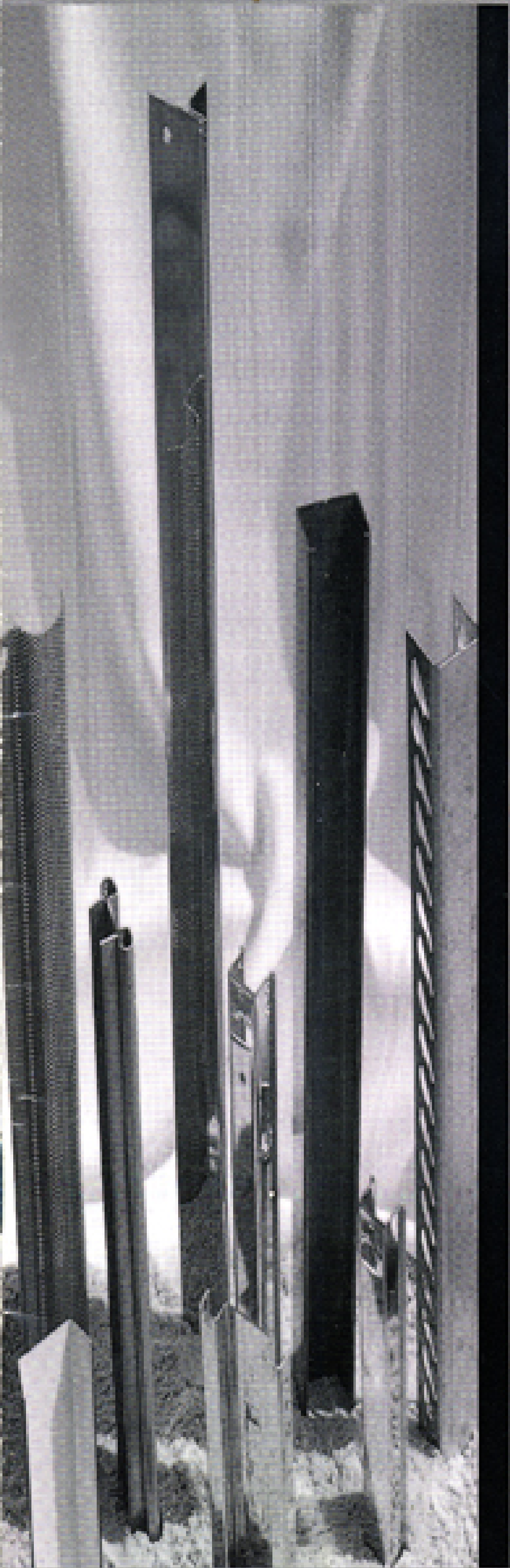

Handbook of Custom Roll Forming

This information is a summary from the Handbook of Custom Roll Forming. For more detailed information please access the entire Handbook on the web at www.metalforming.com/crfid.htm.

