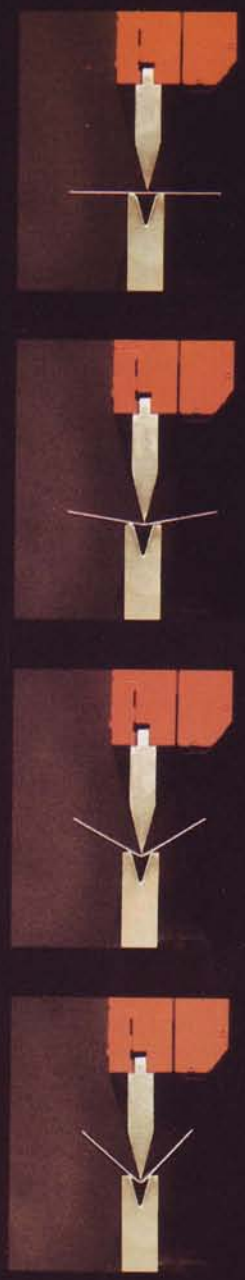
PT-50691

CINCINNATI®

PRESS BRAKE CAPACITIES



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Safety

Good safety practices and proper training of each press brake operator is mandatory. Comprehensive operator, maintenance and safety manuals provide instruction on proper procedures and safety methods and should be with the press brake at all times. Warning signs and a checklist of operator safety guidelines should be placed at strategic locations on the press brake.

Users are responsible for proper installation and continued use of point-of-operation safeguarding and other machine guards. This helps assure operator safety and compliance with OSHA requirements.

Each new CINCINNATI press brake displays a tag showing that it meets ANSI B11.3 construction requirements. A copy of this standard, which covers the proper care and use of press brakes, is included to help users with their safety programs. Refer to the Safety Manuals, Press Brake Safeguarding Bulletin PI50686, ANSI B11.3 Safety Standards or consult Cincinnati Incorporated for further information.

Bending on a CINCINNATI Press Brake

Press Brake Rating

All CINCINNATI press brakes are rated for a maximum bending pressure, or tonnage. Tonnage can then be converted into bending capacities through an understanding of basic factors affecting the formability of metal. Bending factors, or "rules of thumb", for press brake forming are based on using mild steel (60,000 psi maximum tensile strength). An explanation of these factors will help you understand the performance of your press brake and the mild steel air bend capacity charts presented in this booklet.

Vee Die Opening and Inside Radius

The recommended vee die opening for mild steel up to 1/2" (.500") thick is eight times the metal thickness. For thicker than 1/2" mild steel, it may be necessary to increase the vee die opening up to ten times the material thickness to minimize cracking of the material. To determine the vee opening for a simple 90° bend, multiply the metal thickness by eight. The answer is then rounded to the next higher 1/8" figure. For example: 14 ga. (.075") x 8 = .600". This is rounded to a 5/8" vee opening.

The inside radius of a bend in mild steel is about 5/32" (.156") x the vee die opening regardless of the gauge of metal being formed. This figure was determined by measuring formed samples bent over various die openings. To illustrate: If a 1/8" (.125") sheet and a 1/4" (.250") plate are formed over a 2" vee die, each will have the same inside radius of approximately 5/16" (.312").

Springback

Metal formed by an upper and lower die as shown in Figure 1 only has three points of contact. If metal is pushed into a lower die sufficient to form a specific angle, when the force is released, the angle will open up due to springback. Normal springback for mild steel is 2° to 4°. If the material is hard, has a higher tensile strength, or a larger than normal inside radius, the springback will be greater.

Air Bending (Figure 1)

Air bending metal into a straight line angle is the most common form of press brake work. A top, or upper die, pushes the metal into a lower vee die. The metal only touches the point of contact of the upper die nose and the two edges of the lower vee die (Figure 1). The material does not contact any other part of the tooling during the forming cycle.

Most "air bend" tools are manufactured so that the upper and lower dies have the same angle. This is done to minimize set-up time. In order to obtain a true 90° air bend, the tooling must be cut to allow sufficient springback to attain a 90° bend. In most cases, the angle cut on the dies will be between 30° to 85°. For air bending, the nose radius of the upper die should be equal to or slightly less than one metal thickness using simple fractions.

Note: *If parts are to be formed with air bend dies on a press brake with computer control to determine ram reversal positions, the dies must be cut to an angle that will compensate for all possible material springback.*

Bottom Bending

Bottom bending material with dies cut to approximately the finished angle (e.g. 88°, 89° or 90°) will increase the forming tonnage. The reason for "true" bottoming and coining is to "set" the material in order to overcome springback and obtain better angular accuracy (see Figures 3 and 4). Bottoming is often selected when forming boxes or panels. Minimizing the overbending keeps the final bends from hitting the previously formed flanges and causing distortion. Potentially smaller inside radii may also be achieved using the coining process. There are three different types of forming which are classified as "bottom" bending: bottoming with spring back, true bottoming and coining.

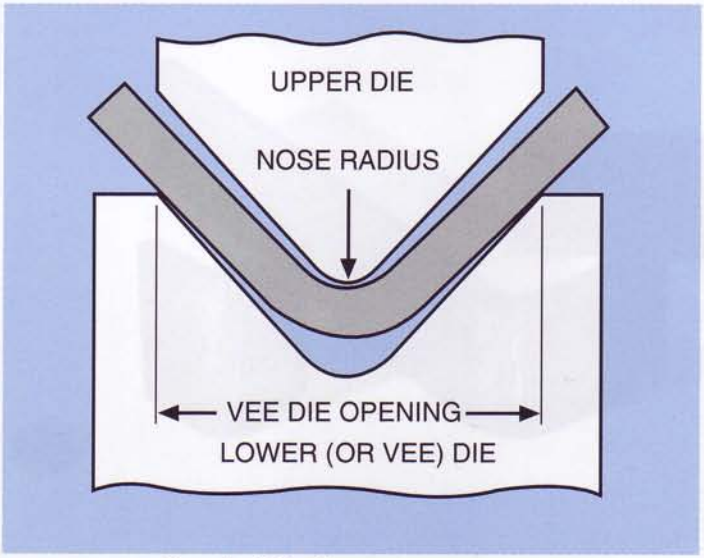


Figure 1–Air Bending

Bottoming with Springback (Figure 2)

Bottoming with springback is not considered "true" bottoming. When metal is pushed into recommended tooling, it will form an inside radius that is equivalent to the 5/32 x vee die opening rule. Pressure is then built up at the bottom of the stroke causing the formed metal to "kink" in the inside radius area. This causes the legs of the formed metal to

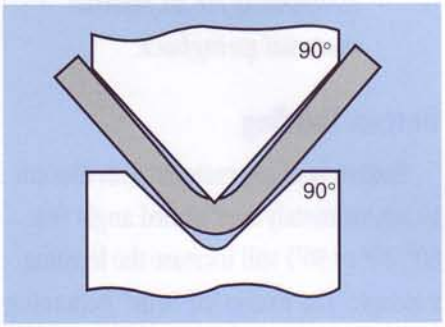


Figure 2–Overbending during forming operation

overbend enough to touch the corners of the upper die (Figure 2). The force buildup will be about 1 1/2 to 2 1/2 times the tonnage required for air bending. When the forming pressure is released, the part may spring back to the desired angle. The angular consistency of this method is dependent on uniform material thickness. Normally, angular tolerances are similar to air bending.

True Bottoming (Figure 3)

When the upper die is made with a radius of one metal thickness (to the closest simple fraction), sufficient tonnage must be built up at the bottom of the stroke to "set" the metal and eliminate spring back. The required tonnage will range from three to five times the normal air bend tonnage.

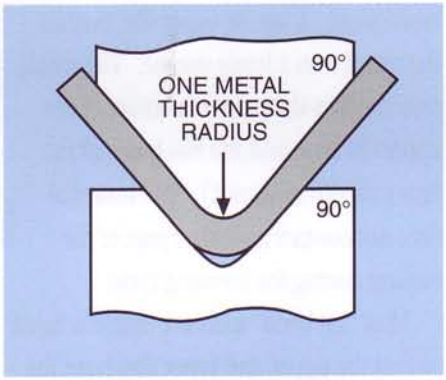


Figure 3–Bottoming

Coining (Figure 4)

When the upper die is made with less than one metal thickness radius, the nose of the die will embed into the metal causing an apparent overbend condition. In order to push the upper die into the metal far enough to obtain the desired inside radius and bend angle, the required tonnage will be at least five times the air bend tonnage. If the desired inside radius is one-half the metal thickness or less, the forming load could approach ten times the tonnage shown on the air bend chart. When the top die embeds, or displaces metal, in order to obtain a sharper than one metal thickness inside radius, the term "coining" is applied.

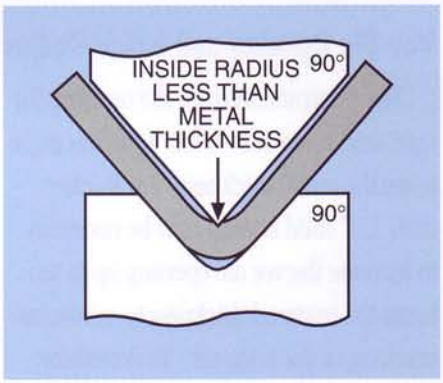
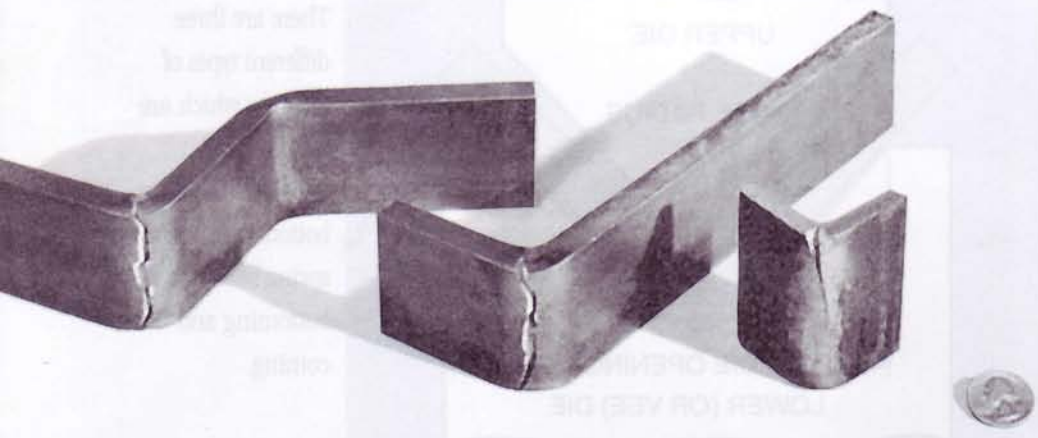


Figure 4–Coining



Cracking

When forming plate, "cracking" can be erratic. Small flanges can often be formed whereas making the same bend in the center of the sheet will cause failure. Differences will also be found when bending across the grain versus bending with the grain. Cracking is often minimized by increasing the nose radius of the upper die.

