HOLLOW METAL MANUAL

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METAL DOORS & FRAMES

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MANUFACTURING OF HOLLOW METAL DOORS AND FRAMES

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HOLLOW METAL MANUFACTURERS ASSOCIATION

A Division of

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NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS

Hollow Metal Manufacturers Association

Division of the National Association of Architectural Metal Manufacturers

This manual was developed by representative members of the Hollow Metal Manufacturers Association Division (HMMA) of the National Association of Architectural Metal Manufacturers (NAAMM) to provide information and guidance on the selection of hardware for hollow metal doors and frames. This manual contains advisory information only and is published as a public service by NAAMM and its HMMA Division.

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MANUFACTURING OF HOLLOW METAL DOORS AND FRAMES

1. MATERIALS

A. GENERAL

The raw materials for hollow metal doors and frames are steel coils and sheets. At the mills, steel is processed into slabs and "rolled" into coils of varying thicknesses. The thickness or gage of the steel is controlled by adjusting the distance between the rollers through which the red-hot steel passes. As the steel is rolled, it is spooled into coils. These coils may then be further processed into other types of steels. After the final processing step, the steel is either shipped as a coil or is passed through a series of rollers (leveled) and cut into sheets of a fixed length.

Several types of carbon steel and their uses in hallow metal work are as follows:

1. hot rolled (HR)-reinforced and heavy gage doors and frames
2. cold rolled (CR)-typical commercial hollow metal
3. electrolytic zinc coated (ELECTRO)-slightly enhanced protection against elements
4. hot dipped galvanized (GALV)-enhanced protection against elements
5. stainless steel (SS)-corrosive environments or esthetic applications

By far the most commonly used material for commercial hollow metal is cold-rolled steel. The use of hot-rolled steel is generally limited to hardware reinforcements and heavy gage doors and frames. Zinc-coatd sheets, either galvanized or electrolytically coated, are often used corrosion protection from the elements. Various grades of stainless steel sheets, either cold-rolled finish (2B) or polished as specified, are used for applications where maximum cleanliness, severe corrosion resistance, or high degree of esthetics are required.

B. HOT ROLLED STEEL

Hot-rolled steel is rolled to the required thickness at temperatures where scale (ferrous oxide) is formed on its surfaces. When required, the steel is pickled to remove the scale, and is supplied either dry or oiled. Hot-rolled steel is available in commercial, drawing, and physical qualities. It is the commercial quality that is generally used for hollow metal work. The standard usually referenced for such sheets is ASTM A569, "Standard Specification for Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet, and Strip, Commercial Quality". This type of steel is used for such heavy gage items as hardware reinforcements. Pickled or pickled-and-oiled hot-rolled sheets (HRPO) are also used for heavy gage doors and frames.

C. COLD-ROLLED STEEL

Cold-rolled steel is made from hot-rolled descaled coils, reduction, in the cold rolling process to the desired thickness. Similar to hot-rolled steel, cold-rolled steel is made in three different qualities: commercial quality, which are further processed by annealing anddrawing quality, and physical quality. Commercial quality sheet is used for most hollow metal work. After proper pre-treatment, this steel is suitable painting. The specification commonly referenced for uncoated cold-rolled sheets is ASTM A366, "Cold-Rolled Carbon Steel Sheet, Commercial Quality".

D. ZINC-COATED STEEL

Zinc-coated sheets are cold-rolled sheets that have been covered on both sides with a coating of zinc to improve corrosion resistance. The coating may be applied by various means, but in the hollow metal industry the most common methods are hot dip galvanizing using and electrolytic coating. It is important to understand the proper terminology when referencing zinc-coated sheets. The term "galvanized sheet"denotes that the sheet is coated by the hot dip process. The term "electrolytic zinc-coated" should be used when referring to sheets that are coated by electrolytic action. Since both types of sheets are used for hollow metal work, it is important that the distinction between the two be clearly recognized.

