

METAL DOORS & FRAMES



NAAMM HMMA 802-07  
May, 2007

# MANUFACTURING OF HOLLOW METAL DOORS AND FRAMES

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*Current information on all NAAMM Standards may be received by calling or writing the National Association of Architectural Metal Manufacturers, or going to [www.naamm.org](http://www.naamm.org).*

### **National Association of Architectural Metal Manufacturers**

800 Roosevelt Road, Building C, Suite 312

Glen Ellyn, Illinois 60137

Website: [www.naamm.org](http://www.naamm.org)

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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 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.

Types of carbon steel commonly used in hollow metal work are as follows:

1. Hot-Rolled (HR) – reinforcement and doors and frames of thicker steel
2. Cold-Rolled (CR) – typical commercial hollow metal
3. Zinc-Coated Steel – enhanced protection against elements
4. Stainless Steel (SS) – corrosive environments or aesthetic 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 thicker steel doors and frames. Zinc-coated sheets, either galvanized or galvanized are recommended to enhance corrosion protection from the elements. Various grades of stainless steel sheets, either cold-rolled finish or polished as specified, are used for applications where maximum cleanliness, severe corrosion resistance, or high degree of aesthetics 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 A1011/A1011M, “Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.” This type of steel is used for such thicker steel items as hardware reinforcements. Pickled or pickled-and-

oiled hot-rolled sheets (HRPO) are also used for thicker steel doors and frames.

### C. COLD-ROLLED STEEL

Cold-rolled steel is made from hot-rolled descaled coils, which are further processed by annealing and 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, drawing and physical quality. Commercial quality sheet is used for most hollow metal work. After proper pre-treatment, this steel is suitable for painting. It is available oiled or electrolytic zinc-coated for protection prior to manufacturing. The specification commonly referenced for uncoated cold-rolled sheets is ASTM A1008/A1008M, “Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.”

### D. ZINC-COATED STEEL

Zinc-coated sheets are cold-rolled sheets that have been covered on both sides with a milled applied coating of zinc to improve corrosion resistance. The coating may be applied by various means, but in the hollow metal industry the recommended methods are hot-dip galvanizing. It is important to understand the proper terminology when referencing zinc-coated sheets. The term “galvanized” or “galvanized” sheet denotes that the sheet is coated by the “Hot-dip” process. The standard referenced for hot-dipped galvanized or galvanized sheet is ASTM A653/A653M, “Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot-Dip Process”. This standard includes, by reference, all of the applicable requirements of a more comprehensive standard, ASTM A924/A924M, which covers the general requirements of all qualities, including tolerances, of such sheets. They list two general types and 15 designations (by weight) of coating. Table 1 shows the coating rates referenced in HMMA standards. Regular [G (Z)] coatings are applied on continuous coating lines and may have either a “regular spangle” finish or may be treated to have a duller “minimized spangle” normally provided only in coating designations G90 (Z275) and lighter. Alloyed [A (ZF)] 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.

There are two types of hot-dipped zinc-coated sheets used:

- a. Those having a spangled coating (in all G (Z) coating designations) or a minimized spangle (in G90 (Z275) and lighter designations).
- b. Those which are heat-treated (annealed) after galvanizing to produce a fully alloyed zinc-rich coating (in coating designations A60 (ZF180) and lighter). The heat-treated sheets are commonly referred to as galvalannealed.

## E. STAINLESS STEEL

Stainless steel sheets may be used for doors and frames in locations where cleanliness and corrosion resistance 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 commonly used where moderately corrosive applications occur and corrosion resistance and aesthetic appearance are of equal concern. Where primary resistance to corrosion is required, Type 316 should be specified. The reference standard for the Types 300 series is ASTM A666, "Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar."

The finishes used in hollow metal work range from 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 2 describes these finishes:

## F. APPLICATIONS

Zinc-coated sheets, both Galvanneal and Galvanized types are used for doors and frames where corrosion due to moisture, humidity, or the elements is of concern. Hollow metal in certain environments require heavier galvanized coatings or the use of stainless steel.