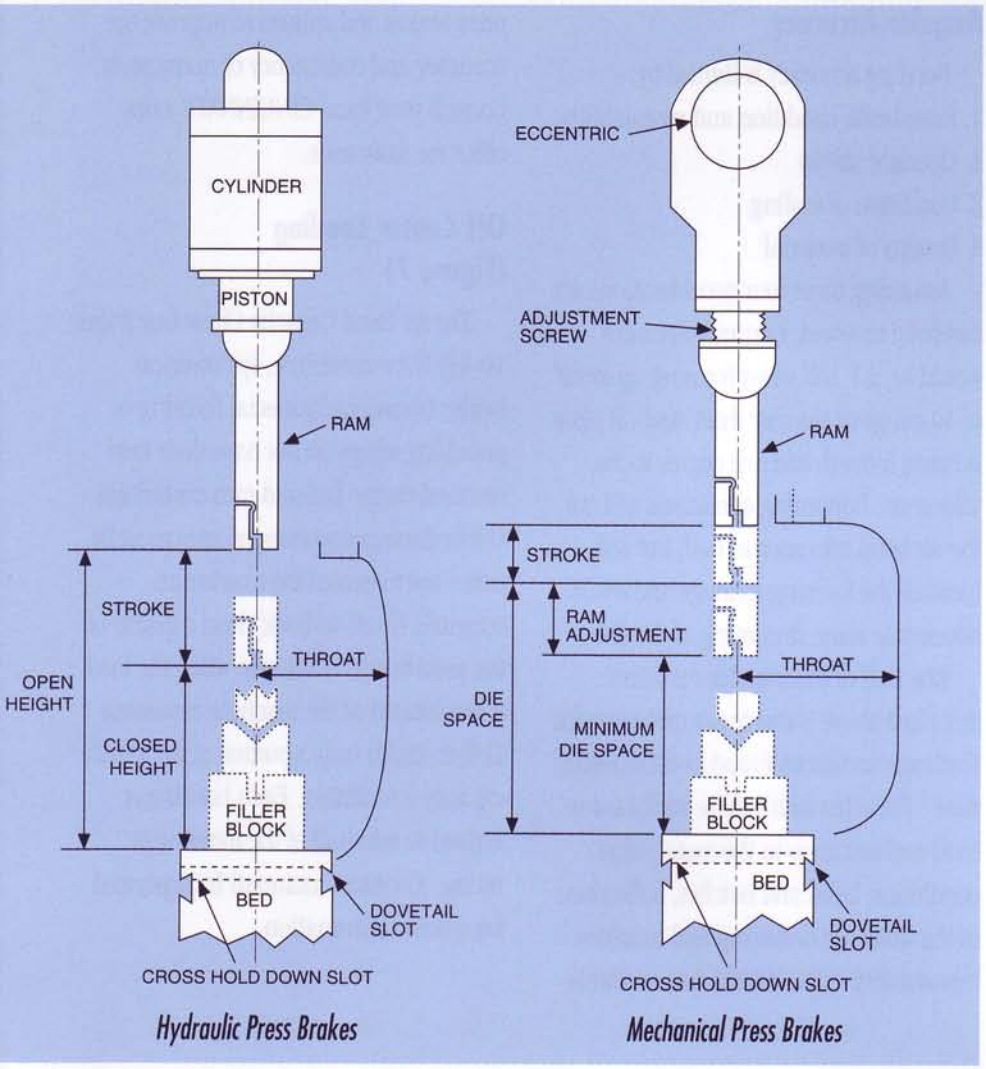


Figure 5—Die Space

Die Space (Figure 5)

Always total the height of the press brake dies and the height of the filler block (die holder) to make sure the tooling will fit into the available die space. For complete information on "die height selection", request current literature from Cincinnati Incorporated.

Die Alignment (Figure 6)

In order to obtain good accuracy in press brake forming, the tooling must be aligned so that the nose of the upper die is as central to the lower vee die as possible. With most press brakes, many bends could be made with an alignment accuracy of ±1/64" around the centerline of the vee opening.

Press brakes featuring computerized controls that allow the operator to input a specific bend angle depend on mathematical models to obtain good

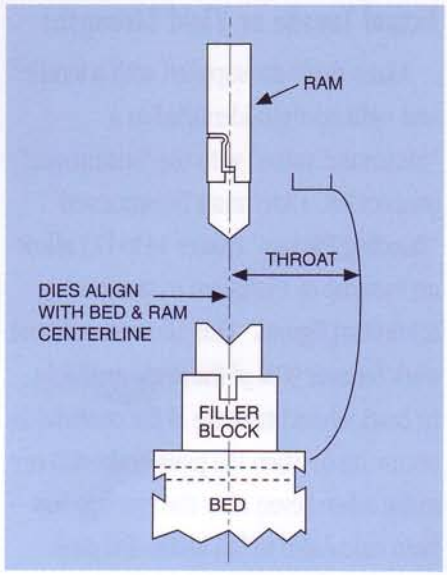


Figure 6—Die Alignment

consistency. If the dies are not closely aligned to the tooling centerline, inaccuracies can occur. As a result, it is important to evaluate the available tooling with respect to the type of press brake being used in order to obtain the best possible forming angles. Vee dies with a 5/8" vee opening or less may require a ±.005" alignment to obtain good consistency.

Bend Allowance

In order to determine the proper blank size prior to forming a part on a press brake, a bend allowance for each bend must be determined. This information has been made available through many engineering textbooks but the information provided is not consistent. If questions arise concerning a blank development for your part, CINCINNATI has available a bend allowance chart which may be helpful. Contact your CINCINNATI representative to obtain more information.

Actual Tensile or Yield Strengths

Many steels are supplied with a tensile and yield strength identified as a "minimum value" with the "maximum" unspecified. Cincinnati Incorporated "Bending Factors" (pages 14 to 17) allow an increase of 15,000 psi in steels using minimum figures. This allowance should work for over 90% of the steels available. In cases where breakage of the material is occurring or when the press brake will not make a bend even after the tonnage has been calculated to fall within the press brake capacity, the material should be tested to identify the actual tensile and yield strengths.

Forming High Tensile Steels

High tensile steels (70,000 psi or higher) do not react like mild steel. The material may form to the radius of the upper die. In this case, the nose radius of the die should conform to the steel manufacturer's recommendations. A larger vee opening may be required to obtain acceptable tonnages and angular accuracy. See "Bending Factors" chart on pages 14 to 17 for typical recommendations.

Note: *Stainless steels usually react similar to mild steel.*

Bending Factor Determination

"Bending Factors" are obtained by relating the actual tensile and yield strengths of the steel being formed to those of mild steel. Consideration has been given in Cincinnati Incorporated's "Bending Factors" chart to allow for increasing the inside radius of the plate if required to eliminate cracking.

Angular Accuracy

Bending accuracy is limited by:

1. Press brake condition and repeatability
2. Operator ability
3. Condition of tooling
4. Quality of material

Assuming these four considerations are carefully reviewed, normal tolerances would be ±1 1/2° when forming up to 10' of 10 gauge or thinner sheet steel. If plate is being formed, add one degree to the tolerance. Bottoming operations will cut the air bend tolerance in half, but will increase the forming tonnage and could necessitate some shimming of the dies.

One half of the angular variation described above is due to normal material thickness variations found in commercial steel. The other half can be attributed to hard and soft spots in the metal, edge conditions, holes and notches, deflections in the machine or tooling and machine repeatability. CINCINNATI has available press brakes and options to improve the accuracy and consistency of many parts. Consult your local CINCINNATI sales office for assistance.

Off Center Loading (Figure 7)

The Air Bend Capacity Chart (see pages 10-13) is for centerline, symmetrical loads. Occasionally special forming or punching setups do not have their load centered on the bed and ram centerlines. Under these circumstances, care must be taken not to exceed the maximum eccentric (front-to-back) load capacity of the press brake. Similarly, when the load is not located at the machine centerline (left-to-right) only a portion of full rated capacity is available. Each housing is limited to one-half of the maximum rating. Contact Cincinnati Incorporated for specific information.

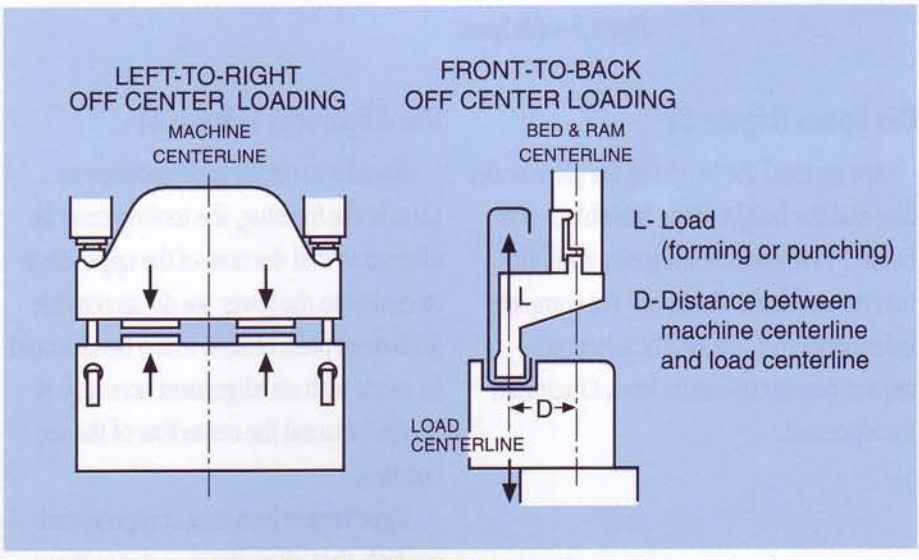


Figure 7—Off Center Loading

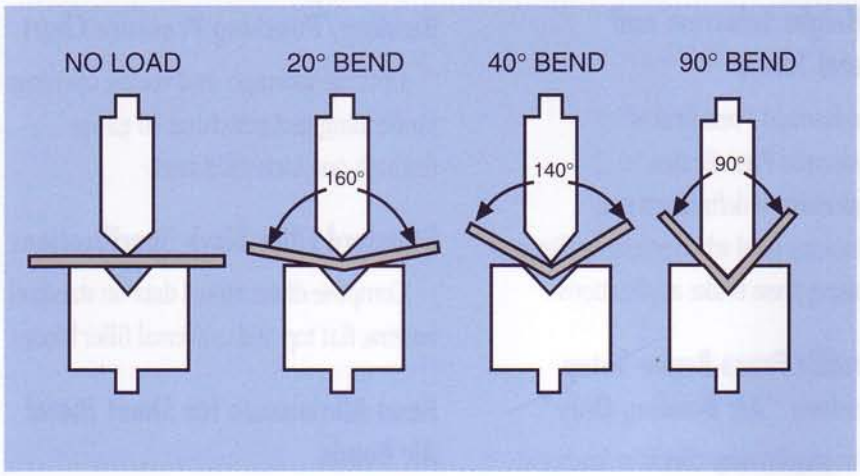


Figure 8—Tonnage Build-Up

Tonnage Build-Up (Figure 8)

When making a 90° air bend, the load increases very rapidly, reaching 85% of maximum when the metal is bent 20° (10° per side). Maximum tonnage is reached when the metal is bent a total of 40°. The load drops off a few percent when the metal is bent to 90°.

Shimming (Figure 9)

To compensate for bed and ram deflection, as well as uneven wear on the press brake and tooling, shimming of the tooling may be required to obtain a uniform bend. All shimming should be done with a good quality steel (not brass) shim stock. In some cases, paper can be used. Keep all surfaces free from dirt or nicks since forming accuracy can be affected by poor work habits.

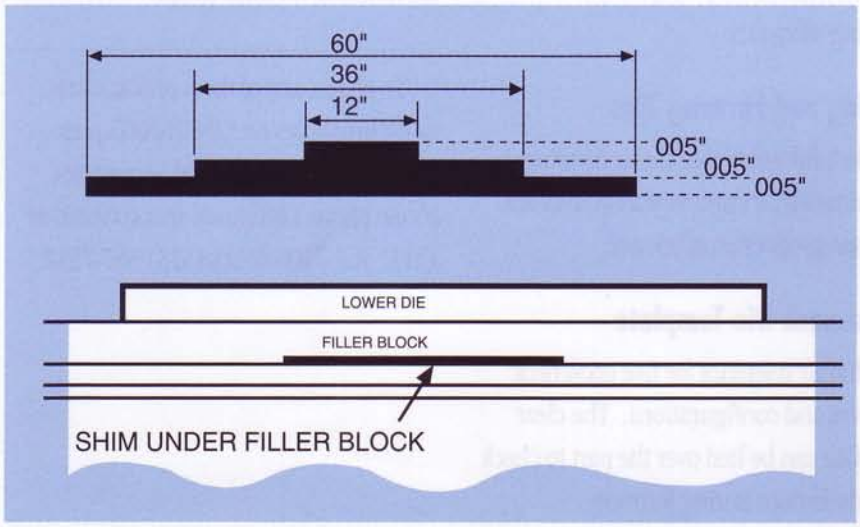


Figure 9—Typical Shimming Configuration

Gaging

In order to obtain good consistency during the forming operation, the gaging sequence must be evaluated prior to parts being formed. The availability of CNC gaging, manually set front and back gaging or gages mounted to the lower die all must be reviewed to determine the best method.

Note: Remember that gaging determines the position of the bend. Angular accuracy is determined by the method of forming.