CRFI
CUSTOM ROLL FORMING INSTITUTE
A DIVISION OF PRECISION METALFORMING ASSOCIATION

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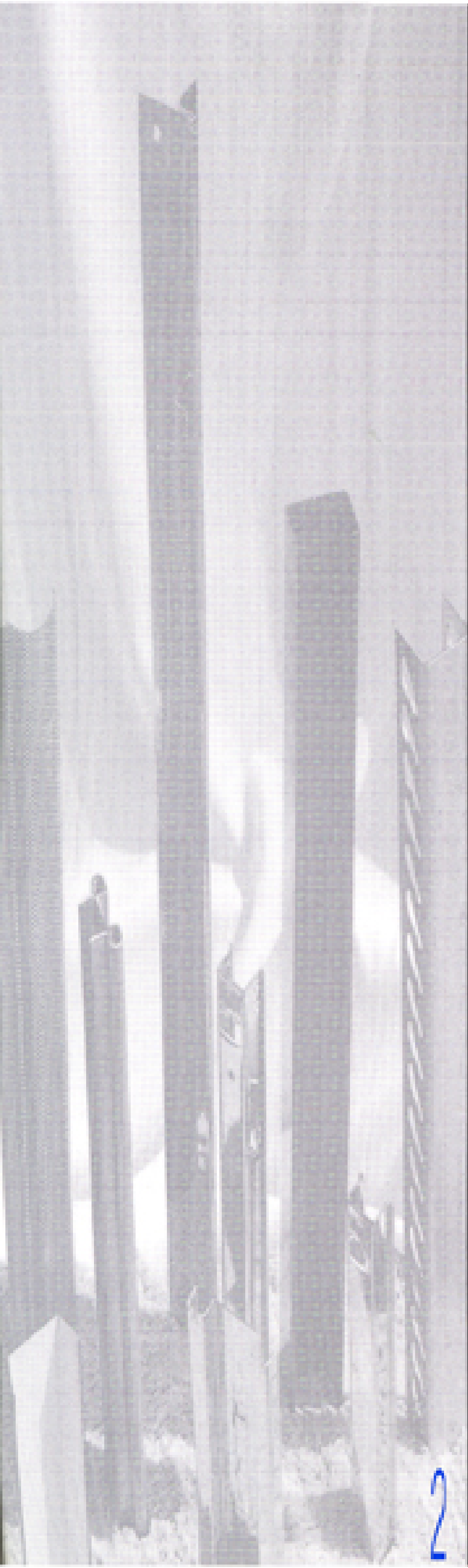


What is Roll Forming?

Roll forming is a continuous bending operation done at room temperature in which sheet or strip metal is plastically deformed along a linear axis. Tandem sets of rolls (known as roll stations) shape the metal in a series of progressive stages until the desired cross-sectional configuration is obtained. Because of the progressive manner in which the bending takes place, there is little or no change in cross-sectional area of the work-piece.

Draw a continuous line of any shape on a piece of paper. As long as the line does not cross itself, the roll forming process can probably produce that shape. Potential applications for roll formed shapes are limited only by the imagination. When designing a product, designers should not restrict their thinking. Instead, it is important to think in terms of bending metal into the functional configuration that is really needed.

As a continuous process, roll forming is ideal for producing parts with long lengths or in large quantities. Virtually any material that can be formed by sheet forming techniques can be roll formed. The process typically runs at speeds from 30 to 600 ft/min., depending on the desired configuration, tolerances required and material being formed.

By its very nature, the roll forming process produces a high quality product. It permits close tolerances for both heavy and light gauge material and provides uniform shapes and dimensions. Finished shapes have excellent surface finish and exhibit fine detail.

Some of the best applications for roll forming are large quantities of parts with constant, complex cross section. The process is ideal for producing shapes of any length.

How Can Roll Forming Solve your Problems?

- Stable, quality-oriented process
- Close tolerances
- Uniformity throughout the part
- Superior surface finish
- Part length unlimited by the process
- Production of thin wall hollow or semi-hollow shapes
- Large production volumes
- Energy efficient, requiring no process heat
- Additional operations performed in line

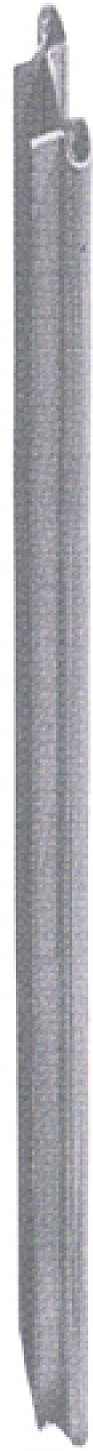
- Holes or slots where you need them
- Strength for structural rigidity
- Same tooling used for different materials
- Appropriate for any bendable material
- Simultaneous forming of two materials
- Two parts can be run together to form one assembly.