It is not practical to hot-dip galvanize hollow metal sections and assemblies after fabrication. Hot-dip galvanizing of hollow metal assemblies are subject to warpage and distortion due to the heating and cooling during the galvanizing operation. There are many coatings which provide corrosion resistance similar to the zinc process. These can be applied to areas that have had the zinc-coating removed through the normal course of fabrication.

| TABLE 1 – ASTM A653/A653M DESIGNATIONS OF ZINC-COATINGS<br>REFERENCED IN HMMA STANDARDS |                     |       |                                      |          |                                      |          |                                  |      |
|-----------------------------------------------------------------------------------------|---------------------|-------|--------------------------------------|----------|--------------------------------------|----------|----------------------------------|------|
| Type                                                                                    | Coating Designation |       | Minimum Check Limit Triple Spot Test |          | Minimum Check Limit Single Spot Test |          | Average Coating Thickness / Side |      |
|                                                                                         | in-lb               | SI    | oz./sq. ft.*                         | g/sq. m* | oz./sq. ft.*                         | g/sq. m* | inches                           | mm   |
| Galvanized                                                                              | G90                 | Z275  | 0.90                                 | 275      | 0.80                                 | 235      | .0008                            | .019 |
|                                                                                         | G60                 | Z180  | 0.60                                 | 180      | 0.50                                 | 150      | .0005                            | .013 |
| Galvanneal                                                                              | A60                 | ZF180 | 0.60                                 | 180      | 0.50                                 | 150      | .0005                            | .013 |
|                                                                                         | A40                 | ZF120 | 0.40                                 | 120      | 0.30                                 | 90       | .0003                            | .009 |
|                                                                                         | A25                 | ZF75  | 0.25                                 | 75       | 0.20                                 | 60       | .0002                            | .005 |

\* NOTE: The weight of coating in oz./sq. ft. and g/sq. m refers to the total coating on both surfaces.

**TABLE 2 – DESIGNATION AND DEFINITION OF STANDARD MECHANICAL FINISHES  
FOR STAINLESS STEEL SHEET IN ACCORDANCE WITH ASTM A480/A480M**

**Unpolished Finishes:**

|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| No. 1           | <b>Hot-rolled, annealed and descaled</b> – Commonly referred to as hot-rolled, annealed and pickled or descaled. This is a dull, non-reflective finish.                                                                                                                                                                                                                                                                                     |
| No. 2D          | <b>Cold-rolled, dull finish</b> – A smooth, non-reflective cold-rolled, annealed, and pickled or descaled finish. This non-directional finish is favorable for retention of lubricants in deep drawing applications.                                                                                                                                                                                                                        |
| No. 2B          | <b>Cold-rolled, bright finish</b> – A smooth, moderately reflective cold-rolled annealed and pickled or descaled finish typically produced by imparting a final light cold-rolled pass using polished rolls. This general-purpose finish is more readily polished than a No. 1 or 2D finishes. Product with 2B finish is normally supplied in the annealed plus lightly cold rolled condition unless a tensile-rolled product is specified. |
| Bright Annealed | <b>A bright, cold-rolled finish retained by final annealing in a controlled atmosphere furnace</b> – A smooth, bright, reflective finish typically produced by cold rolling followed by annealing in a protective atmosphere so as to prevent oxidation and scaling during annealing.                                                                                                                                                       |

**Polished Finishes:**

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| No. 3                  | <b>Intermediate polished finish, one or both sides</b> – A linearly textured finish that is produced by either mechanical polishing or rolling. Average surface roughness ( $R_a$ ) can generally be up to 40 micro-inches. A skilled operator can generally blend this finish. Surface roughness measurements differ with different instruments, laboratories, and operators. There can also be overlap in measurements of surface roughness for both No. 3 and No. 4 finishes.    |
| No. 4                  | <b>General purpose polished finish, one or both sides</b> – A linearly textured finish that is produced by either mechanical polishing or rolling. Average surface roughness ( $R_a$ ) can generally be up to 25 micro-inches. A skilled operator can generally blend this finish. Surface roughness measurements differ with different instruments, laboratories, and operators. There can also be overlap in measurements of surface roughness for both No. 3 and No. 4 finishes. |
| No. 6                  | <b>Dull, satin finish, Tampico brushed, one or both sides</b> – This finish has a soft, satin appearance typically produced by Tampico brushing a No. 4 finish.                                                                                                                                                                                                                                                                                                                     |
| No. 7                  | <b>High luster finish</b> – Has a high degree of reflectivity. It is produced by buffing a finely ground surface, but the grit lines are not removed. It is chiefly used for architectural or ornamental purposes.                                                                                                                                                                                                                                                                  |
| No. 8                  | <b>Mirror finish</b> – This is a highly reflective, smooth finish typically produced by polishing with successively finer grit abrasives, then buffing. Typically, very faint buff of polish lines can still be visible on the final product. Blending after part assembly can be done with buffing.                                                                                                                                                                                |
| TR Finish              | <b>Cold-worked to obtain specified properties</b> – The finish resulting from the cold-rolling of an annealed and descaled or bright annealed condition. Appearance will vary depending upon the starting finish, amount of cold work, and the alloy.                                                                                                                                                                                                                               |
| Architectural Finishes | Sometimes described as a No. 5 finish, these are a separate category and may be negotiated between buyer and seller, as there are many techniques and finish variations available throughout the world.                                                                                                                                                                                                                                                                             |