Marking

General purpose vee dies sometimes cause marks on polished stainless, aluminum or painted stock. Marking can be minimized by:

1. Increasing the corner radius at the top of the vee die opening,
2. Polishing the entire vee die opening,
3. Hardening the corners of the larger lead-in radii.

In some cases, tape or die coverings can be used. Plastic coating on stainless steel may give inconsistent results in the reduction of die marks. Contact your CINCINNATI representative for additional information.

Note: *Sectionalizing the lower die often results in objectionable marking.*

CINCINNATI Forming Publications

The following brochures and technical data sheets provide helpful information on the most effective techniques for safe and efficient press brake operation.

Press Brake Safeguarding—Suggestions for Owners and Their Employees

Required reading for all press brake users, this booklet illustrates recommended safeguarding devices and proper methods for safe operation. It also lists other suppliers of safety devices.

Operation, Safety and Maintenance Manuals

- 4 Series through 50 Series Mechanical Press Brakes
- CB Press Brake
- CB II Press Brake
- Form Master Press Brake
- Form Master II CNC Press Brake
- AUTOSHAPE® CNC Forming Center
- AUTOFORM® CNC Forming Center

Complete guides to the installation, setup, operation, adjustment and maintenance of each CINCINNATI press brake model line. They include bending fundamentals, basic safety procedures and proper gaging methods.

Die Height Selection and General Terms

- Mechanical Press Brakes
- Hydraulic Press Brakes

A glossary of definitions and terminology used when selecting dies and discussing press brake applications.

Hydraulic Press Brake Setup Procedure "Air Bending Only"

This step-by-step checklist leads the operator through the proper setup procedure for air bending.

Basic Punching Rules on Press Brakes

Fundamental steps to follow for safe and efficient punching.

Improving Part Quality and Productivity: How Advanced Press Brake Technology Can Help

An overview of bending techniques and use of the latest press brake technology to achieve maximum part quality and forming efficiency.

Gaging and Forming Tips

A helpful guide that shows bending techniques that improve part quality and increase production efficiency.

Gooseneck Die Template

A handy reference for five gooseneck die sizes and configurations. The clear template can be laid over the part to check for interference during forming.

Bending/Punching Pressure Chart

Optimal tonnages and vee die openings for bending and punching 20 gauge through one inch mild steel.

Standard Filler Block Specifications

Complete dimensional data on standard narrow, flat top and universal filler blocks.

Bend Allowances for Sheet Metal Air Bends

This chart shows 90° bend allowance for 23 gauge through 5/8" mild steel, based on recommended vee die width, upper die radius and theoretical bend radius.

Major Conditions Causing Excessive Bow

A detailed explanation of the various stresses which cause bow in formed parts.

Minimizing Die Marks on Quality Bends

Provides 13 steps that aid in reducing die marking on sheet metal.

To obtain any of these publications, or for brochures on CINCINNATI press brake models, die sets and accessories, please phone Cincinnati Incorporated at (513) 367-7100 or fax (513) 367-7552.

Press Brake Bending Capacity

Air Bend Capacity Chart

The Air Bend Capacity Chart (pages 10-13) lists the press brake bending capacities in linear feet of mild steel for different metal thicknesses when air bending only. The shaded area indicates the recommended vee die opening for each metal thickness. The nominal bending force in tons/foot (1 ton = 2000 lbs.) is listed in the third column. All capacities are listed for mild steel with a maximum tensile strength of 60,000 psi and a maximum yield strength of 40,000 psi. Nominal material variation allowances have been made for all capacity ratings. For materials other than mild steel, refer to the "Bending Factors" chart (pages 14 to 17) for the proper formability factor.

Bending Factors Chart

When material other than mild steel is to be formed , the required forming tonnage will probably change. The "Bending Factors" chart (pages 14 to 17) offers a wide selection of ASTM numbers, their recommended upper die nose radii and vee die openings. The equivalent length of any special material which can be formed on a given press brake is calculated by dividing the mild steel capacity by the formability factor. This formability factor is shown in the far right hand column.

Steel Cross Reference Chart

This chart (pages 18 & 19) is provided to cross-index manufacturers' trade names with the proper ASTM specification. For names or classifications not listed, contact Cincinnati Incorporated for assistance.

How to Use the Charts

1. Determine the maximum length of 1/4" (.250") mild steel a 5 Series press brake can air bend using the recommended vee die opening (8 x metal thickness).
   Step 1: Locate .250" thickness in the first column on the Air Bend Capacity Chart (page 10).
   Step 2: Follow the recommended 2.00" vee die opening shaded line over to the intersecting vertical line for standard 5 Series mechanical press brake. Read maximum length of six feet. A 5 Series AC is listed at eight feet of bending capacity provided it is used at low speed.
2. Determine air bending capacity of a 230 ton hydraulic press brake when bending 1/4" (.250") thick Cor-Ten A.
   Step 1: Refer to "Steel Cross Reference Chart" (page 18) to find proper ASTM specification number. Select ASTM A242 for Cor-Ten A plate.
   Step 2: Refer to ASTM A242 on Bending Factors Chart (page 14) to determine recommended vee die opening for 1/4" plate. 12T= 12 x .250" = 3.00".
   Step 3: Determine the proper formability factor for A242 from the Bending Factors chart (page 14)—1.7.
   Step 4: Determine the bending capacity for a 230 ton hydraulic press brake when forming .250" mild steel over 3.00" vee die opening by using the Air Bend Capacity Chart (page 11)—21'.7.
   Step 5: Divide the maximum air bend capacity (Step 4) by the formability factor (Step 3) 21.7'/1.7 = 12.8 feet.
3. Select the proper size press brake to air bend 12' of 3/8" (.375") thick A36 steel with a maximum yield strength of 45,000 psi.
   Step 1: Determine the nominal vee die opening for A36 from the Bending Factors Chart (page 14)—8T = 8 x .375" = 3.00".
   Step 2: Determine the formability factor for A36 (maximum yield strength of 45,000 psi) from the Bending Factors Chart (page 14)—1.3.
   Step 3: Determine the equivalent length of mild steel by multiplying the material length times the formability factor—12' x 1.3 = 15. 6'.
   Step 4: Determine the smallest press brake that can be used from the Air Bend Capacity Chart (pages 12 and 13) by selecting the first press brake, mechanical or hydraulic, which exceeds 15.6' capacity for .375" thick material over a 3.00" vee die. A 21 Series mechanical (21.0') or 500 ton hydraulic (17.7') press brake will form this material.
4. Always check the tons per foot of force required to form mild steel with the available press brake tooling. This information can be used for designing tools and determining the unit pressure loading on the bed and ram, which must not exceed 15 tons/in.^{2} (1 ton = 2000 lbs.).

Caution: *The Air Bend Capacity Chart does not apply to non-standard stroke mechanical press brakes. Consult the factory on these applications.*

MILD STEEL AIR BEND CAPACITY CHART

MILD STEEL THICK. NOMINAL INCHES	VEE DIE OPENING NOMINAL INCHES	TONS (2000 LB) PER FOOT	LINEAR FEET — MECHANICAL PRESS BRAKES-STANDARD STROKE ONLY												
			5	5AC	9	9AC	12	12AC	13	13AC	21	34	36	50	*
			90/135	90/135	150/225	150/225	200/300	200/300	260/400	260/400	400/600	520/750	650/1000	1000/1500	
	.25	3.1	40.3	40.3	67.1	67.1	89.5	89.5	-	-	-	-	-	-	
	.312	2.3	54.3	54.3	90.5	90.5	-	-	-	-	-	-	-	-	
(20 GA.)	.375	1.7	73.4	73.4	-	-	-	-	-	-	-	-	-	-	
0.036	.438	1.4	89.1	89.1	-	-	-	-	-	-	-	-	-	-	
	.50	1.1	-	-	-	-	-	-	-	-	-	-	-	-	
	.625	.09	-	-	-	-	-	-	-	-	-	-	-	-	
	.25	5.3	23.6	23.6	39.3	39.3	52.3	52.3	69.8	69.8	-	-	-	-	
	.312	4.0	31.2	31.2	52.0	52.0	69.4	69.4	92.5	92.5	-	-	-	-	
	.375	3.0	41.6	41.6	69.4	69.4	92.6	92.6	-	-	-	-	-	-	
(18 GA.)	.438	2.5	50.0	50.0	83.3	83.3	-	-	-	-	-	-	-	-	
0.048	.50	2.2	56.7	56.7	94.6	94.6	-	-	-	-	-	-	-	-	
	.625	1.7	73.4	73.4	-	-	-	-	-	-	-	-	-	-	
	.75	1.3	-	-	-	-	-	-	-	-	-	-	-	-	
	.375	5.6	22.3	22.3	37.2	37.2	49.6	49.6	66.1	66.1	99.1	-	-	-	
	.438	4.5	27.8	27.8	46.3	46.3	61.7	61.7	82.2	82.2	-	-	-	-	
	.50	3.8	32.0	32.0	54.8	54.8	73.0	73.0	-	-	-	-	-	-	
(16 GA.)	.625	2.8	44.6	44.6	74.3	74.3	-	-	-	-	-	-	-	-	
0.060	.75	2.2	56.7	56.7	94.6	94.6	-	-	-	-	-	-	-	-	
	.875	1.8	69.4	69.4	-	-	-	-	-	-	-	-	-	-	
	1.00	1.5	83.3	83.3	-	-	-	-	-	-	-	-	-	-	
	.438	7.6	16.4	16.4	27.4	27.4	36.5	36.5	48.7	48.7	73.0	-	-	-	
	.50	6.3	19.8	19.8	33.0	33.0	44.0	44.0	58.7	58.7	88.1	-	-	-	
	.625	4.7	26.0	26.0	44.3	44.3	59.0	59.0	78.7	78.7	-	-	-	-	
(14 GA.)	.75	3.5	35.7	35.7	59.5	59.5	79.3	79.3	-	-	-	-	-	-	
0.075	.875	3.0	41.6	41.6	69.4	69.4	-	-	-	-	-	-	-	-	
	1.00	2.5	50.0	50.0	83.3	83.3	-	-	-	-	-	-	-	-	
	1.125	2.1	59.5	59.5	-	-	-	-	-	-	-	-	-	-	
	1.25	1.8	69.4	69.4	-	-	-	-	-	-	-	-	-	-	
	.625	9.7	12.9	12.9	21.5	21.5	28.6	28.6	38.1	38.1	57.2	71.5	-	-	
	.75	8.0	15.6	15.6	26.0	26.0	34.7	34.7	46.3	46.3	69.4	-	-	-	
	.875	6.5	19.0	19.0	32.0	32.0	42.7	42.7	56.9	56.9	85.3	-	-	-	
(12 GA.)	1.00	5.6	22.3	22.3	37.2	37.2	49.6	49.6	66.1	66.1	-	-	-	-	
0.105	1.125	4.6	27.1	27.1	45.2	45.2	60.3	60.3	80.4	80.4	-	-	-	-	
	1.25	4.1	30.5	30.5	50.8	50.8	67.7	67.7	-	-	-	-	-	-	
	1.50	3.2	38.4	39.0	65.0	65.0	86.7	86.7	-	-	-	-	-	-	
	2.00	2.3	40.2	53.5	90.4	90.4	-	-	-	-	-	-	-	-	
	.75	11.1	11.3	11.3	18.8	18.8	25.0	25.0	33.3	33.3	50.0	63.0	83.3	-	
	.875	9.0	13.9	13.9	23.1	23.1	30.8	30.8	41.1	41.1	61.7	77.1	-	-	
	1.00	7.5	16.7	16.7	27.8	27.8	37.0	37.0	49.3	49.3	74.0	-	-	-	
(11 GA.)	1.125	6.3	19.8	19.8	33.0	33.0	44.0	44.0	58.7	58.7	88.1	-	-	-	
0.120	1.25	5.5	22.7	22.7	37.8	37.8	50.5	50.5	67.3	67.3	-	-	-	-	
	1.50	4.4	27.9	28.4	47.3	47.3	63.1	63.1	84.1	84.1	-	-	-	-	
	2.00	2.9	31.9	42.4	71.7	71.7	-	-	-	-	-	-	-	-	
	.875	11.9	10.5	10.5	17.5	17.5	23.3	23.3	31.1	31.1	46.6	58.3	77.7	-	
	1.00	9.9	12.6	12.6	21.0	21.0	28.0	28.0	37.4	37.4	56.1	70.1	-	-	
	1.125	8.5	14.0	14.0	25.0	25.0	32.0	32.0	43.5	43.5	65.3	-	-	-	
(10 GA.)	1.25	7.3	17.1	17.1	28.5	28.5	38.0	38.0	50.7	50.7	76.0	-	-	-	
0.135	1.50	5.8	21.2	21.5	35.9	35.9	47.8	47.8	63.8	63.8	-	-	-	-	
	2.00	4.0	23.1	30.8	52.0	52.0	69.4	69.4	92.4	92.4	-	-	-	-	
	2.50	3.1	25.3	31.8	57.0	57.0	88.8	88.8	-	-	-	-	-	-	
	1.125	16.4	7.6	7.6	12.7	12.7	16.9	16.9	22.6	22.6	33.8	42.3	56.4	84.6	
	1.25	14.3	8.7	8.7	14.6	14.6	19.4	19.4	25.9	25.9	38.8	48.5	64.7	-	
	1.50	11.2	11.0	12.0	19.0	19.0	25.0	25.0	34.0	34.0	49.6	61.9	82.6	-	
0.188	2.00	7.5	12.3	16.4	27.8	27.8	37.0	37.0	49.3	49.3	74.0	92.4	-	-	
	2.50	5.7	13.8	17.3	31.0	31.0	48.3	48.3	62.3	62.3	-	-	-	-	
	3.00	4.4	14.0	18.6	32.7	40.9	60.0	60.0	70.9	70.9	-	-	-	-	
	1.25	29.5	4.2	4.2	7.1	7.1	9.4	9.4	12.5	12.5	18.8	23.5	31.3	47.0	
	1.50	22.7	5.5	5.5	9.2	9.2	12.2	12.2	16.3	16.3	24.4	30.6	40.7	61.1	
	2.00	15.4	6.0	8.0	13.0	14.0	18.0	18.0	24.0	24.0	36.0	45.0	60.0	90.1	
0.250	2.50	11.4	6.5	8.6	15.5	15.5	24.2	24.2	31.0	31.0	46.6	60.9	81.0	-	
	3.00	9.0	6.8	9.1	16.0	20.0	29.3	29.3	34.7	34.7	56.0	74.6	-	-	
	3.50	7.4	7.1	9.5	16.7	20.8	31.1	31.1	40.5	40.5	58.4	-	-	-	
	4.00	6.1	7.4	10.0	17.6	22.0	32.7	32.7	43.7	45.9	65.6	-	-	-	