Process Evolution and Roll Forming Equipment

The draw bench was the forerunner of the modern day roll forming machine. Originally, metal blanks were pulled through stationary dies, imparting the desired contour to the part. Later these stationary dies were replaced by a series of idling rollers which progressively deformed the metal. The first generation of modern roll forming machines were being built commercially as early as 1921. Initially, they were used to form blanks that had been sheared from sheet metal. As coil material became more popular and readily available in the 1930s and 1940s, roll forming evolved into the process we know today—a continuous, high production process with driven rollers that cause the coil material to flow through the dies. Door and window frames, automobile radiator tubing, decorative trim and roof decking were among the products being roll formed by the 1940s. With improved equipment, tremendous advances in raw material, and a much better understanding of roll forming technology, the process is now being used to produce components for applications as diverse as appliances, material handling equipment and the space shuttle.

A roll forming line can typically be divided into four major parts: material entry section, roll forming machine, cutoff press, and exit section.

At the entry section of a roll forming line, material may be fed in sheet form, transferred directly from another operation (such as piercing) or more commonly, fed from a continuous coil. *Roll forming* machines generally consist of roll stations, a drive system to power the rolls and drive the material, a brake that prevents "coasting" after shutdown, and a coolant/lubricant system, to reduce tool wear and energy requirements as well as galling and material buildup on rollers. A straightener is usually located following the last set of rolls. The third major element of a roll forming line is the *cutoff* press. Due to the continuous nature of the roll forming process, flying die cutoff techniques are frequently utilized. Flying dies accelerate to the speed of the moving strip, synchronizing with the material, to perform the cutoff stroke. *The exit section* of the roll forming line is the fourth stage and as with the cutoff press, it may affect the maximum line speed. Normally the roll formed shape exits the roll forming line onto a table or roller conveyor where it is manually removed. When parts can be conveniently stacked, a drop table is often employed. Schematics of simple and complex roll forming lines are found on page 9.



Recent Trends

Computer-Aided Tooling Design is in widespread use to generate what are known as flower diagrams, depicting the anticipated flow of material through the dies. While this function has not been transferred totally to computers,

CAD/CAM roll design systems in use today can scientifically produce tooling designs for forming almost any profile. Once the number and configuration of the roll tooling stations have been mathematically defined in the computer, it is a relatively simple matter to output this information to a numerically controlled lathe, which cuts the rolls.

Programmable Logic Controllers (PLCs) and microprocessors are being utilized to help control processing on roll forming lines. More accurate measurement instruments are allowing hole placement and length tolerances to become tighter and more accurate. A single controller or monitoring system may be used to track critical conditions on multiple roll forming lines simultaneously.

Welding technology advancements have increased roll forming's capability. Shapes can be open or closed (hollow). Closed shapes have typically been produced using a lock seam to mechanically fasten the two edges. Resistance and electric induction welding are more often used today to join strip edges. Roll formers have also used laser welding for several years, but due to limited capacity and high cost of industrial lasers, it was used mostly to weld light gauge aluminum sections. With increased wattage and reduced costs, the new generation of lasers can efficiently weld aluminum, stainless steel, high strength steels and galvanized steel up to .120" thick, depending upon the weld penetration required and production speed. Lasers can have many advantages over TIG, high frequency, and other types of welding. Each project needs to be evaluated for the best manufacturing process.

Tool material improvements have increased and improved roll life.

Improved changeover techniques for tooling and cutoff dies have allowed for smaller batch sizes to be processed more economically and rapidly to meet customers' Just-in-Time requirements.

Value-Added Services are particularly suited to roll forming operations. Secondary operations can often be incorporated in-line eliminating unnecessary handling and reducing cost. What can't be done in line can be done after the shape is formed. Custom roll formers can perform hole punching, bending, cutting, parts cleaning, welding and joining, finishing, assembly and fabrication, buffing, polishing, deburring, and even heat treating, if necessary.