## 2. FABRICATION

### A. GENERAL

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 table-like “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 (12.16 m) on the largest power-operated shears. Power shears used in the hollow metal industry range in length from 8 to 20 feet (2.43 to 6.08 m). Shearing is sometimes done at the same time as blanking when computerized numerical control (CNC) punch presses or lasers are used.

### C. BLANKING

Blanking (punching or laser cutting) operations are employed to make the numerous cutouts in the flat sheared pieces of metal that will later be formed into hollow metal components. Punching operations are accomplished by positioning the metal between the upper and lower components of a die set, usually consisting of 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.

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. CNC turret punch 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.



**PUNCHING OPERATION**

Blanking can also be done utilizing a laser machine to cut the metal. Typical to a CNC punch press, lasers are numerically controlled and by interfacing to computer-aided design are very accurate.

### D. 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 manufacturing 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 spe-

cially 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 (3.05 to 3.66 m), and they exert forces from 50 (45 360 kg) to greater than 600 tons (544 310 kg). 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.

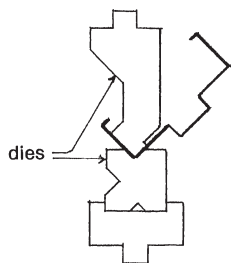


**BRAKE FORMING OF FRAME SECTION**

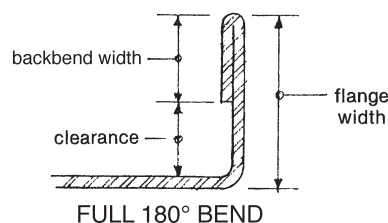
## E. GENERAL FABRICATION CAPABILITIES

There are certain fabrication limitations to be observed in design of members. Listed are a few of the basic ones.

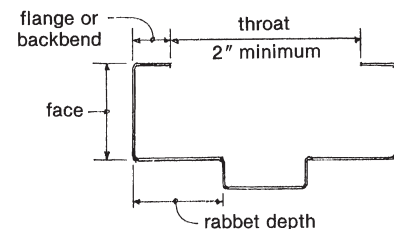
- One of the inherent characteristics of any cold-formed sheet section is that external corners are rounded and the inside radius for most angular bends is generally equal to the approximate thick-