.1 Electrolytic Coated Steel
Electrolytically coated steel has a much thinner zinc coating than steel coated by the hot dip process. The standard referenced for such sheets is ASTM A591, "Standard Specification for Electrolytic Zinc-Coated Steel Sheets." This standard defines three classes of coatings as shown in Table 1.

.2 Hot Dipped Coated Steel
The standard references for hot dip galvanized steel is ASTM A526, "Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process, Commercial Quality". This standard includes, by reference, all of the requirements of a more comprehensive standard, ASTM A525, which covers the general requirements of all qualities of such sheets, listing two general types and 12 designations (by weight) of coating, as shown in Table 2. Regular (G) coatings are applied on continuous coating lines and may have either a "rectangular spangle" finish or may be treated to have a duller "minimized spangle" normally provided only in coating designations G90 and lighter. Alloyed (A) coatings are provided by special processing which produces an iron-zinc alloy coating that is not spangled but is dull gray in appearance and suitable for immediate painting without further treatment other than normal cleaning.

TABLE 1 - DESIGNATION OF ELECTROLYTIC ZINC COATINGS (ASTM A 591)

Coating Class	Minimum Coating Weight (total, both sides) Oz/ft2 of sheet — Triple Spot Test	Single Spot Test
A (flash coat)	no min.	no min.
B	0.075	0.07
C	0.165	0.15

TABLE 2 - DESIGNATION OF HOT DIP GALVANIZED COATING (ASTM A 525)

			Minimum coating weight (total, both sides) Oz/ft2 of sheet	
Type	Coating Designation	Previous Coating Class	Triple Spot Test	Single SpotTest
Regular	G 235	2.75	2.35	2.00
	G 210	2.50	2.10	1.80
	G 185	2.25	1.85	1.60
	G 165	2.00	1.65	1.40
	G 140	1.75	1.40	1.20
	G 115	1.50	1.15	1.00
	G 90	1.25 Commercial	0.90	0.80
	G 60	Light Commercial	0.60	0.50
	G 30	--	0.30	0.25
	G 01	--	no min.	no min.
Alloyed	A 60	--	0.60	0.50
	A 40	--	0.40	0.30
	A 25	--	0.25	0.20

Generally, there are four types of hot dip galvanized sheets available;

a. Those having either a regular spangled coating (in all G coating designations) or a minimized spangle (in G90 and lighter designations);
b. Those which are heat treated or wiped after galvanizing to produce a fully alloyed zinc-rich coating (in coating designations A60 and lighter). The heat- treated sheets are commonly referred to as galvannealed;
c. Those which are phosphatized/bonderized after galvanizing (in all G designations); and, after galvanizing (in all G designations) and
d. Those that are "differentially coated," i.e., have coatings of different thickness on their two surfaces (in all G coating designations).

.3 Stainless Steel

Stainless Steel Sheets may be used for doors and frames in locations where cleanliness is a critical factor, such as hospitals, food processing plants, some chemical plants, and sterile manufacturing areas. The chromium-nickel (non magnetic) Type 304 is most commonly used. Where maximum resistance to corrosion is required, Type 316 may be specified. For some interior doors where esthetic considerations are the primary concern, the magnetic Type 430 is sometimes used. The reference standard for the Types 300 series is ASTM A167, "Standard Specification for Stainless and Heat- Resisting Chromium-Nickel Steel Plate, Sheet and Strip," and that for Type 430 IS ASTM A176, "Standard Specification for Stainless and Heat- Resisting Chromium Steel Plate, Sheet and Strip." The finishes used in hollow metal work range from AISI unpolished 2B finish to the polished finishes 3 through 8. The 2B specifies a bright cold rolled finish without directional texture. The polished finishes, 3 through 8, provide increasing levels of brightness. Table 3 below describes these finishes:

.4 Applications

Zinc-coated sheets, both Regular and Alloy types, are used for doors and frames where corrosion due to moisture, humidity, or the elements is of concern. Electrolytically coated sheets, with Class C coating, are appropriate for interior doors in locations such as locker rooms, kitchens, and laundries. Galvanized sheets, usually A60 coating

TABLE 3 - AISI FINISH NOS.