*Press brake tonnage capacity at mid stroke and near bottom of stroke.
Series 5AC, 9AC and 13AC tonnage capacity ratings listed are for low speed operation.

MILD STEEL AIR BEND CAPACITY CHART

MILD STEEL THICK. NOMINAL INCHES	VEE DIE OPENING NOMINAL INCHES	TONS (2000 LB) PER FOOT	LINEAR FEET — HYDRAULIC PRESS BRAKE TONNAGE														
			60	90	135	175	230	300	350	400	500	600	750	1000	1250	1500	2000
	.25	3.1	16.4	24.6	37.0	48.0	63.0	82.0	95.9	109.7	-	-	-	-	-	-	-
	.312	2.3	22.2	33.3	49.9	64.7	85.0	110.8	-	-	-	-	-	-	-	-	-
(20 GA.)	.375	1.7	30.0	45.0	67.5	87.5	115.0	-	-	-	-	-	-	-	-	-	-
0.036	.438	1.4	36.4	54.6	81.9	106.2	-	-	-	-	-	-	-	-	-	-	-
	.50	1.1	46.3	69.5	104.3	-	-	-	-	-	-	-	-	-	-	-	-
	.625	0.9	56.7	85.0	-	-	-	-	-	-	-	-	-	-	-	-	-
	.25	5.3	9.6	14.4	21.7	28.1	36.9	48.1	56.1	64.2	80.2	96.2	120.3	-	-	-	-
	.312	4.0	12.7	19.1	28.7	37.2	48.9	63.8	74.4	85.0	106.3	-	-	-	-	-	-
(18 GA.)	.375	3.0	17.0	25.5	38.3	49.6	65.2	85.0	99.1	113.3	-	-	-	-	-	-	-
0.048	.438	2.5	20.4	30.6	45.9	59.5	78.2	102.0	-	-	-	-	-	-	-	-	-
	.50	2.2	23.2	34.8	52.2	67.6	88.8	-	-	-	-	-	-	-	-	-	-
	.625	1.7	30.0	45.0	67.5	87.5	115.0	-	-	-	-	-	-	-	-	-	-
	.75	1.3	39.2	58.8	88.2	114.4	-	-	-	-	-	-	-	-	-	-	-
	.375	5.6	9.1	13.7	20.5	26.6	34.9	45.5	53.1	60.7	75.9	91.1	113.8	-	-	-	-
	.438	4.5	11.3	17.0	25.5	33.1	43.4	56.7	66.1	75.6	94.4	113.3	-	-	-	-	-
(16 GA.)	.50	3.8	13.4	20.1	30.2	39.1	51.4	67.1	78.3	89.5	111.8	-	-	-	-	-	-
0.060	.625	2.8	18.2	27.3	41.0	53.1	69.8	91.1	106.2	121.4	-	-	-	-	-	-	-
	.75	2.2	23.2	34.8	52.2	67.6	88.8	115.9	-	-	-	-	-	-	-	-	-
	.875	1.8	28.3	42.5	63.8	82.6	108.6	-	-	-	-	-	-	-	-	-	-
	1.00	1.5	34.0	51.0	76.5	99.2	-	-	-	-	-	-	-	-	-	-	-
	.438	7.6	6.7	10.1	15.1	19.6	25.7	33.6	39.1	44.7	55.9	67.1	83.9	111.8	-	-	-
	.50	6.3	8.1	12.1	18.2	23.6	31.0	40.5	47.2	54.0	67.5	81.0	101.2	-	-	-	-
	.625	4.7	10.9	16.3	24.4	31.6	41.6	54.3	63.3	72.3	90.4	108.5	-	-	-	-	-
(14 GA.)	.75	3.5	14.6	21.9	32.8	42.5	55.9	72.9	85.0	97.1	121.4	-	-	-	-	-	-
0.075	.875	3.0	17.0	25.5	38.3	49.6	65.2	85.0	99.1	113.3	-	-	-	-	-	-	-
	1.00	2.5	20.4	30.6	45.9	59.5	78.2	102.0	-	-	-	-	-	-	-	-	-
	1.125	2.1	24.3	36.4	54.6	70.8	93.1	-	-	-	-	-	-	-	-	-	-
	1.25	1.8	28.3	42.5	63.8	82.6	108.6	-	-	-	-	-	-	-	-	-	-
	.625	9.7	5.2	7.9	11.8	15.3	20.1	26.3	30.7	35.1	43.8	52.6	65.7	87.6	109.5	-	-
	.75	8.0	6.4	9.6	14.3	18.6	24.4	31.9	37.2	42.5	53.1	63.8	79.7	106.3	-	-	-
	.875	6.5	7.8	12.0	17.7	22.9	30.1	39.2	45.8	52.3	65.4	78.5	98.1	130.8	-	-	-
(12 GA.)	1.00	5.6	9.1	13.7	20.5	26.6	34.9	45.5	53.1	60.7	75.9	91.1	113.8	-	-	-	-
0.105	1.125	4.6	11.1	16.6	24.9	32.3	42.5	55.4	64.7	73.9	92.4	110.9	-	-	-	-	-
	1.25	4.1	12.5	18.7	28.0	36.3	47.7	62.2	72.6	82.9	103.7	-	-	-	-	-	-
	1.50	3.2	15.9	23.9	35.9	46.5	61.1	79.7	93.0	106.3	-	-	-	-	-	-	-
	2.00	2.3	22.1	33.2	49.9	64.7	85.0	110.8	-	-	-	-	-	-	-	-	-
	.75	11.1	4.6	6.9	10.3	13.4	17.6	23.0	26.8	30.6	38.3	45.9	57.4	76.6	95.7	114.9	-
	.875	9.0	5.6	8.5	12.8	16.5	21.7	28.3	33.0	37.8	47.2	56.7	70.8	94.4	118.0	-	-
(11 GA.)	1.00	7.5	6.8	10.2	15.3	19.8	26.1	34.0	39.7	45.3	56.7	68.0	85.0	113.3	-	-	-
0.120	1.125	6.3	8.1	12.1	18.2	23.6	31.0	40.5	47.2	54.0	67.5	81.0	101.2	-	-	-	-
	1.25	5.5	9.3	13.9	20.9	27.0	35.5	46.4	54.1	61.8	77.3	92.7	115.9	-	-	-	-
	1.50	4.4	11.6	17.4	26.1	33.8	44.4	58.0	67.6	77.3	96.6	115.9	-	-	-	-	-
	2.00	2.9	17.6	26.4	39.6	51.3	67.4	87.9	102.6	117.2	-	-	-	-	-	-	-
	.875	11.9	4.3	6.4	9.6	12.5	16.4	21.4	25.0	28.6	35.7	42.9	53.6	71.4	89.3	107.1	-
	1.00	9.9	5.1	7.7	11.6	15.0	19.7	25.8	30.0	34.3	42.9	51.5	64.4	85.9	107.3	-	-
(10 GA.)	1.125	8.5	6.0	9.0	13.5	17.5	23.0	30.0	35.0	40.0	50.0	60.0	75.0	100.0	-	-	-
0.135	1.25	7.3	7.0	10.5	15.7	20.4	26.8	34.9	40.8	46.6	58.2	69.9	87.3	116.4	-	-	-
	1.50	5.8	8.8	13.2	19.8	25.6	33.7	44.0	51.3	58.6	73.3	87.9	109.9	-	-	-	-
	2.00	4.0	12.7	19.1	28.7	37.2	48.9	63.8	74.4	85.0	106.3	-	-	-	-	-	-
	2.50	3.1	16.5	24.7	37.0	48.0	63.0	82.2	95.9	109.7	-	-	-	-	-	-	-
	1.125	16.4	3.1	4.7	7.0	9.1	11.7	15.5	18.1	20.7	25.9	31.1	38.9	51.8	64.8	77.7	103.7
	1.25	14.3	3.5	5.3	8.0	10.4	13.7	17.8	20.8	23.8	29.7	35.7	44.6	59.4	74.3	89.2	118.9
0.188	1.50	11.2	4.5	6.8	10.3	13.3	17.4	22.8	25.5	30.4	37.9	45.5	56.9	75.9	94.9	113.8	-
	2.00	7.5	6.8	10.2	15.3	19.8	26.1	34.0	39.7	45.3	56.7	68.0	85.0	113.3	-	-	-
	2.50	5.7	8.9	13.4	20.1	26.1	34.3	44.7	52.2	59.6	74.6	89.5	111.8	-	-	-	-
	3.00	4.4	11.6	17.4	26.1	33.8	44.4	58.0	67.6	77.3	96.6	115.9	-	-	-	-	-
	1.25	29.5	1.7	2.6	3.9	5.0	6.6	8.6	10.1	11.5	14.4	17.3	21.6	28.8	36.0	43.2	57.6
	1.50	22.7	2.2	3.4	5.1	6.6	8.6	11.2	13.1	15.0	18.7	22.5	28.1	37.4	46.8	56.2	74.9
	2.00	15.4	3.3	5.0	7.5	10.0	12.8	16.6	19.3	22.1	27.6	33.1	41.4	55.2	69.0	82.8	110.4
0.250	2.50	11.4	4.4	6.7	10.1	13.0	17.1	22.4	26.1	29.8	37.3	44.7	55.9	74.6	93.2	111.8	-
	3.00	9.0	5.6	8.5	12.8	16.5	21.7	28.3	33.0	37.8	47.2	56.7	70.8	94.4	118.0	-	-
	3.50	7.4	6.9	10.3	15.5	20.1	26.4	34.4	40.2	45.9	57.4	68.9	86.1	114.9	-	-	-
	4.00	6.1	8.3	12.5	18.8	24.4	32.0	41.8	48.8	55.7	69.7	83.6	104.5	-	-	-	-