**BRAKE FORMING OF FRAME**



**FIGURE 1**



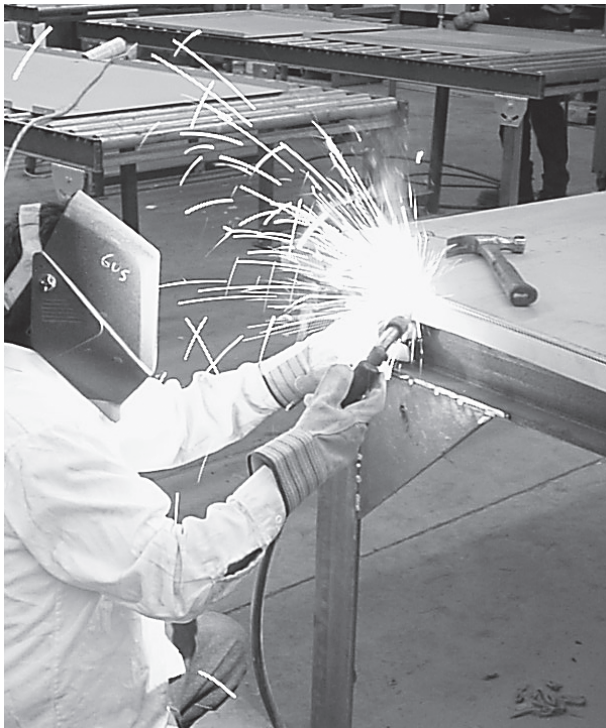
**FIGURE 2**

ness of the metal being bent. For full 180° bends (Figure 1), however, carbon steel and annealed stainless steel sheet can be bent flat upon itself.

- 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 returns and the width of the throat opening illustrated in Figure 2. Normally, the return (flange) width should be no less than 1/2" (12.7 mm) and no more than 1-1/2" (38.1 mm); not too narrow to be formed with standard brake dies or so wide that there is a tendency for it to warp or be easily deformed during installation. Another rule to follow in section design is for all legs to be a minimum of four times the thickness. To avoid complex forming operations involving special dies, the throat opening width should be no less than 2" (50.8 mm).
- The minimum recommended face dimension of a framing member is 1" (25.4 mm). Any lesser width is hard to maintain to a true line and dimension. The maximum face width should be 8" (203.2 mm) unless stiffened on the backside, or when 0.093 in. (2.3 mm) or thicker material is used. As a general rule the open area of a section should not be deeper than it is wide.
- The minimum hole size to be punched in any part needs to be equal or greater than the thickness of the material being punched. Punches used for hole sizes less than the material thickness will break when punching.

## 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 projection welding are the most commonly used resistance welding methods.



**ARC WELDING**

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.

## **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 gas; helium, argon, or a combination of the two and no flux is required.

## **2. Spot Welding**

Spot welding 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. Spot welding is commonly used to fasten internal stiffeners to door face sheets, connection of closure reinforcements to door and header faces, 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 backsides of frames.



**SPOT WELDING**

## **G. MANUFACTURING TOLERANCES**

Refer to ANSI/NAAMM HMMA 841 for manufacturing tolerances as seen practical for normal applications and it is not the intent to encompass special or unusual conditions.

## **H. PRIME PAINTING**

Cold-rolled and hot-rolled steel products need a prime coat of paint at the factory with the finish paint being applied in the field, after installation, by the painting subcontractor. HMMA specifications require the primer must meet or exceed ANSI A250.10, "Test Procedures and Acceptance Criteria for Prime Painting Steel Surfaces for Steel Doors and Frames."

Prior to prime painting, a 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 as described in SSPCSP1 from The Society for Protective Coatings. 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 galvanized or phosphatized finish usually requires only a thorough detergent and water cleaning.

After appropriate metal preparation, exposed surfaces of doors and frames shall receive a rust inhibitive primer. 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 flow coating. After application, the paint may be air-dried or heat cured.

Spot weld marking is difficult or impractical for complete removal and is not considered a manufacturing defect. The markings may not be visible with a flat low gloss primer but may appear after a high gloss finish coat is applied. The use of high gloss paint will increase the show through tendencies and is not recommended. A maximum paint gloss rating of 20% reflectance, measured using a 60° gloss meter, would be standard recommendation.

The importance of proper site storage and the means of providing it are explained in, HMMA 840, "Installation and Storage of Hollow Metal Doors and Frames."



## **RECOMMENDED GUIDE SPECIFICATIONS FOR HMMA HOLLOW METAL DOORS AND FRAMES**

**HMMA 860 — Hollow Metal Door and Frames**

**ANSI/NAAMM**

**HMMA 861 — Commercial Hollow Metal Doors and Frames**

**ANSI/NAAMM**

**HMMA 862 — Commercial Security Hollow Metal Doors and Frames**

**ANSI/NAAMM**

**HMMA 863 — Detention Security Hollow Metal Doors and Frames**

**ANSI/NAAMM**

**HMMA 865 — Swinging Sound Control Hollow Metal Doors and Frames**

**ANSI/NAAMM**

**HMMA 866 — Stainless Steel Hollow Metal Doors and Frames**

**ANSI/NAAMM**

**HMMA 867 — Commercial Laminated Core Hollow Metal Doors and Frames**