Attributes

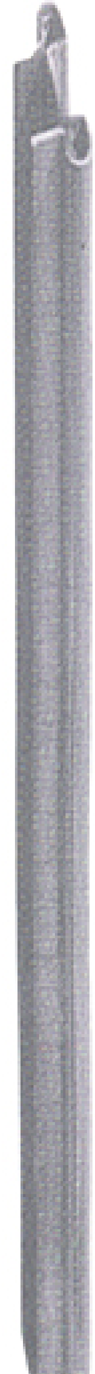
Uniformity of roll formed shapes allows them to be easily bent. When producing rings or segments of rings, shapes can be curved to uniform radii at the rolling machine without wrinkles and without disturbing a pre-finished surface. Helices are also possible. Material elongation should be considered in designing parts for rings to help eliminate wrinkles and fractures. Usually, the more elongation a material has, the easier it is to bend. Where curves are not a constant radius, the uniformity of roll formed shapes makes them ideal for stretching or tangent bending.

Prepiercing is the fabrication of a series or pattern of holes in the flat strip stock before forming. It is done in one continuous operation together with roll forming and, therefore, can be a cost saver. Repetitive piercing, as in wallboard plaster bead or shelf posts, will minimize the piercing tool cost because a small die can be used.

Postpiercing is done in-line but after the part is formed. It is part of a sequence of operations performed without handling and thus is very efficient. Often this is less expensive and more desirable than prepiercing because better accuracy from the end of the part can be obtained.

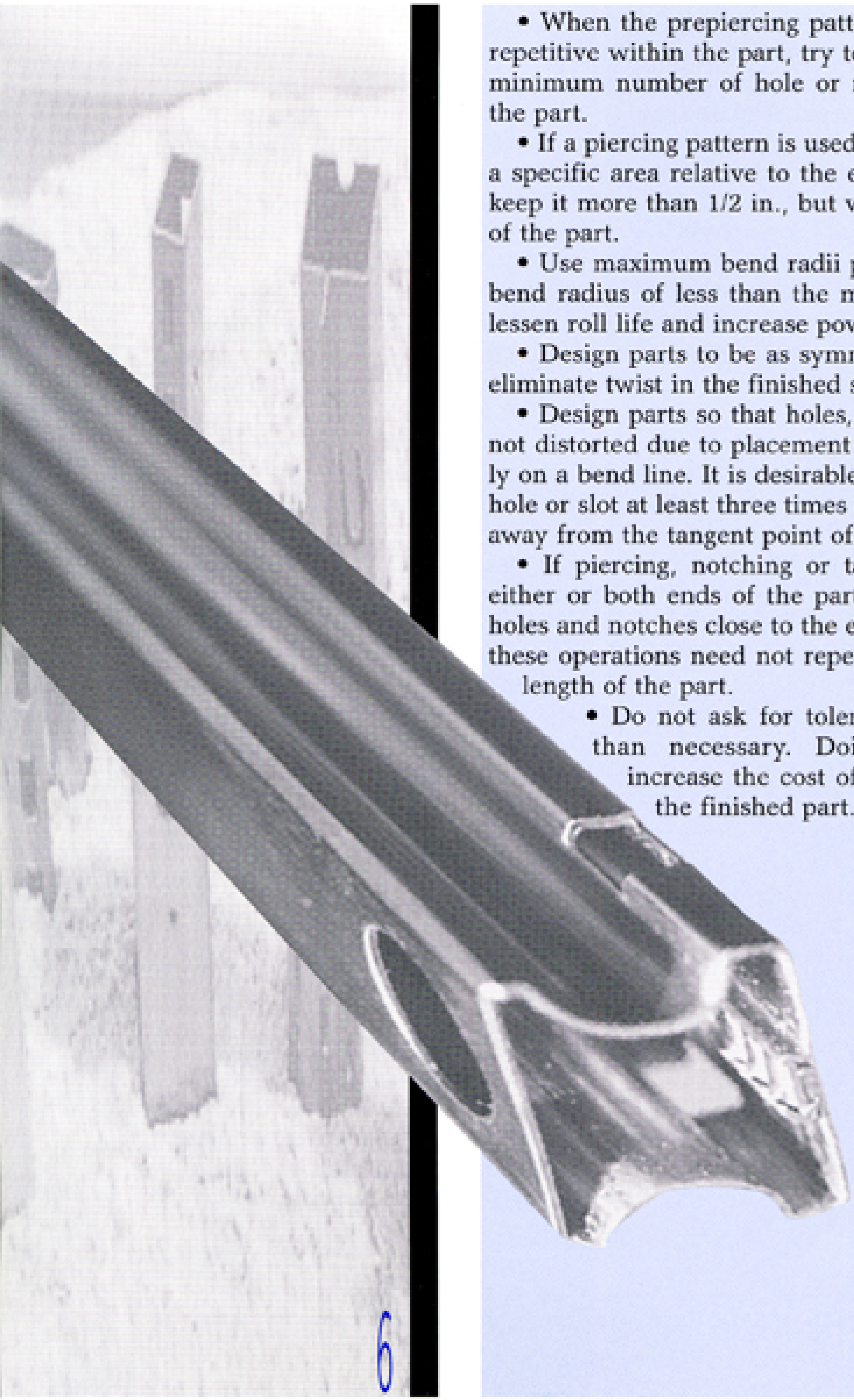
Welded dimples or projections can be formed while the parts are being rolled to improve accuracy and economy in the finished part. Tabs, stops and raised areas can also be formed.