MILD STEEL AIR BEND CAPACITY CHART

MILD STEEL THICK. NOMINAL INCHES	VEE DIE OPENING NOMINAL INCHES	TONS (2000 LB) PER FOOT	LINEAR FEET — MECHANICAL PRESS BRAKES-STANDARD STROKE ONLY											
			5	5AC	9	9AC	12	12AC	13	13AC	21	34	36	50
			90/135	90/135	150/225	150/225	200/300	200/300	260/400	260/400	400/600	520/750	650/1000	1000/1500
.313	1.50	39.8	3.1	3.1	5.2	5.2	7.0	7.0	9.3	9.3	13.9	17.4	23.2	34.9
	2.00	27.0	3.4	4.6	7.7	7.7	10.3	10.3	13.7	13.7	20.6	25.7	34.3	51.4
	2.50	19.7	4.0	5.0	9.0	9.0	14.0	14.0	18.0	18.0	27.0	34.0	46.9	70.4
	3.00	15.3	4.2	5.4	9.4	11.8	17.2	17.2	20.4	20.4	32.9	43.9	60.5	90.6
	3.50	12.7	4.4	5.5	9.7	12.1	18.5	18.5	23.6	23.6	35.0	50.8	68.1	-
	4.00	10.5	4.6	5.8	10.3	12.8	19.0	19.0	25.4	26.7	38.1	57.1	76.2	-
	5.00	7.7	-	-	-	-	25.2	25.2	27.6	34.6	44.8	72.8	-	-
.375	2.00	42.3	2.2	2.9	4.9	4.9	6.6	6.6	8.7	8.7	13.1	16.4	21.9	32.8
	2.50	30.9	2.4	3.2	5.7	5.7	8.9	8.9	11.4	11.4	17.2	22.4	29.9	44.9
	3.00	24.0	2.6	3.4	6.0	7.5	11.0	11.0	13.0	14.0	21.0	28.0	36.0	57.8
	3.50	19.6	2.7	3.6	6.3	7.9	11.7	11.7	15.3	15.3	22.6	32.9	44.1	70.7
	4.00	16.3	2.8	3.8	6.6	8.3	12.3	12.3	16.4	17.2	24.5	36.8	49.0	85.1
	5.00	12.3	-	-	-	-	15.8	15.8	17.3	21.7	28.1	45.6	59.5	-
	6.00	9.5	-	-	-	-	-	-	-	-	-	-	67.6	-
.438	2.50	45.8	-	2.2	3.9	3.9	6.0	6.0	7.8	7.8	11.6	15.1	20.2	30.3
	3.00	35.4	-	2.3	4.1	5.1	7.5	7.5	8.8	8.8	14.2	19.0	26.1	39.2
	3.50	28.6	-	2.4	4.3	5.4	8.0	8.0	10.5	10.5	15.5	22.5	30.2	48.5
	4.00	24.4	-	2.5	4.4	5.5	8.2	8.2	10.9	11.5	16.4	24.6	32.8	54.5
	5.00	17.3	-	-	-	-	11.2	11.2	12.3	15.4	20.0	32.4	42.3	69.6
	6.00	14.8	-	-	-	-	-	-	-	-	-	-	43.4	76.0
	7.00	11.2	-	-	-	-	-	-	-	-	-	-	-	-
.500	3.50	39.7	-	-	3.1	3.9	5.8	5.8	7.6	7.6	11.2	16.2	21.8	34.9
	4.00	33.3	-	-	3.2	4.1	6.0	6.0	8.0	8.4	12.0	18.0	24.0	39.9
	5.00	24.6	-	-	-	-	8.0	8.0	8.6	10.8	14.0	20.0	29.7	49.0
	6.00	19.4	-	-	-	-	-	-	-	-	-	-	33.1	58.0
	7.00	15.9	-	-	-	-	-	-	-	-	-	-	-	63.2
	8.00	13.1	-	-	-	-	-	-	-	-	-	-	-	69.8
.625	4.00	58.3	-	-	-	2.3	3.4	3.4	4.6	4.8	6.9	10.3	13.7	22.8
	5.00	43.1	-	-	-	-	4.5	4.5	5.0	6.2	8.0	13.0	17.0	28.0
	6.00	33.3	-	-	-	-	-	-	-	-	-	-	19.3	33.8
	7.00	27.4	-	-	-	-	-	-	-	-	-	-	-	36.7
	8.00	23.3	-	-	-	-	-	-	-	-	-	-	-	39.3
	10.00	16.9	-	-	-	-	-	-	-	-	-	-	-	-
.750	6.00	53.5	-	-	-	-	-	-	-	-	-	-	12.0	21.0
	7.00	43.6	-	-	-	-	-	-	-	-	-	-	-	24.9
	8.00	36.5	-	-	-	-	-	-	-	-	-	-	-	26.0
	10.00	27.1	-	-	-	-	-	-	-	-	-	-	-	-
	12.00	21.0	-	-	-	-	-	-	-	-	-	-	-	-
.875	7.00	64.6	-	-	-	-	-	-	-	-	-	-	-	15.6
	8.00	52.9	-	-	-	-	-	-	-	-	-	-	-	17.3
	10.00	39.7	-	-	-	-	-	-	-	-	-	-	-	-
	12.00	31.6	-	-	-	-	-	-	-	-	-	-	-	-
	14.00	25.2	-	-	-	-	-	-	-	-	-	-	-	-
1.000	7.00	91.2	-	-	-	-	-	-	-	-	-	-	-	11.4
	8.00	76.2	-	-	-	-	-	-	-	-	-	-	-	12.0
	10.00	56.3	-	-	-	-	-	-	-	-	-	-	-	-
	12.00	44.2	-	-	-	-	-	-	-	-	-	-	-	-
	14.00	35.2	-	-	-	-	-	-	-	-	-	-	-	-
	16.00	29.4	-	-	-	-	-	-	-	-	-	-	-	-
1.250	10.00	97.0	-	-	-	-	-	-	-	-	-	-	-	-
	12.00	75.5	-	-	-	-	-	-	-	-	-	-	-	-
	14.00	61.6	-	-	-	-	-	-	-	-	-	-	-	-
	16.00	51.1	-	-	-	-	-	-	-	-	-	-	-	-
	20.00	37.7	-	-	-	-	-	-	-	-	-	-	-	-
1.500	12.00	119.0	-	-	-	-	-	-	-	-	-	-	-	-
	14.00	97.3	-	-	-	-	-	-	-	-	-	-	-	-
	16.00	80.6	-	-	-	-	-	-	-	-	-	-	-	-
	20.00	59.5	-	-	-	-	-	-	-	-	-	-	-	-
	24.00	46.8	-	-	-	-	-	-	-	-	-	-	-	-
1.750	16.00	118.0	-	-	-	-	-	-	-	-	-	-	-	-
	20.00	87.5	-	-	-	-	-	-	-	-	-	-	-	-
	24.00	68.8	-	-	-	-	-	-	-	-	-	-	-	-
	30.00	50.7	-	-	-	-	-	-	-	-	-	-	-	-
2.000	16.00	165.0	-	-	-	-	-	-	-	-	-	-	-	-
	20.00	122.0	-	-	-	-	-	-	-	-	-	-	-	-
	24.00	96.0	-	-	-	-	-	-	-	-	-	-	-	-
	30.00	70.8	-	-	-	-	-	-	-	-	-	-	-	-

*Press brake tonnage capacity at mid stroke and near bottom of stroke. Series 5AC, 9AC and 13AC tonnage capacity ratings listed are for low speed operation.