Unpolished Finishes:	
No. 1	A comparatively rough dull surface produced by hot rolling to the specified thickness, followed by annealing and descaling.
No. 2DA	dull cold rolled finish produced by cold rolling to the specified thickness, followed by annealing and descaling. May also be accomplished by a final light pass on dull rolls.
No. 2B	A bright cold rolled finish commonly produced in the same way as No. 2D finish, except that the annealed and descaled sheet receives a final cold roll pass on polished rolls. This is a general purpose cold rolled finish, and in more readily polished than the No. 1 or No. 2D.
Polished Finishes:	
No. 3	A polished finish obtained by finishing with an approximately 100 grit abrasive. Generally used where a semi-finished polished surface is required for later finishing following fabrication.
No. 4	A general purpose bright polished finish obtained by finishing with a 120-150 mesh abrasive, following initial grinding with coarser abrasives.
No. 6	A soft satin finish having lower reflectivity than the No. 4 finish. It s produced by Tampico brushing the No. 4 finish, using a medium abrasive.
No. 7	A highly reflective finish produced by buffing a surface which has first been finely ground, but "grit" lines are not removed.
No. 8	The most reflective finish commonly produced. It is obtained by polishing with successively finer abrasives, then buffing with a very fine buffing compound. The surface is essentially free of grit lines caused by preliminary grinding operations.

designation, are used where greater protection is required. Hollow Metal in certain industrial or in seaside environments or doors in sewage or water treatment plants may require heavier galvanized coatings or the use of stainless steel. It is not practical to hot-dip galvanize fabricated hollow metal sections and assemblies. Hot-dip galvanizing of hollow metal assemblies are subject to warpage and distortion due to the heating and cooling incidental to the galvanizing operation. There are many commercially available primers which provide corrosion resistance similar to the zinc coating process. These can be spray-applied to areas of hollow metal doors and frames which have had galvanizing removed through the normal course fabrication.

2. FABRICATION

A. GENERAL

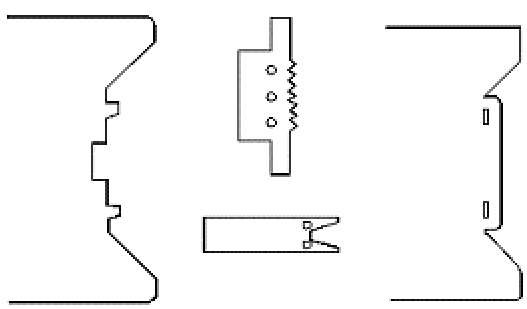
Custom hollow metal permits the architect freedom of design. It is important to have an understanding of materials used and the fabrication process. The common methods of cutting, forming, and assembling for hollow metal products are therefore of concern to the architect. These operations include shearing, blanking, brake forming, and welding.

B. SHEARING

Most raw material stock for hollow metal is purchased by the fabricator in the form of flat sheets which, prior to forming, must be cut to exact sizes. Shearing is the simplest method of obtaining straight cuts. It is typically done on a machine called a shear, which consists of a tablelike "bed" on which the sheet to be cut is positioned. At the back edge of a shear is a stationary lower blade and a heavy movable upper blade. The upper blade is brought downward clearing the edge of the bed by a carefully controlled clearance. The length of cut possible may vary from only a few feet on the smaller manually operated shears to as much as 40 feet on the largest power-operated shears. Power shears used in the hollow metal industry range in length from 8 to 20 feet. Shearing is sometimes done at the same time as blanking when computerized numerical control (CNC) punch presses are used.