Almost any *material* available as coil or sheet can be roll formed. The material should be as ductile as design strength will allow to permit crisp, sharp corners and easy bending. When high-strength alloy steels, heat-resistant steels, titanium and other alloys are used, bend radii specified by the mill should be followed.



Designing for Economy

- Roll formed shapes should not be too deep. Profiles that are deep require larger diameter forming rolls that are more expensive and require larger machines. One rule-of-thumb for average size machines is that maximum form depth should be four inches. Greater depths are also available but require the use of larger machines and more expensive tooling.
- Parts should have uniform thickness throughout since the raw stock is sheet or strip. Thickness may be increased by folding the material back on itself.
- If wide, flat areas are required at the edge of a part, consider using small stiffening ribs. The part will stay flatter and be much stronger.
- When planning a leg, as with an angle or channel, the length of the leg should not be less that three times the material thickness (3T) past the tangent point. Legs shorter than 3T are difficult to form because it is hard to get enough leverage to bend the leg up. This also applies when hemming or bending the material back on itself.
- To plan prepiercing where hole location is not critical, design the pattern to be repetitive without specifying the location of the beginning of the pattern from the end of the part.



• When the prepiercing pattern is critical and not repetitive within the part, try to design it to have the minimum number of hole or notch patterns within the part.

• If a piercing pattern is used that requires holes in a specific area relative to the end of the part, try to keep it more than 1/2 in., but within 4 in. of the end of the part.

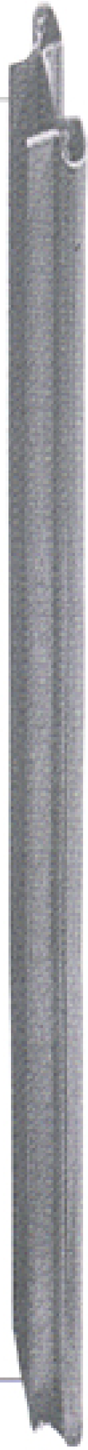
• Use maximum bend radii permissible. An inside bend radius of less than the material thickness will lessen roll life and increase power requirements.

• Design parts to be as symmetrical as possible to eliminate twist in the finished shape.

• Design parts so that holes, slots and notches are not distorted due to placement too close to or directly on a bend line. It is desirable to have the edge of a hole or slot at least three times the material thickness away from the tangent point of the nearest bend.