MILD STEEL AIR BEND CAPACITY CHART

MILD STEEL THICK. NOMINAL INCHES	VEE DIE OPENING NOMINAL INCHES	TONS (2000 LB) PER FOOT	LINEAR FEET — HYDRAULIC PRESS BRAKE TONNAGE														
			60	90	135	175	230	300	350	400	500	600	750	1000	1250	1500	2000
.313	1.50	39.8	-	-	2.9	3.7	4.9	6.4	7.5	8.5	10.7	12.8	16.0	21.4	26.7	32.0	42.7
	2.00	27.0	-	2.8	4.3	5.5	7.2	9.4	11.0	12.6	15.7	18.9	23.6	31.5	39.3	47.2	63.0
	2.50	19.7	-	3.9	5.8	7.6	9.9	12.9	15.1	17.3	21.6	25.9	32.4	43.1	53.9	64.7	86.3
	3.00	15.3	-	5.0	7.5	9.7	12.8	16.7	19.4	22.2	27.8	33.3	41.7	55.6	69.4	83.3	111.1
	3.50	12.7	-	6.0	9.0	11.7	15.4	20.1	23.4	26.8	33.5	40.2	50.2	66.9	83.7	100.4	-
	4.00	10.5	-	7.3	10.9	14.2	18.6	24.3	28.3	32.4	40.5	48.6	60.7	81.0	101.2	-	-
	5.00	7.7	-	9.9	14.9	19.3	25.4	33.1	38.6	44.1	55.2	66.2	82.8	110.4	-	-	-
.375	2.00	42.3	-	-	2.7	3.5	4.6	6.0	7.0	8.0	10.0	12.1	15.1	20.1	25.1	30.1	40.2
	2.50	30.9	-	2.5	3.7	4.8	6.3	8.3	9.6	11.0	13.8	16.5	20.6	27.5	34.4	41.3	55.0
	3.00	24.0	-	3.2	4.8	6.3	8.3	10.0	12.4	14.2	17.7	21.3	26.6	35.4	44.3	53.1	70.8
	3.50	19.6	-	3.9	5.9	7.6	10.0	13.0	15.2	17.3	21.7	26.0	32.5	43.4	54.2	65.1	86.7
	4.00	16.3	-	4.7	7.0	9.1	12.0	15.6	18.3	20.9	26.1	31.3	39.1	52.1	65.2	78.2	104.3
	5.00	12.3	-	6.2	9.3	12.1	15.9	20.7	24.2	27.6	34.6	41.5	51.8	69.1	86.4	103.7	-
	6.00	9.5	-	8.0	12.0	15.6	20.6	26.8	31.3	35.8	44.7	53.7	67.1	89.5	111.8	-	-
.438	2.50	45.8	-	-	2.5	3.2	4.3	5.6	6.5	7.4	9.3	11.1	13.9	18.6	23.2	27.8	37.1
	3.00	35.4	-	2.2	3.2	4.2	5.5	7.2	8.4	9.6	12.0	14.4	18.0	24.0	30.0	36.0	48.0
	3.50	28.6	-	2.7	4.0	5.2	6.8	8.9	10.4	11.9	14.9	17.8	22.3	29.7	37.2	44.6	59.4
	4.00	24.4	-	3.1	4.7	6.1	8.0	10.5	12.2	13.9	17.4	20.9	26.1	34.8	43.5	52.3	69.7
	5.00	17.3	-	4.4	6.6	8.6	11.3	14.7	17.2	19.7	24.6	29.5	36.8	49.1	61.4	73.7	98.3
	6.00	14.8	-	5.2	7.8	10.1	13.2	17.2	20.1	23.0	28.7	34.4	43.1	57.4	71.8	86.1	114.9
	7.00	11.2	-	6.8	10.2	13.3	17.4	22.8	26.6	30.4	37.9	45.5	56.9	75.9	94.9	113.8	-
.500	3.50	39.7	-	-	2.9	3.7	4.9	6.4	7.5	8.6	10.7	12.8	16.1	21.4	26.8	32.1	42.8
	4.00	33.3	-	2.3	3.4	4.5	5.9	7.7	8.9	10.0	12.8	15.3	19.1	25.5	31.9	38.9	51.1
	5.00	24.6	-	3.1	4.7	6.1	8.0	10.4	12.0	13.8	17.3	20.7	25.9	34.6	43.2	51.8	69.1
	6.00	19.4	-	3.9	5.9	7.7	10.1	13.1	15.3	17.5	21.9	26.3	32.9	43.8	54.8	65.7	87.6
	7.00	15.9	-	4.8	7.2	9.4	12.3	16.0	18.7	21.4	26.7	32.1	40.1	53.5	66.8	80.2	106.9
	8.00	13.1	-	5.8	8.8	11.4	14.9	19.5	22.7	26.0	32.4	38.9	48.7	64.9	81.1	97.3	129.8
.625	4.00	58.3	-	-	-	2.6	3.4	4.4	5.1	5.8	7.3	8.7	10.9	14.6	18.2	21.9	29.2
	5.00	43.1	-	-	2.7	3.5	4.5	5.9	6.9	7.9	9.9	11.8	14.8	19.7	24.7	29.6	39.4
	6.00	33.3	-	2.3	3.4	4.5	5.9	7.7	8.9	10.0	13.0	15.3	19.1	25.5	31.9	38.9	51.1
	7.00	27.4	-	2.8	4.2	5.4	7.1	9.3	10.9	12.4	15.5	18.6	23.3	31.0	38.8	46.5	62.0
	8.00	23.3	-	3.4	4.9	6.4	8.4	10.9	12.8	14.6	18.2	21.9	27.4	36.5	45.6	54.7	73.0
	10.00	16.9	-	4.5	6.8	8.8	11.5	15.1	17.6	20.1	25.1	30.2	37.7	50.3	62.9	75.4	100.6
.750	6.00	53.5	-	-	2.1	2.8	3.7	4.8	5.6	6.4	7.9	9.5	11.9	15.9	19.9	23.8	31.8
	7.00	43.6	-	-	2.6	3.4	4.5	5.8	6.8	7.8	9.7	11.7	14.6	19.5	24.4	29.2	39.0
	8.00	36.5	-	2.1	3.1	4.1	5.4	7.0	8.5	9.3	11.6	14.0	17.5	23.3	29.1	34.9	46.6
	10.00	27.1	-	2.8	4.2	5.5	7.2	9.4	11.0	12.5	15.7	18.8	23.5	31.4	39.2	47.0	62.7
	12.00	21.0	-	-	-	7.1	9.3	12.1	14.2	16.2	20.2	24.3	30.4	40.5	50.6	60.7	80.9
.875	7.00	64.6	-	-	-	2.3	3.0	3.9	4.6	5.3	6.6	7.9	9.9	13.2	16.4	19.7	26.3
	8.00	52.9	-	-	2.2	2.8	3.7	4.8	5.6	6.4	8.0	9.6	12.1	16.1	20.1	24.1	32.1
	10.00	39.7	-	-	2.9	3.7	4.9	6.4	7.5	8.6	10.7	12.8	16.1	21.4	26.8	32.1	42.8
	12.00	31.6	-	-	-	4.7	6.2	8.1	9.4	10.8	13.4	16.1	20.2	26.9	33.6	40.3	53.8
	14.00	25.2	-	-	-	-	-	10.1	-	13.5	16.9	20.2	25.3	33.7	42.2	50.6	67.5
1.000	7.00	91.2	-	-	-	-	2.1	2.8	3.3	3.7	4.7	5.6	7.0	9.3	11.7	14.0	18.6
	8.00	76.2	-	-	-	2.0	2.6	3.3	3.9	4.5	5.6	6.7	8.4	11.1	13.9	16.7	22.3
	10.00	56.3	-	-	2.0	2.6	3.5	4.5	5.3	6.0	7.5	9.1	11.0	15.0	18.9	22.6	30.2
	12.00	44.2	-	-	-	3.4	4.4	5.8	6.7	7.7	9.6	11.5	14.4	19.2	24.0	28.8	38.5
	14.00	35.2	-	-	-	-	-	7.2	-	9.7	12.1	14.5	18.1	24.1	30.2	36.2	48.3
	16.00	29.4	-	-	-	-	-	8.7	-	11.6	14.5	17.3	21.7	28.9	36.1	43.4	57.8
1.250	10.00	97.0	-	-	-	-	2.0	2.6	3.1	3.5	4.4	5.3	6.6	8.8	10.9	13.1	17.5
	12.00	75.5	-	-	-	2.0	2.6	3.4	3.9	4.5	5.6	6.8	8.4	11.3	14.1	16.9	22.5
	14.00	61.6	-	-	-	-	-	4.1	-	5.5	6.9	8.3	10.3	13.8	17.0	20.7	27.6
	16.00	51.1	-	-	-	-	-	5.0	-	6.7	8.3	10.0	12.5	16.6	20.8	24.9	33.3
	20.00	37.7	-	-	-	-	-	6.8	-	9.0	11.3	13.5	16.9	22.5	28.2	33.8	45.1
1.500	12.00	119	-	-	-	-	-	2.1	2.5	2.9	3.6	4.3	5.4	7.1	8.9	10.7	14.3
	14.00	97.3	-	-	-	-	-	2.6	-	3.5	4.4	5.2	6.6	8.7	10.9	13.1	17.5
	16.00	80.6	-	-	-	-	-	3.2	-	4.2	5.3	6.3	7.9	10.5	13.2	16.0	21.1
	20.00	59.5	-	-	-	-	-	4.3	-	5.7	7.1	8.6	10.7	14.3	17.9	21.4	28.6
	24.00	46.8	-	-	-	-	-	5.4	-	7.3	9.1	10.9	13.6	18.2	22.7	27.2	36.3
1.750	16.00	118	-	-	-	-	-	2.2	-	2.9	3.6	4.3	5.4	7.2	9.0	10.8	14.4
	20.00	87.5	-	-	-	-	-	2.9	-	3.9	4.9	5.8	7.3	9.7	12.1	14.6	19.4
	24.00	68.8	-	-	-	-	-	3.7	-	4.9	6.2	7.4	9.3	12.4	15.4	18.5	24.7
	30.00	50.7	-	-	-	-	-	5.0	-	6.7	8.4	10.0	12.6	16.8	21.0	25.1	33.5
2.000	16.00	165	-	-	-	-	-	-	-	2.1	2.6	3.1	3.9	5.2	6.4	7.7	10.3
	20.00	122	-	-	-	-	-	2.1	-	2.8	3.5	4.2	5.2	7.0	8.7	10.5	13.9
	24.00	96.0	-	-	-	-	-	2.7	-	3.5	4.4	5.3	6.6	8.9	11.1	13.3	17.7
	30.00	70.8	-	-	-	-	-	3.6	-	4.8	6.0	7.2	9.0	12.0	15.0	18.0	24.0

BENDING FACTORS CHART

ASTM SPECIFICATION			TENSILE STRENGTH K.S.I.	YIELD STRENGTH K.S.I.	MATERIAL THICKNESS INCHES	NOMINAL VEE DIE OPENING	NOMINAL UPPER DIE RADIUS	FORMABILITY FACTOR
No.	TYPE	GRADE						
A-36	STRUCTURAL STEEL		58-60	36-51	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.3
				51-65	.180 - .500 .500 - 1.000	10T 12T	1.5T 2T	1.6
A-131	STRUCTURAL STEEL FOR SHIPS	ALL	58-71	34 Min.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.2
A-242	HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL		70 MIN.	50 MIN.	.180 -.250 .250 - .500	12T 12T	2T 3T	1.7
A-283	LOW AND INTERMEDIATE TENSILE STRENGTH CARBON STEEL PLATES OF STUCTURAL QUALITY	A	45-55	24 Min.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.0
		B	50-60	27 Min.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.0
		C	55-65	30 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.1
		D	60-72	33 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.2
A-285	LOW AND INTERMIDATE TENSILE STRENGTH CARBON STEEL PLATES FOR PRESSURE VESSELS	A	45-65	24 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.0
		B	50-70	27 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.1
		C	55-75	30 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.2
A-299	CARBON MANGANESE SILICON STEEL PLATE FOR PRESSURE VESSELS		75-95	42 MIN.	.180 - 1.00	12T	1.5T	1.5
A-514	HIGH-YIELD STRENGTH, QUENCHED AND TEMPERED ALLOY STEEL PLATE SUITABLE FOR WELDING		110-130	100 MIN.	.180 - 1.000 OVER 1.000	16T 16T	2T 3T	3.1
A515	CARBON STEEL PLATES FOR INTERMEDIATE AND HIGHER TEMPERATURE SERVICE FOR PRESSURE VESSELS	55	55-75	30 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.2
		60	60-80	32 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.3
		65	65-85	35 MIN.	.180 - .500 .500 - 1.000	10T 12T	1.5T 2T	1.45
		70	70-90	38 MIN.	.180 - .500 .500 - 1.000	12T 14T	2T 2T	1.6
A516	CARBON STEEL PLATES FOR MODERATE AND LOWER TEMPERATURE SERVICE FOR PRESSURE VESSELS	55	55-75	30 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.2
		60	60-80	32 MIN.	.180 - .500 .500 - 1.000	8T 10T	1T 1.5T	1.3
		65	65-85	35 MIN.	.180 - .500 .500 - 1.000	10T 12T	1.5T 2T	1.45
		70	70-90	38 MIN.	.180 - .500 .500 - 1.000	12T 14T	2T 2T	1.6
A-517	HIGH STRENGTH, ALLOY STEEL QUENCHED AND TEMPERED PLATES FOR PRESSURE VESSELS		115-135	100 MIN.	.180 - 1.000 OVER 1.000	16T 16T	2T 3T	3.1
A-537	HEAT TREATED, CARBON MANGANESE-SILICON STEEL PLATE FOR PRESSURE VESSEL	CLASS I	70-90	50 MIN.	.180-1.250 OVER 1.250	14T 16T	3T 4T	1.9
		CLASS II	80-100	60 MIN.	.180-1.250 OVER 1.250	16T 16T	4T 5T	2.0
A-572	HIGH-STRENGTH LOW-ALLOY COLUMBIUM-VANADIUM STEELS OF STRUCTURAL QUALITY	42	60 MIN.	42 MIN.	.180-.250 .250-.500	10T 12T	1.5T 2T	1.4
		50	65 MIN.	50 MIN.	.180-.250 .250-.500	12T 12T	2T 2.5T	1.6
		60	75 MIN.	60 MIN.	.180-.250 .250-.500	14T 14T	3T 3.5T	1.8
		65	80 MIN.	65 MIN.	.180-.250 .250-.500	14T 16T	3.5T 4T	1.9
A588	HIGH-STRENGTH LOW-ALLOY STRUCTUAL STEEL WITH 50,000 PSI MINIMUM YEILD POINT TO 4" THICK	ALL	70 MIN.	50 MIN.	.180-.250 .250-.500	10T 12T	2T 3T	1.7
A-606	STEEL SHEET AND STRIP, HOT ROLLED AND COLD ROLLED, HIGH-STRENGTH, LOW-ALLOY WITH IMPROVED CORROSION RESISTANCE	H.R.	70 MIN.	50 MIN.	0-.062 .062-.250 .250-.500	8T 10T 12T	1T 2T 3T	1.7
		C.R. ANNEAL. NORM.	65 MIN.	45 MIN.	0-.062 OVER .062	8T 10T	1T 2T	1.6
A-633	NORMALIZED HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL	A-B C-D E	63-83 70-90 80-100	42MIN. 50 MIN. 60 MIN.	0-1.00 0-1.00 0-1.00	12T 12T 12T	2T 2T 2T	1.6 1.7 2.0
A-656	HOT-ROLLED STRUCTURAL STEEL, HIGH-STRENGTH LOW-ALLOY STEEL PLATE WITH IMPROVED FORMABILILTY	50	60 MIN.	50 MIN.	0-.250 .250-.750	8T 10T	1T 1.5T	1.5
		60	70 MIN.	60 MIN.	0-.250 .250-.750	8T 10T	1T 1.5T	1.6
		70	80 MIN.	70 MIN.	0-.250 .250-.750	8T 10T	1T 1.5T	1.8
		80	90 MIN.	80 MIN.	0-.250 .250-.750	8T 10T	1T 1.5T	2.1

BENDING FACTORS CHART (CONTINUED)

The tensile and/or yield strength of many ASTM steels are specified as minimum values with no limit on the maximum. This chart is based on the actual tensile strength and/or yield strengths 15,000 PSI above the specified minimum values. Steel exceeding this value must be limited to thinner material than shown in the chart. The actual physical properties and chemical analysis of a steel may meet more than one specification and/or grade within a specification. In this case the capacities for the specification and/or grade with the highest mechanical properties must be used. The ASTM specifications listed are those in effect on January 1, 2000.