C. BLANKING

Blanking (or punching) operators are employed to make the numerous hardware cutouts in the flat sheared pieces of metal that will later be formed into hollow metal components. These operations are accomplished by positioning the metal between the upper and lower components of a die set, usually consisting of a lower stationary "die" and an upper movable punch. The punch and die are machined so that they fit together with close clearances and are designed to produce the desired configuration of cut by a single hit. A series of hits using multiple die sets is often used to produce cutouts whose size exceed maximum die size or whose pattern does not conform to typical die shapes. Piercing of the steel is done by pushing a punch through the metal and into the shoe. The pressure required to push the punch through the metal may range from 5 to 400 tons depending on the type and thickness of metal and the shape, size, and number of holes being blanked at one time. Blanking can be done with several types of machines. A Punch press can be used to power one die set for blanking material while a press brake can be used to power several die sets simultaneously. Turret presses are also used for blanking operations. A turret press has many die sets loaded in a rotating turret. These machines are also equipped with tables, and work holders to hold flat steel. The work holders move to position the steel sheet to a desired location. While the sheet is held in place, the turret rotates to a specified die and pierces the steel. The process can continue on a repetitive basis until all the blanking requirements for a particular sheet are met. Coupled with computer software, turret presses provide "soft -tooling" for the punching of almost unlimited patterns. Numerical control turret presses not only provide for interfacing to computer aided design, but also result in increased speed and improved accuracy in the fabrication process.



TYPICAL BLANKED CUTS AND PIECES

D. BRAKE FORMING

This basic method of forming is common to all sheet metals and is performed on a machine called a press brake. Fabricators of hollow metal work use a variety of press brakes in the manufacture of their products as this machine offers the widest range of adaptability to forming requirements. It does have certain limitations, however, as will be explained.

Only straight-line bends can be made on the press brake. The bend radius and angle, which are a function of die design, can be varied over a wide range. Almost any configuration can be produced provided it is a single curvature form. In addition to the many standard dies, an infinite variety of specially designed dies may be used and a great many bend configurations can be produced by successive operations employing such dies. The length of the bend is dependent on the press brake capacity and length of the die set. Lengths commonly used in the hollow metal industry range from 10 to 12 feet, and they exert forces from 50 to greater than 600 tons.

Brake forming is an economical method of forming straight-line bends when the quantity of items to be formed ranges from one of a kind to hundreds or even thousands. Most hollow metal sections, therefore, are formed in this way.

E. LIMITATIONS

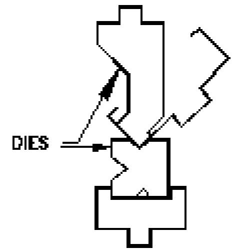
There are certain limitations to be observed in the design of sections to be produced by brake forming. One of the inherent characteristics of any cold-formed sheet section is that external corners are rounded and the inside radius for most angular bends is generally equal to the approximate thickness of the metal being bent. For full 180(bends, however, carbon steel and annealed stainless steel sheet can be bent flat upon itself with zero radius. There are also certain other dimensional limitations to be observed in the design of typical frame members. Among these are the width of flanges or backbends and the width of the throat opening illustrated in Figure 1. Normally, the backbend (flange) width should be no less than 1/2" and no more 1 1/2"; not too narrow to be formed with standard brake dies or so wide that there is tendency for it to warp or be easily deformed during installation. To avoid complex forming operations involving special dies, the throat opening width should be no less than 2". The minimum recommended face dimension of a framing member is 1". Any lesser width is hard to maintain to a true line and dimension The maximum face width should be 8" unless stiffened on the back side or thicker (12 gage or thicker) gage material is used.

F. WELDING

Hollow metal products are generally assembled by welding. Several Types of both fusion welding and resistance welding are commonly employed in the industry. The usual fusion welding method is metal-arc welding which is either shielded or unshielded. Gas welding is a fusion method with limited use. Spot welding and protection welding are the most commonly used resistance welding methods.

The amount of welding on hollow metal products varies as a function of application and design. Frame corner joints may be face welded or face and soffit welded or fully welded.

As with other processes, welding has practical limitations. Mullion and transom sections should be welded and ground smooth only on their faces. If the entire length of a mullion joint is welded, the inside corners of the rabbets, stops, and soffits cannot be properly finished. This practice is therefore not recommended.



