Multiple simple shaped holes may be produced in one stage, but complex holes are created in multiple stages. In the final stage, the part is punched free from the “web”.

A typical CNC **turret punch** has a choice of up to 60 tools in a “turret” that can be rotated to bring any tool to the punching position. A simple shape (e.g., a square, circle, or hexagon) is cut directly from the sheet. A complex shape can be cut out by making many square or rounded cuts around the perimeter. A punch is less flexible than a laser for cutting compound shapes, but faster for repetitive shapes (for example, the grille of an air-conditioning unit). A CNC punch can achieve 600 strokes per minute.

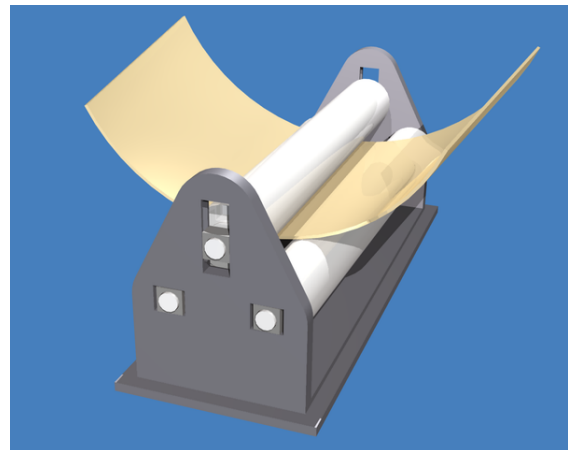
A typical component (such as the side of a computer case) can be cut to high precision from a blank sheet in under 15 seconds by either a press or a laser CNC machine..

### 3.15 Roll forming

Main article: [Roll forming](#)

A continuous bending operation for producing open profiles or welded tubes with long lengths or in large quantities.

### 3.16 Rolling



*Bending sheet metal with rollers*

Main article: [Rolling](#)

[16]

### 3.17 Spinning

Main article: [Metal spinning](#)

Spinning is used to make tubular (axis-symmetric) parts by fixing a piece of sheet stock to a rotating form (mandrel). Rollers or rigid tools press the stock against the form, stretching it until the stock takes the shape of the form. Spinning is used to make rocket motor casings, missile nose cones, satellite dishes and metal kitchen funnels.

### 3.18 Stamping

Main article: [Stamping](#)

Stamping includes a variety of operations such as punching, blanking, embossing, bending, flanging, and coining; simple or complex shapes can be formed at high production rates; tooling and equipment costs can be high, but labor costs are low.

Alternatively, the related techniques [repoussé](#) and [chasing](#) have low tooling and equipment costs, but high labor costs..

### 3.19 Water jet cutting

Main article: [Water jet cutting](#)

A water jet cutter, also known as a waterjet, is a tool capable of a controlled erosion into metal or other materials using a jet of water at high velocity and pressure, or a mixture of water and an abrasive substance.

### 3.20 Wheeling

Main article: [Wheeling](#)

[17]

## 4 Fasteners

Fasteners that are commonly used on sheet metal include:

- [Clekos](#)<sup>[18]</sup>
- [Rivets](#)<sup>[19]</sup>
- Sheet metal screws

## 5 See also

- Circle grid analysis
- Corrugated galvanised iron, also known as Corrugated Sheet Metal

- [Diamond plate](#)
- [Forming limit diagram](#)
- [Strip steel](#)
- [Temper mill](#)

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## 7 External links

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