ASTM SPECIFICATION		TENSILE STRENGTH K.S.I.	YIELD STRENGTH K.S.I.	MATERIAL THICKNESS INCHES	NOMINAL VEE DIE OPENING	NOMINAL UPPER DIE RADIUS	FORMABILITY FACTOR
No.	TYPE						
A1008 STEEL, SHEET, COLD ROLLED, CARBON, STRUCTURAL, HIGH-STRENGTH LOW-ALLOY AND HIGH-STRENGTH LOW-ALLOY WITH IMPROVED FORMABILITY	CS Type A, B, & C	NOT SPECIFIED	20-40	ALL	8T	1T	1.0
	DS Type A & B	NOT SPECIFIED	22-35	ALL	8T	1T	1.0
	DDS	NOT SPECIFIED	17-29	ALL	8T	1T	1.0
	EDDS	NOT SPECIFIED	15-25	ALL	8T	1T	1.0
	SS: Grade 25	42 MIN.	25 MIN.	ALL	8T	1T	1.0
	SS: Grade 30	45 MIN.	30 MIN.	ALL	8T	1T	1.0
	SS: Grade 33 Type 1 & 2	48 MIN.	33 MIN.	ALL	8T	1T	1.0
	SS: Grade 40 Type 1 & 2	52 MIN.	40 MIN.	ALL	8T	1T	1.0
	SS: Grade 80	82 MIN.	80 MIN.				
	HSLAS: Grade 45 Class 1	60 MIN.	45 MIN.	0-.180 .180-.230	8T 10T	1T 1.5T	1.5
	HSLAS: Grade 45 Class 2	55 MIN.		0-.180 .180-.230	8T 10T	1T 1.5T	
	HSLAS: Grade 50 Class 1	65 MIN.	50 MIN.	0-.180 .180-.230	10T 12T	1.5T 2T	1.6
	HSLAS: Grade 50 Class 2	60 MIN.		0-.180 .180-.230	10T 12T	1.5T 2T	
	HSLAS: Grade 55 Class 1	70 MIN.	55 MIN.	0-.180 .180-.230	12T 12T	2T 2.5T	1.7
	HSLAS: Grade 55 Class 2	65 MIN.		0-.180 .180-.230	12T 12T	2T 2.5T	
	HSLAS: Grade 60 Class 1	75 MIN.	60 MIN.	0-.180 .180-.230	12T 14T	2.5T 3T	1.8
	HSLAS: Grade 60 Class 2	70 MIN.		0-.180 .180-.230	12T 14T	2.5T 3T	
	HSLAS: Grade 65 Class 1	80 MIN.	65 MIN.	0-.180 .180-.230	14T 14T	3T 3.5T	1.9
	HSLAS: Grade 65 Class 2	75 MIN.		0-.180 .180-.230	14T 14T	3T 3.5T	
	HSLAS: Grade 70 Class 1	85 MIN.	70 MIN.	0-.180 .180-.230	16T 16T	4T 5T	2.0
	HSLAS: Grade 70 Class 2	80 MIN.		0-.180 .180-.230	16T 16T	4T 5T	
	HSLAS-F: Grade 50	60 MIN.	50 MIN.	0-.230	10T	1.5T	1.5
	HSLAS-F: Grade 60	70 MIN.	60 MIN.	0-.180 OVER .180	8T 10T	1.5T 2T	1.6
	HSLAS-F: Grade 70	80 MIN.	70 MIN.	0-.180 OVER .180	10T 10T	2T 2.5T	1.8
	HSLAS-F: Grade 80	90 MIN.	80 MIN.	0-.180 OVER .180	10T 12T	2T 2.5T	2.0

NOTE: 1. The formability factors listed in the chart are based on a factor of 1.0 for mild steel with a tensile strength of 60,000 p.s.i. and a yield strength of 40,000 p.s.i.

2. The ASTM specifications listed are those in effect January 1, 2000.

3. High strength low alloy steel and stainless steel should not be formed at temperatures below 50°F (10°C).

BENDING FACTORS CHART (CONTINUED)

ASTM SPECIFICATION		TENSILE STRENGTH K.S.I.	YIELD STRENGTH K.S.I.	MATERIAL THICKNESS INCHES	NOMINAL VEE DIE OPENING	NOMINAL UPPER DIE RADIUS	FORMABILITY FACTOR
No.	TYPE						
A-1011 STEEL, SHEET AND STRIP, HOT ROLLED, CARBON, STRUCTURAL, HIGH-STRENGTH LOW-ALLOY AND HIGH-STRENGTH LOW-ALLOY WITH IMPROVED FORMABLITY	CS Type A, B, & C	NOT SPECIFIED	30-50	0-.230	8T	1T	1.0
	DS Type A & B	NOT SPECIFIED	30-45	0-.230	8T	1T	1.0
	SS: Grade 30	49 MIN.	30 MIN.	0-.230	8T	1T	1.1
	SS: Grade 33	52 MIN.	33 MIN.	0-.230	10T	1.5T	1.15
	SS: Grade 36 Type 1	53 MIN.	36 MIN.	0-.230	10T	1.5T	1.15
	SS: Grade 36 Type 2	58-80	36 MIN.	0-.230	10T	1.5T	1.3
	SS: Grade 40	55 MIN.	40 MIN.	0-.230	12T	2T	1.25
	SS: Grade 45	60 MIN.	45 MIN.	0-.230	12T	2T	1.5
	SS: Grade 50	65 MIN.	50 MIN.	0-.230	12T	2.5T	1.6
	SS: Grade 55	70 MIN.	55 MIN.	0-.230	12T	3T	1.7
	HSLAS: Grade 45 Class 1	60 MIN.	45 MIN.	0-.180 .180-.230	8T 10T	1T 1.5T	1.5
	HSLAS: Grade 45 Class 2	55 MIN.		0-.180 .180-.230	8T 10T	1T 1.5T	
	HSLAS: Grade 50 Class 1	65 MIN.	50MIN.	0-.180 .180-.230	10T 12T	1.5T 2T	1.6
	HSLAS: Grade 50 Class 2	60 MIN.		0-.180 .180-.230	10T 12T	1.5T 2T	
	HSLAS: Grade 55 Class 1	70 MIN.	55 MIN.	0-.180 .180-.230	12T 12T	2T 2.5T	1.7
	HSLAS: Grade 55 Class 2	65 MIN.		0-.180 .180-.230	12T 12T	2T 2.5T	
	HSLAS: Grade 60 Class 1	75 MIN.	60 MIN.	0-.180 .180-.230	12T 14T	2.5T 3T	1.8
	HSLAS: Grade 60 Class 2	70 MIN.		0-.180 .180-.230	12T 14T	2.5T 3T	
	HSLAS: Grade 65 Class 1	80 MIN.	65 MIN.	0-.180 .180-.230	14T 14T	3T 3.5T	1.9
	HSLAS: Grade 65 Class 2	75 MIN.		0-.180 .180-.230	14T 14T	3T 3.5T	
	HSLAS: Grade 70 Class 1	85 MIN.	70 MIN.	0-.180 .180-.230	16T 16T	4T 5T	2.0
	HSLAS: Grade 70 Class 2	80 MIN.		0-.180 .180-.230	16T 16T	4T 5T	
	HSLAS-F: Grade 50	60 MIN.	50 MIN.	0-.230	10T	1.5T	1.5
	HSLAS-F: Grade 60	70 MIN.	60 MIN.	0-.180 OVER .180	8T 10T	1.5T 2T	1.6
	HSLAS-F: Grade 70	80 MIN.	70 MIN.	0-.180 OVER .180	10T 10T	2T 2.5T	1.8
	HSLAS-F: Grade 80	90 MIN.	80 MIN.	0-.180 OVER .180	10T 12T	2T 2.5T	2.0

MATERIAL	TYPE	TENSILE STRENGTH K.S.I.	YIELD STRENGTH K.S.I.	MATERIAL THICKNESS INCHES	NOMINAL VEE DIE OPENING	NOMINAL UPPER DIE RADIUS	FORMABILITY FACTOR
STAINLESS STEEL	302 304, 304L, 316, & 316L	80-90	30-40	0-.500 .500-1.000	8T 10T	1T 1.5T	1.3
ALUMINUM	3004-H34	35 TYP.	21 TYP	0-.125 .125-.188	8T 10T	1T 1.5-3T	0.6
	5052-H32	33 TYP.	28 TYP.	0-.031 .031-.062	8T 10T	1T 2T	0.7
	6061-T6	42 TYP.	37 TYP.	0-.031 .031-.062	8T 10T	1T 2T	0.8

In Jan of 2000 new ASTM Specifications A1008 & A1011 replaced several old ASTM Specifications. The chart shown here is a cross reference between the old and the new specifications.

ASTM SPEC.		
NO.	GRADE	PREVIOUS SPEC.
A1008 COLD ROLLED SHEET	CS Type A	
	CS Type B	A-366
	CS Type C	
	DS Type A	
	DS Type B	A-620
	DDS	A-963
	EDDS	A-969
	SS: Grade 25	A-611 GR A
	SS: Grade 30	A-611 GR B
	SS: Grade 33 Type 1	A-611 GR C Type 1
	SS: Grade 33 Type 2	A-611 GR C Type 2
	SS: Grade 40 Type 1	A-611 GR D Type 1
	SS: Grade 40 Type 2	A-611 GR D Type 2
	SS: Grade 80	A-611 GR E
	HSLAS: Grade 45 Class 1	A-607 GR 45 Class 1
	HSLAS: Grade 45 Class 2	A-607 GR 45 Class 2
	HSLAS: Grade 50 Class 1	A-607 GR 50 Class 1
	HSLAS: Grade 50 Class 2	A-607 GR 50 Class 2
	HSLAS: Grade 55 Class 1	A-607 GR 55 Class 1
	HSLAS: Grade 55 Class 2	A-607 GR 55 Class 2
	HSLAS: Grade 60 Class 1	A-607 GR 60 Class 1
	HSLAS: Grade 60 Class 2	A-607 GR 60 Class 2
	HSLAS: Grade 65 Class 1	A-607 GR 65 Class 1
	HSLAS: Grade 65 Class 2	A-607 GR 65 Class 2
	HSLAS: Grade 70 Class 1	A-607 GR 70 Class 1
	HSLAS: Grade 70 Class 2	A-607 GR 70 Class 2
	HSLAS-F: Grade 50	A-715 GR 50
	HSLAS-F: Grade 60	A-715 GR 60
	HSLAS-F: Grade 70	A-715 GR 70
	HSLAS-F: Grade 80	A-715 GR 80
A1011 HOT ROLLED SHEET	CS Type A	
	CS Type B	A-569
	CS Type C	
	DS Type A	
	DS Type B	A-622
	SS: Grade 30	A-570 GR 30
	SS: Grade 33	A-570 GR 33
	SS: Grade 36 Type 1	A-570 GR 36
	SS: Grade 36 Type 2	
	SS: Grade 40	A-570 GR 40
	SS: Grade 45	A-570 GR 45
	SS: Grade 50	A-570 GR 50
	SS: Grade 55	A-570 GR 55
	HSLAS: Grade 45 Class 1	A-607 GR 45 Class 1
	HSLAS: Grade 45 Class 2	A-607 GR 45 Class 2
	HSLAS: Grade 50 Class 1	A-607 GR 50 Class 1
	HSLAS: Grade 50 Class 2	A-607 GR 50 Class 2
	HSLAS: Grade 55 Class 1	A-607 GR 55 Class 1
	HSLAS: Grade 55 Class 2	A-607 GR 55 Class 2
	HSLAS: Grade 60 Class 1	A-607 GR 60 Class 1
	HSLAS: Grade 60 Class 2	A-607 GR 60 Class 2
	HSLAS: Grade 65 Class 1	A-607 GR 65 Class 1
	HSLAS: Grade 65 Class 2	A-607 GR 65 Class 2
	HSLAS: Grade 70 Class 1	A-607 GR 70 Class 1
	HSLAS: Grade 70 Class 2	A-607 GR 70 Class 2
	HSLAS-F: Grade 50	A-715 GR 50
	HSLAS-F: Grade 60	A-715 GR 60
	HSLAS-F: Grade 70	A-715 GR 70
	HSLAS-F: Grade 80	A-715 GR 80