BRAKE FORMING OF FRAME

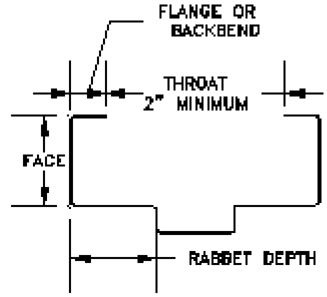


FIGURE 1

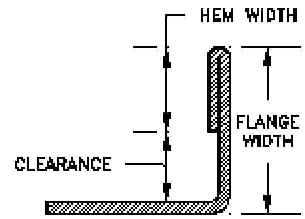


FIGURE 2

1. Fusion Welding

The metal-arc method, using a consumable flux coated rod, is commonly used to weld the miter and butt joints at the frame corners with the welds usually being placed on the concealed inner face of the frame members. This method of welding is fast and provides strong joints. With the shielded metal-arc (MIG or heliarc) method, which uses an automatically fed bare electrode in wire form, the arc is enveloped by a stream of inert has - helium, argon, or a combination of the two - and no flux is required.

2. Spot welding

Spotwelding is a type of resistance welding commonly used in the industry to join two overlapping pieces of metal, face to face. It readily permits the joining of different thicknesses of metal without problems of warping or buckling. Spotwelding leaves small marks in the metal surface which my be visible when glossy finishes are used. Their complete removal is difficult and may be impractical. In most cases, even surface grinding will not remove the marks. Spotwelding is commonly used to fasten internal stiffeners to door face sheets, attach hinge and strike reinforcements and anchors to frames, and to fasten mortar guards to the hinge and strike reinforcements.

3. Projection Welding

Projection welding is another form of resistance welding. The part to be attached by projection welding must first have a small projection of the proper size formed on it wherever the weld is to be made. Several welds can be made simultaneously at each such projection. This type of welding is often used to fasten hinge and strike reinforcements on doors and frames, and floor anchors to the back sides of frames.

G. PAINTING

Most hollow metal work is given only a prime coat of paint at the factory with the finish paint being applied in the field, after installation, by the painting subcontractor. Because the product will be subjected to the hazards of shipping, handling, and on-site storage in the interim, it is essential that this prime coat be of good quality, properly applied and protected during on-site storage. HMMA specifications require the primer must satisfy salt spray and water fog tests designated by ASTM standards B117 and D1735 respectively.

As with any painting of metal, a prior thorough cleaning of the metal is of critical importance. All surface contaminants such as rust, loose mill scale, grease, oil, and weld deposits must be entirely removed to insure complete adhesion of the primer coat.

Cleaning is accomplished by various methods such as steam cleaning, hot water wash, or other single or multiple stage solvent cleaning systems such as described in the Steel Structures Painting Council's Specification SPI. A detergent is used to remove dirt, oil, grease, and other foreign matter. Hot dip galvanized steel having a spangled finish of any kind requires etching before painting to remove the glaze of galvanizing and make the surface porous enough to provide a proper bond. However, that which has a galvannealed or phosphatizes finish as well as electrolytically zinc-coated steel, usually requires only a thorough cleaning.

Application methods vary depending on the fabricator's practices, facilities, and the size and number of Items being painted. Among the most common methods are conventional spraying, airless spraying, electrostatic spraying, and flowcoating. After application, the paint may be simply air dried or heat cured.

It must be recognized that although every precaution is taken to insure proper cleaning and pretreatment of the metal and the best available primer is used, this cannot insure complete protection of the product when subjected to rough handling or to negligence in protection it from damage before, during , or after installation at the job site. Paint manufacturers advise that the standard primer typically used by custom hollow metal manufacturers should receive a finish coat of paint within 30 days of reciept of materials. After that period of time, the material will likely need to be sanded and touched up before applying the finish coat(s) of paint. The importance of proper site storage and the means of providing it are fully explained in a publication dealing with installation, HMMA 840, "Installation and Storage of Hollow Metal Doors and Frames.