Extract of the book:
The Fascinating World of Sheet Metal

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TRUMPF GmbH + Co.
Johann Maus Straße 2
71254 Ditzingen
Federal Republic of Germany

Authors:
Dr. Hubert Bitzel, Johanna Borcherdt, Jörg Müller, Frank Neidhart, Dr. Klaus Parey, Armin Rau, Sabine Riecke, Annegret Schmid, Gabriele Trentmann, Gerald Vorländer, Klaus Zimmermann.

Graphics:
Gisela Ostermann, Rainer Deuschle, Bernhard Walter

Translation:
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Project coordination:
Annegret Schmid

Cover photo:
Udo Loster Fotostudio GmbH

Layout design:
Heike Hauß, Jürgen G. Rothfuß

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Sheet Metal

The production and the processing of materials to create forms which cannot be found in nature are among the most significant developments of mankind. Whereas in the Stone Age naturally-occuring materials – primarily wood and stone – were directly processed into finished products, the beginning of the Bronze Age is characterized by natural products (ores) being initially formed into an intermediate product. The finished product was then produced in a second step. In nature there are very few examples of homogeneous, flat products. Woven materials, fabrics, paper and glass and, of course, sheet metal owe their existence to the way mankind has developed its processing techniques.

The most important characteristic of sheet metal and plates in contrast to other rectangular forms such as bars, strips, and flats is that its thickness is relatively small compared to its length and width.

The difference between sheet metal and plates is determined by their thicknesses. Sheet metal has a thickness of less than 5.0 mm (3/16"); thicker delivery material is referred to as a plate. Thin materials are also supplied as coils. As processing sheet metal, plates, and coils is in many cases identical, it is often not necessary to take these various delivery forms into consideration.

The material used for sheet metal in industry is usually always steel, but other metals such as aluminum, copper, silver, and gold are also processed.

Characteristic properties

The thinness and the deformability of the metals are the aspects that make workpieces manufactured from sheet metal so useful.

The thickness of the workpiece has a bearing on the weight and the amount of force and energy required during processing, whether cutting or forming. As sheet metal parts are thin, they are light and therefore very inexpensive. They can be processed using suitable sheet metal processing machines quickly and easily.

The metals used for sheet metal have one important property – they are deformable (ductile) while retaining their molecular structure. The cross-section of a workpiece can therefore be

Suits of armor in Erbach Castle, Germany

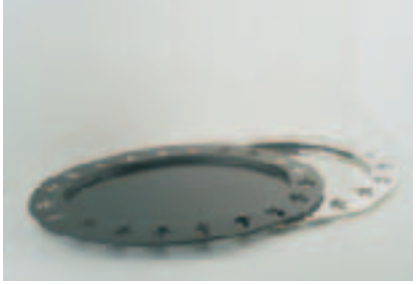

Wedding
Reinickendorf
E 26
ICC

Industrial building

altered by the excertion of force without loss of strength. The metal is not only deformable when it is red-hot during the forging process, but also when it is at a normal temperature. It is also noteworthy that these metals can be rolled down to an extremely thin form – gold, for example, as little as 1/100 mm.

Sheet metal has a low rigidity in one direction which is advantageous in manufacturing but has its drawbacks in practical use. It is the designer's task to ensure that products manufactured from sheet metal can withstand the demands placed on them. This can make it highly desirable for the finished product to be plastically deformable. For example, the crumple zone of a car body absorbs a large amount of the impact energy in a collision and thus prevents the passengers from being seriously injured.

Plate with perforated edge



The merits of sheet metal

Sheet metal has a number of desirable properties. It is, for example:

- flat
- thin, light
- smooth, level, even
- decorative
- can be cut or punched
- elastic, plastically bendable
- can be formed or bent
- can be deep-drawn
- can be welded
- easy to assemble
- recyclable

Many of the properties listed above make it clear why sheet metal is the ideal starting material for any kind of guard or cover. In these cases, the sheet metal takes up only a small proportion of the load as, for example, in the case of a top cover.

If the stability of sheet metal is increased by forming it in the appropriate way, the proportion of the total load-carrying ability is also increased.

In recent decades, the use of sheet metal in mechanical engineering has increased greatly. This is primarily due to the continued development of the processes and the processing machinery which makes sheet very inexpensive to produce. Since the Fifties it has been possible to weld plates with a thickness of more than 100 mm (4") perfectly. Ever since then, whole areas of technology, such as frame construction have forsaken cast-metal for welded constructions. The further development of bending techniques has led to the replacement of integral components consisting of profile sections by folded products. With sheet metal products, it is easy to see the relationship between the end product and the manufacturing process used to create it.