• If piercing, notching or tabbing is required at either or both ends of the part, keep the pattern of holes and notches close to the end of the part, so that these operations need not repeat throughout the full length of the part.

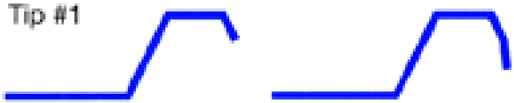
• Do not ask for tolerances that are closer than necessary. Doing so will greatly increase the cost of both the tooling and the finished part.



Roll Forming Design Tips

Instead of this... **Try this**

Tip #1

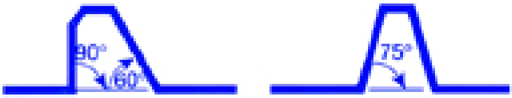


Legs, such as this one on the outside of metal building panel stock, when rolled straight, will be wavy. A slight bend designed into the leg will help keep it flat.

Tip #2

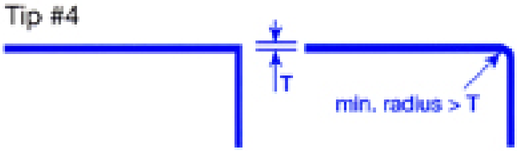
When roll formed, the flat 180° hem will be wavy. Forming the hem in a tear drop shape will keep the edge flat.

Tip #3



Forming a 90° sidewall adds more forming passes, increases roll wear and may result in tooling marks on the leg. Leaving sufficient draft, as with a 75° angle, reduces the number of roll stations needed to form the shape and should prevent scoring of the workpiece.

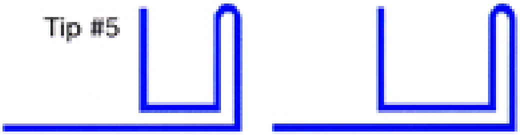
Tip #4



Sharp inside radii are difficult to form without marking the outside radius or causing cracks in prepainted materials or materials with poor ductility. A larger radius reduces this problem. If sharp corners are necessary, they can be achieved by beading thin stock or grooving thick stock.

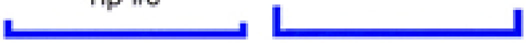
Instead of this... **Try this**

Tip #5



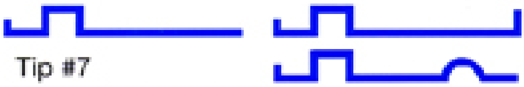
Narrow slot designs can lead to roll breakage. A wider slot design will alleviate the problem.

Tip #6



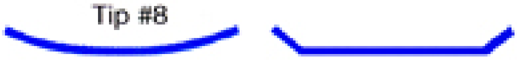
Extremely short legs can be difficult to form. Design leg length to be at least three times material thickness past the tangent point.

Tip #7



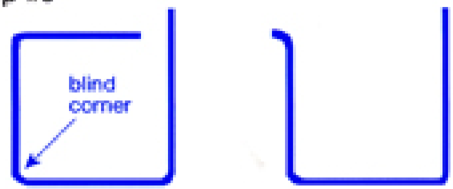
Adding a bead or a leg to wide flat areas will help maintain straightness and avoid the tendency toward waviness or other irregularities.

Tip #8



Wide sweeping radii may be difficult to control when the material is not formed beyond its elastic limit. Put a bend in each end to keep it straight.

Tip #9



Blind corners are less accurate and more difficult to control because roll tooling cannot contact both sides of the stock. If close tolerances or precise bends are required, try a design in which both sides of the stock can be controlled by rolls.

PMA

Materials

Virtually any bendable metal or material can be rollformed. Following is a list of many of the metals being roll formed today. Some metals that could be roll formed, such as tool steel, are not included on this list because they are not readily available in coil or sheet form.