The range of products that can be made from sheet metal and plates is very diverse. It includes coverings, wall and roof covers. In these cases, very thin sheets are used to cover large areas. The cover rigidity required for use as façades is achieved by using corrugated sheets and trapezoidal surfaces. Apart from their use as coverings, metal sheets are used to store and convey liquids and bulk goods. This includes the vast amount of beverage cans made from thin aluminum sheet with a thickness of less than 0.2 mm (.001") and also the huge tanks for the oil and chemical industry. There are also smaller products made of sheet metal that do not require

Kitchen range with extractor hood

any additional reinforcement. For the next group of sheet metal products: housings for equipment and apparatuses, switching cabinets, furniture and vehicles such as cars, trains, ships and planes there are many cases in which the sheets not only have a covering function, but also a supportive one. This is particularly obvious for structural supporting automobile bodies. In the automotive and ship building industries, one can see the entire range of material thicknesses. Whereas the car bodies often have a thickness of less than 1 mm (.05"), ships use plates of more than 100 mm (4"). The same holds true for mechanical engineering where, for example, contact plates are made of thin sheets

"A river of steel"

and machine stands of very thick plates. Furthermore, very complex workpieces are formed by bending and welding.

Sheets are used in mass production as well as manufacturing individual parts. The most conspicuous mass-produced product is surely the automobile. Among the single products made of sheet metal are models for prototypes as well as art objects which round off this diverse spectrum.

Manufacturing sheets

Creating sheets by hammering is a method that goes back to antiquity. A metal block is simply flattened to the desired form with a hammer. Even today, precious pieces are usually hammered to form small sheets.

A 2.5 m wide, mobile bed was found in the grave of a Celtic prince in the town of Hochdorf near Stuttgart. The bed had been constructed from thin bronze sheets more than 2500 years ago. The sheets were reinforced at the edges with an inserted wire and an appropriate shaped form. This type of edge reinforcement is still common today.

Hammering by hand was replaced by gradual, mechanical pressing. Leonardo da Vinci designed a type of roll press press which formed spring bands to the desired size. Blueprints are still on hand for a device for rolling strips.

Approx. 200 years ago, the technique of rolling sheets and strips was introduced. It gained acceptance in the last century.

Rolling is a process in which a starting block (slab) is pulled through a gap by two powered rollers which reduce the slab thickness by approx. 20 – 30 %. This process has two variants: hot and cold rolling. Hot rolling is the process of rolling red-hot metal to produce thicker

Rolling mill by Leonardo da Vinci

sheets and plates. Thin sheets, on the other hand, are cold rolled because they dissipate heat so quickly that the glowing temperature cannot be maintained. Cold rolling produces more precise tolerances as well as harder and better surfaces.

After rolling, thicker sheets are cut to the desired formats with shears or flame cutting machines from runs which are up to 40 m in length. Thinner strips are cut lengthwise with slitting lines into smaller strips or into sheets using cut-to-length lines.

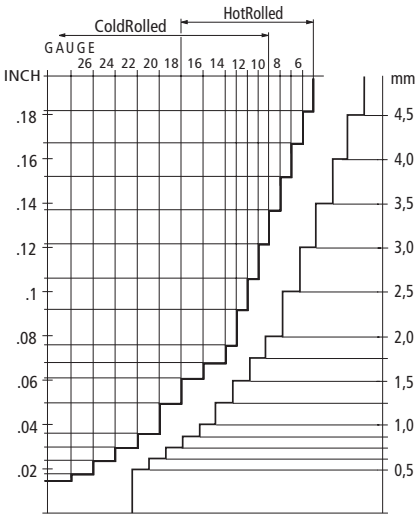
Rolling is not only limited to the manufacture of sheets and strips. Rods, profile sections, wires and pipes can also be manufactured with the appropriate rolling mills.

2500 year old bed made of bronze sheets

Selection criteria for sheet dimensions

To determine the most suitable sheet metal for a particular workpiece, the geometric dimensions and the most practical material should be chosen. The following criteria give an indication of the wide variety of options:

Thickness: In addition to mm, the material thickness of sheets is also measured in inches and gauges in certain countries. The selection of nominal thicknesses for thin sheets is so varied that the right sheet thickness is available for just about any conceivable task.
The rolling of the two sheets is so amazingly precise that only very slight differences in thickness are produced.



Commercial graduations in thickness in mm

Sheets, plates and coils

These thickness tolerances depend on the sheet thickness, the sheet format, the material and the manufacturing form. They are agreed upon with the sheet manufacturer according to the delivery conditions. The maximum deviation from a level surface must also be specified. The flatness of sheets is necessary for trouble-free operation during processing.

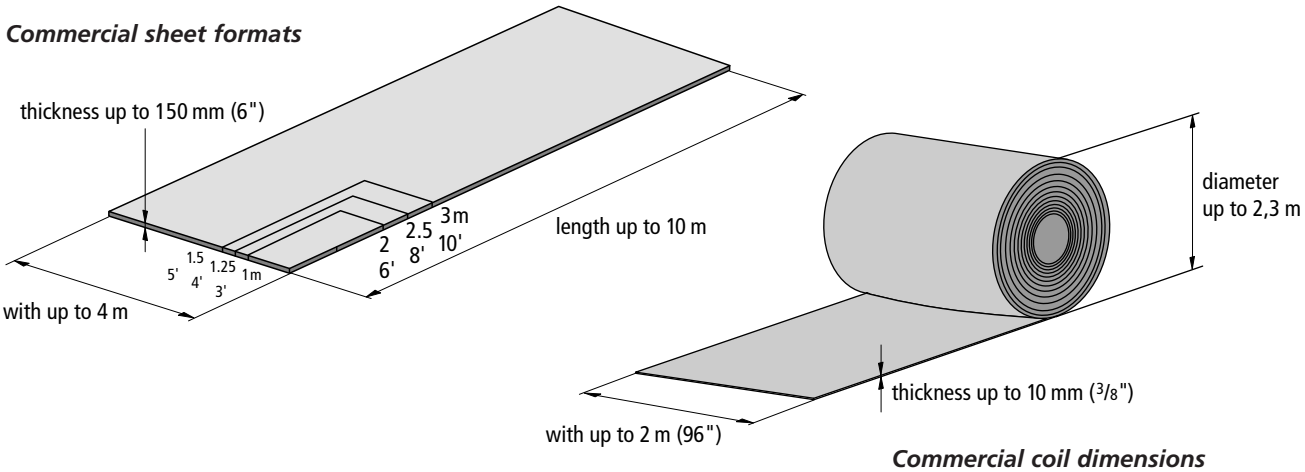
Formats and delivery formats: The maximum width of sheets depends on the width of the roller path. You can find sheets up to 4 m wide and 10 m long in the delivery lists from sheet metal suppliers. The most popular sheet formats are between 1000 x 2000 mm, and 1500 x 3000 mm, in North America between 3' x 6' and 5' x 10'.

Strips in the form of a rolled up coil can be several 100 meters long. The coils have a maximum width of 2 m (96"), a maximum diameter of 2.3 m and a weight of up to 40 tons (50,000 lbs.). The thickness of the strips is usually less than 3 mm (1/8"), but coils consisting of strips with a thickness of 10 mm (3/8") are also available.

Special forms of sheet metal

Aside from the usual delivery form as a homogeneous sheet of metal with a double-sided, flat, smooth, unprocessed surface, there are a series of special features. This means the user does not have to ask the manufacturer to make a modification for a particular application.

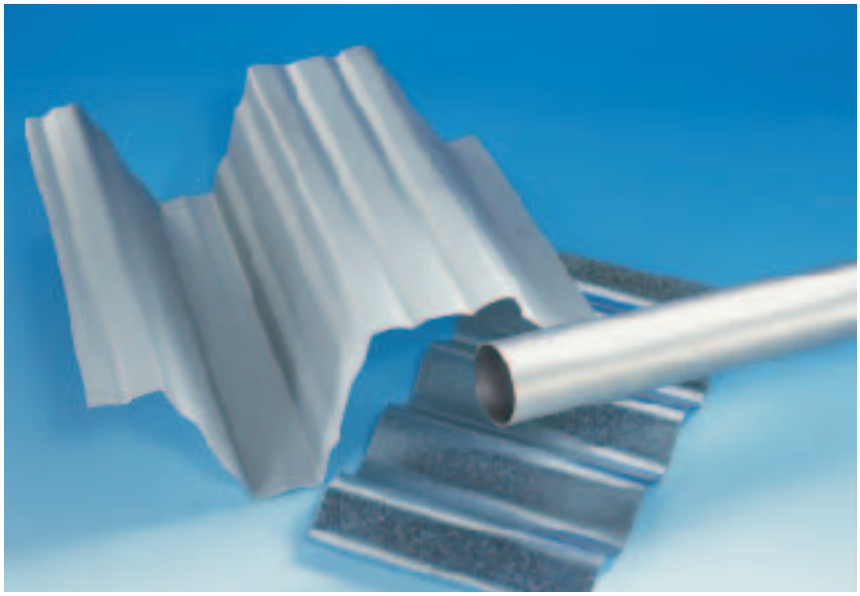
Commercial sheet formats



Commercial coil dimensions

Sheets made of various materials (for example, mild steel, galvanized steel, aluminum, copper, bronze)