Aluminum—common and heat treatable alloys

Brass   Bronze

Bi-metals   Bi-materials

Two metals rolled simultaneously—such as rolling thin stainless tubes on the outside of thicker carbon tubes to take advantage of the low cost and high strength of carbon steel and the attractive appearance of stainless

Coated metals—clad, galvanized, prefinished, pre-plated, prepainted, vinyl laminated, tin plated

Coated alloys - for aerospace, petrochemical and military applications

Composites

Copper and copper alloys

Exotic alloys - niobium, tantalum, zirconium

High temperature alloys such as Hastelloy, Inconel and heat resistant nickel-based alloys

Lead   Magnesium alloys

Nickel alloys   Precious metals

Steel—carbon, alloy and stainless, HSLA, cold rolled, hot rolled, all commercial quality steel, aluminized steel

Tin alloys   Titanium   Zinc

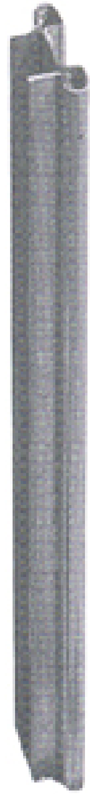
Tolerances for Roll formed Shapes

Dimensional variations in roll formed parts are based on material, equipment and application. Tolerances vary due to material springback, variations in material width and thickness, material properties, tooling quality and wear, machine condition and setup, and operator skill.

Whenever possible supply a sample assembly drawing to illustrate the end use of the part and areas where tighter tolerances are required. The drawing of the shape should become part of the purchase order once an agreement is reached with the roll former.

While the greatest economies are usually realized when specified tolerances are as generous as possible, tolerances tighter than those cited below are routinely achieved. Often dimensional problems can be avoided by ordering the material to be formed with somewhat tighter than commercial quality tolerances.

The following tolerances are given as general guidelines only. Far tighter tolerances are possible but may add to the cost due to greater tooling expense, longer development time, or the need for a higher grade material. If more restrictive tolerances are required the designer should clearly define them and discuss them with the custom roll formed shape producer.



Tolerances

Cross-sectional

±0.031 in. for fractional dimensions
±0.010 in. for decimal dimensions
±1° for angular dimensions

Straightness (bow or camber)

0.015 in. maximum deviation per ft. of length

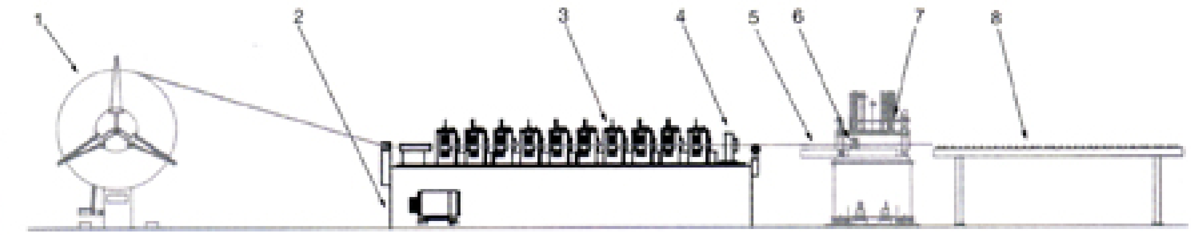
Twist

1/2° maximum deviation per ft. of length

Length

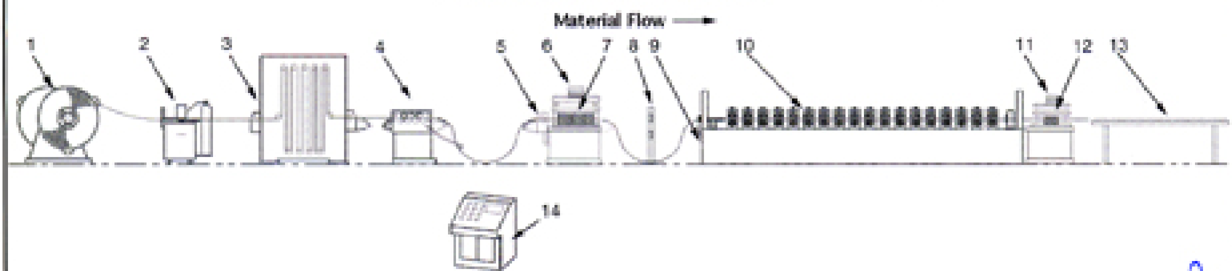
±0.015 in. for parts up to 36 in. long
±0.030 in. for parts from 36 to 96 in. long
±0.060 in. for parts from 96 to 144 in. long
±0.250 in. for parts longer than 144 in. long