Sheets with a fine and coarse structured surface (for example, stainless steel with a ground surface, high-grade steel with a foil cover, chequer plate, bubble pattern, and rib pattern)



Sheets with a profile (for example, trapezoidal sheet, corrugated sheet, sheet tube)

Mild steel (Cold rolled steel)

EN10130 Type of steel	RM [N/mm²]	A80 [%]	DIN 1623	ASTM
FeP01	290 - 410	28	≈St12	A366
FeP04	270 - 350	38	≈St14	A620

Profiled sheets, corrugated sheets and flooring plates: Particularly for use as facade and roof coverings, sheets are delivered which have been rolled in such a way that their cross sections have a wave-like form or consist of trapezoids lined in a row. These sheets have a considerably higher level of rigidity than flat ones.

If sheets are used as floor coverings – especially for stairs, steps, and catwalks – they must have a nonslip surface. These are provided by a chequer on one side which is raised a few millimeters.

Rhombic passes, formed by crossing two layers of angular ribs and also lens-shaped raised sections have proven themselves to be effective.

Design sheets have a surface which is not as structured as flooring plate. The pattern is more for appearance and replaces in many cases the coat of paint.

Tailored blanks: In contrast to homogeneous sheet metal which has the same thickness and material quality, there have been efforts in recent years to produce single sheets with various thicknesses and levels of quality. These tailored blanks are formed by welding different sheets together. These customized sheets make it possible to gradually modify the sheet thickness to the load it will be exposed to. Put another way, sections subject to a greater load are made thicker.

Pre-working: Many sheet metal suppliers are willing to prepare the sheets so that they are easier to use by their customers. Preworking means not only are the sheets tailored to the desired format, but also ground, rounded off or coated with a foil to allow non-scratch processing.

Selecting criteria for sheet metal materials

The large selection of materials available are not exhausted for workpieces made of sheet metal, because the demands on these pieces are normally not all that varied.

Whereas strength and hardness are the most important selecting criteria for machine parts, it is the working properties and non-corrosive characteristics that are of primary importance for metal sheets. In many cases, the material is selected less for its load resistance than for its suitability for a particular process. Cutability for punching, flame cutting, laser cutting, water jet cutting as well as deformability for deep drawing, roll forming, pressing, bending and welding are all factors to be considered.

Sheet metal parts are highly corrosive due to their large surfaces and also less resistant than massive parts. Apart from switching to stainless steel, light metal alloys or applying an anti-corrosive coat, non-corrosive sheets can also be obtained.

Cold-rolled sheet metal: With these sheets, fracture strain A 80[%] for cold deformability is more important than tensile strength Rm [N/mm²]. For this reason, two different properties suffice to satisfy the various demands in sheet metal working: commercial quality and drawing quality.

Hot-rolled plates: For hot-rolled thicker sheets, strength and weldability are in many cases more important properties than deformability.

Conventional mild steel with a strength between 370–700 N/mm² is preferred.

Stainless steel: The main field of application for stainless steel is the food processing industry. Stainless steel costs many times more than mild steel and is considerably more difficult to process. Due to its alloy components (more than 12% chrome), it offers the guarantee of non-corrosiveness obviating the need for additional protective measures against corrosion superfluous. Here also, only a few sheet metal properties are needed.

Thin sheets used in automotive body construction

The basic material for anti-corrosive sheet metal is steel which has been covered with a metallic protective layer. The layer is applied either by hot-dipping, plating, or electroplating. Electrogalvanized sheet metal is the most important of the non-corrosive sheet metals.

Example of ordering sheet metal

The ordering code contains the geometric dimensions with the additional demands for edge quality, levelness, and side straightness as well as the code designation according to the standards or terms of delivery.

The ordering code for a sheet made from steel of Fe P06 quality with the dimensions 1200 mm x 2500 mm, with a thickness of 0.8 mm, whose level tolerances should be limited (FS), whose surface is smooth (g) and is, at least on one side, free of pores, drag lines, warts and scratches (B) would be:
sheet metal
EN 10131 – 0.8 x 1200 x 2500 FS

steel
EN 10130 – Fe P06 Bg.

If no special characteristics are required in reference to the standard values, the typical dimensions (thickness x width x length) together with the material quality suffice:
sheet 18Ga x 4" x 8" CRS oiled SS 304

Stainless steel

DIN 17441		AISI/SAE
1.4016	X 6 Cr 17	430
1.4310	X 5 Cr Ni 18 10	304/304L
1.4541	X 6 Cr Ni Ti 18 10	321
1.4571	X 6 Cr Ni Mo Ti 17 12 2	316Ti

The model type and surface structure are determined in accordance with country-specific standards such as DIN 17440 or ASTM A 240.

Plates used in mechanical engineering

Stainless steel in a chemical installation