Simple Roll Forming Line



1 Uncoiler 2 Forming Mill 3 Roll Tooling 4 Straightener 5 Die Accelerator 6 Cutoff Die 7 Cutoff Press 8 Runout Table

Complex Roll Forming Line



1 Uncoiler, double-end
2 Shear End Welder
3 Accumulator
4 Powered coil straightener
5 Servo-driven Roll Feed
6 Hydraulic Pre-notch/ Punch Press
7 Pre-punch/Notch Dies
8 Loop Control System
9 Roll Forming Mill
10 Roll Tooling
11 Hydraulic Cut-off Press
12 Cut-off Die
13 Run Out Table
14 Control Panel

Drawings courtesy of Roll-Kraft/Ardcor

APPLICATIONS FOR ROLL FORMED SHAPES

Roll formed shapes are formed in material 0.005 in. thick, weighing ounces, to 3/4 in. thick sections as long as 100 ft. or more that weigh in at over a ton. End use applications for roll formed shapes are numerous and diverse.

The degree to which roll formed shapes have become integral to almost every industry is illustrated by the following list of end use applications. By no means is this list all-inclusive. It is however representative of some of the many areas in which shapes are being used today. In spite of the numerous applications detailed below, the most innovative use of roll formed shapes has yet to be discovered, but is still locked in the imagination of the designer.

Agriculture

Grain bin floors, chicken roosts, trim and structural shapes for tractors and other farm equipment, fence posts, grape arbor stakes, lawn and garden equipment components.

Aircraft/Aerospace

Airframe stringers and longerons, interior components such as trim and window frames, stiffeners and jet engine components such as honeycomb seals, shrouds and backing rings, leading edges of composite helicopter blades.

Appliance

Panels for refrigerators, stoves, microwave ovens, laundry and vending machines; refrigerator shelves, shell fronts and ladder supports, door seal retainers, appliance handles, control panel trim, decorative trim, drawer slides for ovens and trash compactors, structural components for appliances.

Building products

Bleacher sections, interior supports for window reinforcements, sliding door and window tracks, elevator interiors and trim, escalator components, curtain wall sections and window frames, slatted wall dividers and studs, residential steel framing, metal roof decks and siding panels, decorative interior components, gutters and down spouts.

Bridge & highway products

Road signs, highway guardrail, bridge deck reinforcement panels.

Heating, ventilating & air conditioning

Electric heater housings, air conditioner cases, HVAC ducts, pattern control diffusers, air filter frames, cooling tower louvers, solar collector panel components.

Home, office & store furniture and fixtures:

Indoor and outdoor furniture, hardware accessories, modular and sliding partitions, work surface reinforcements, shelves, drawer fronts and slides, kitchen and file cabinets, lighting fixtures, metal picture frames, decorative trim, department store display racks and cases, trim for frozen food cases, store fixtures and supermarket shelving.

Transportation

Components used in automobiles, trucks, buses, trailers, subways, ships and boats; vehicle trim and grill members, window tracks, bumpers, division bars, reinforcement bars, structural components, bus and subway car hand rails, truck trailer and railroad car structural members.

The material in this section was compiled with the assistance of members of the Custom Roll Forming Institute (CRFI) Division of the Precision Metalforming Association (PMA). For more information on the roll forming process, contact PMA in Cleveland, OH at: 216-901-8800, or visit the website at www.metalforming.com/crfid.htm.