CS	= COMMERCIAL STEEL
DS	= DRAWING STEEL
DDS	= DEEP DRAWING STEEL
EDDS	= EXTRA DEEP DRAWING STEEL
SS	= STRUCTURAL STEEL
HSLAS	= HIGH-STRENGTH LOW-ALLOY STEEL
HSLAS-F	= HIGH-STRENGTH LOW-ALLOY STEEL WITH IMPROVED FORMABILITY

STEEL CROSS REFERENCE CHART

ASTM SPEC			PRODUCER AND PRODUCT NAME					
NO.	GRADE	TYPE	ACME STEEL CO.	ALGOMA STEEL INC.	AK STEEL CORP.	BETHLEHEM STEEL CORP.	ISPAT INLAND STEEL CORP.	LTV STEEL CORP.
A242		STRUCTUAL	COR-TEN A & B			MAYARI R		
A514		QUENCH & TEMPER		ALGOMA 100		T-1 "T-1A, T-1B" N-A-XTRA		
A517		QUENCH & TEMPER				T-1 "T-1A, T-1B" N-A-XTRA		
A572	42 50 60 65	STRUCTUAL	A42Y0 A50Y0 A60YK A65YK	ALGOMA'S A572-42 ALGOMA'S A572-50 ALGOMA'S A572-60		A-572-42 A-572-50 A-572-60 A-572-65		LTV 42 XK M LTV 50 XK LTV 60 XK LTV 65 XF M
A588		STRUCTUAL	COR-TEN B	ALGOMA'S A588 GR A ALGOMA'S A588 GR B				
A606	SHEET	SHEET	COR-TEN A	ALGOMA'S A606 TYPE4		MAYARI R B45WK		
A633	A C D E	STRUCTUAL		ALGOMA'S A633 GR A ALGOMA'S A633 GR C ALGOMA'S A633 GR D		RQC-60(N)		
A656	50 60 70 80	PLATE		ALGOMA'S A656 GR50 ALGOMA'S A656 GR60		BETHSTAR 50 BETHSTAR 60 BETHSTAR 70 BETHSTAR 80		A656 Gr 50 A656 Gr 60 A656 Gr 70 A656 Gr 80
A1008	HSLAS: Grade 45 Class 1 HSLAS: Grade 45 Class 2	COLD ROLLED SHEET	A45Y0 A45YK	Cb/V 45	FORMABLE 45	B45X0 B45XK	INX-45	LTV 45 XK
	HSLAS: Grade 50 Class 1 HSLAS: Grade 50 Class 2		A50Y0 A50YK	Cb/V 50	FORMABLE 50	B50X0 B50XK	INX-50 HI-FORM 50	LTV 50XK
	HSLAS: Grade 55 Class 1 HSLAS: Grade 55 Class 2		A55Y0 A55YK	Cb/V 55	FORMABLE 55	B55XK	INX-55	
	HSLAS: Grade 60 Class 1 HSLAS: Grade 60 Class 2		A60Y0 A60YK	Cb/V 60	FORMABLE 65	B60XK	INX-60 HI-FORM 60	LTV 60XK
	HSLAS: Grade 65 Class 1 HSLAS: Grade 65 Class 2		A65YK	Cb/V 65				
	HSLAS: Grade 70 Class 1 HSLAS: Grade 70 Class 2		A70YK			B70XK	HI-FORM 70	
	HSLAS-F: Grade 50		A50XF	ALGOFORM 50B ALGOFORM 50F	FORMABLE 50	B50XF	HI-FORM 50	LTV 50 XF
	HSLAS-F: Grade 60		A60XF	ALGOFORM 60B ALGOFORM 60F	FORMABLE 60	B60XF	HI-FORM 60	LTV 60 XF
	HSLAS-F: Grade 70		A70XF			B70XF	HI-FORM 70	LTV 70 XF
	HSLAS-F: Grade 80		A80XF			B80XF		LTV 80 XF
A1011	HSLAS: Grade 45 Class 1 HSLAS: Grade 45 Class 2	HOT ROLLED SHEET	A45Y0 A45YK	Cb/V 45	FORMABLE 45	B45X0 B45XK	INX-45	LTV 45XK
	HSLAS: Grade 50 Class 1 HSLAS: Grade 50 Class 2		A50Y0 A50YK	Cb/V 50	FORMABLE 50	B50X0 B50XK	INX-50 HI-FORM 50	LTV 50XK
	HSLAS: Grade 55 Class 1 HSLAS: Grade 55 Class 2		A55Y0 A55YK	Cb/V 55	FORMABLE 55	B55XK	INX-55	LTV 55XK
	HSLAS: Grade 60 Class 1 HSLAS: Grade 60 Class 2		A60Y0 A60YK	Cb/V 60	FORMABLE 65	B60XK	INX-60 HI-FORM 60	LTV 60XK
	HSLAS: Grade 65 Class 1 HSLAS: Grade 65 Class 2		A65YK	Cb/V 65				
	HSLAS: Grade 70 Class 1 HSLAS: Grade 70 Class 2		A70YK			B70XK	HI-FORM 70	
	HSLAS-F: Grade 50		A50XF	ALGOFORM 50B ALGOFORM 50F	FORMABLE 50	B50XF	HI-FORM 50	LTV 50 XF
	HSLAS-F: Grade 60		A60XF	ALGOFORM 60B ALGOFORM 60F	FORMABLE 60	B60XF	HI-FORM 60	LTV 60 XF
	HSLAS-F: Grade 70		A70XF			B70XF	HI-FORM 70	LTV070 XF
	HSLAS-F: Grade 80		A80XF			B80XF		LTV 80 XF

STEEL CROSS REFERENCE CHART

ASTM SPEC			PRODUCER AND PRODUCT NAME				
NO.	GRADE	TYPE	NATIONAL STEEL CORP.	OREGAN STEEL IMILLS	ROUGE STEEL CO.	USX STEEL	WHEELING-PITT. STEEL CORP.
A242		STRUCTUAL	NAX-HIGH TENSILE	OREGON'S A242		COR-TEN A	
A514		QUENCH & TEMPER		OREGON'S A514 B, E, F, & H		T-1 T-1A T-1B	
A517		QUENCH & TEMPER		OREGON'S A517 B, E, F, & H		T-1 T-1A T-1B	
A572	42 50 60 65	STRUCTUAL	GLX-42W GLX-50W GLX-60W GLX-65W		A572-42 A572-50 A572-60 A572-65	EX-TEN 42 EX-TEN 50 EX-TEN 60 EX-TEN 65	PITT-TEN X-42W PITT-TEN X-50W
A588		STRUCTUAL	NAX WEATHERING	OREGON'S A588 A, B		COR-TEN B	
A606	SHEET	SHEET	NAX-HIGH TENSILE NAX WEATHERING			COR-TEN A	
A633	A C D E	STRUCTUAL		OREGON'S A633 A OREGON'S A633 C OREGON'S A633 D OREGON'S A633 E		USS 42N USS 50N USS 60N	
A656	50 60 70 80	PLATE	NAX-50 NAX-60 NAX-70 NAX-80	OREGON'S A656 50 OREGON'S A656 60 OREGON'S A656 70 OREGON'S A656 80		A656-50 A656-60 A656-70 A656-80	
A1008	HSLAS: Grade 45 Class 1 HSLAS: Grade 45 Class 2	COLD ROLLED SHEET	GLX-45W NAPAC-45		RSC HR45XK55 RSC HR45YK60	HR45XK60 EX-TEN 45	PITT-TEN X-45K PITT-TEN X-450
	HSLAS: Grade 50 Class 1 HSLAS: Grade 50 Class 2		GLX-50W NAPAC-50		RSC HR50XK60 RSC HR50YK65	HR50XK65 EX-TEN 50	PITT-TEN X-50K PITT-TEN X-500
	HSLAS: Grade 55 Class 1 HSLAS: Grade 55 Class 2		GLX-55W NAPAC-55		RSC HR55XK65 RSC HR55YK70	HR55XK65 EX-TEN 55	PITT-TEN X-55K PITT-TEN X-550
	HSLAS: Grade 60 Class 1 HSLAS: Grade 60 Class 2		GLX-60W NAPAC-60		RSC HR60XK70 RSC HR60YK75	HR50XK75 EX-TEN 60	PITT-TEN X-60K PITT-TEN X-600
	HSLAS: Grade 65 Class 1 HSLAS: Grade 65 Class 2		GLX-65W NAPAC-665		RSC HR65XK75 RSC HR65YK80	HR65XK80	
	HSLAS: Grade 70 Class 1 HSLAS: Grade 70 Class 2		NAPAC-70		RSC HR70XK80 RSC HR70YK85	HR70XK80	
	HSLAS-F: Grade 50		NAX-50		RSC HR50XF60 RSC HR50YF65	HR50XF60	PITT-TEN X-50F
			NAPAC-F-50		RSC CR50XF60 RSC CR50YF65	EX-TEN F50	
	HSLAS-F: Grade 60		NAX-60 NAPAC-F-60		RSC HR60XF70 RSC HR60YF75	HR60XF70 EX-TEN F60	PITT-TEN X-60F
	HSLAS-F: Grade 70		NAX-70 NAPAC-F-70		RSC HR70XF80 RSC HR70XF85	HR70XF80 EX-TEN F70	PITT-TEN X-70F
	HSLAS-F: Grade 80		NAX-80 NAPAC-F-80		RSC HR80XF90	HR80XF90 EX-TEN F80	PITT-TEN X-80F
A1011	HSLAS: Grade 45 Class 1 HSLAS: Grade 45 Class 2	HOT ROLLED SHEET	GLX-45W NAPAC-45		RSC HR45XK55 RSC HR45YK60	HR45XK60 EX-TEN 45	PITT-TEN X-45K PITT-TEN X-450
	HSLAS: Grade 50 Class 1 HSLAS: Grade 50 Class 2		GLX-50W NAPAC-50		RSC HR50XK60 RSC HR50YK65	HR50XK65 EX-TEN 50	PITT-TEN X-50K PITT-TEN X-500
	HSLAS: Grade 55 Class 1 HSLAS: Grade 55 Class 2		GLX-55W NAPAC-55		RSC HR55XK65 RSC HR55YK70	HR55XK65 EX-TEN 55	PITT-TEN X-55K PITT-TEN X-550
	HSLAS: Grade 60 Class 1 HSLAS: Grade 60 Class 2		GLX-60W NAPAC-60		RSC HR60XK70 RSC HR60YK75	HR50XK75 EX-TEN 60	PITT-TEN X-60K PITT-TEN X-600
	HSLAS: Grade 65 Class 1 HSLAS: Grade 65 Class 2		GLX-65W NAPAC-65		RSC HR65XK75 RSC HR65YK80	HR65XK80	
	HSLAS: Grade 70 Class 1 HSLAS: Grade 70 Class 2		NAPAC-70		RSC HR70XK80 RSC HR70YK85	HR70XK80	
	HSLAS-F: Grade 50		NAX-50		RSC HR50XF60 RSC HR50YF65	HR50XF60	PITT-TEN X-50F
			NAPAC-F-50		RSC CR50XF60 RSC CR50YF65	EX-TEN F50	
	HSLAS-F: Grade 60		NAX-60 NAPAC-F-60		RSC HR60XF70 RSC HR60YF75	HR60XF70 EX-TEN F60	PITT-TEN X-60F
	HSLAS-F: Grade 70		NAX-70 NAPAC-F-70		RSC HR70XF80 RSC HR70XF85	HR70XF80 EX-TEN F70	PITT-TEN X-70F
	HSLAS-F: Grade 80		NAX-80 NAPAC-F-80		RSC HR80XF90	HR80XF90 EX-TEN F80	PITT-TEN X-80F

Punching—Tons Required Per Hole For One Level Punching

Thickness		Hole Diameter														
Gauge	Inch	.125	.188	.250	.312	.375	.438	.500	.562	.625	.688	.750	.812	.875	.938	1.00
20	.036	.35	.53	.71	.88	1.1	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5	2.7	2.8
18	.048	.47	.71	.94	1.2	1.4	1.7	1.9	2.1	2.4	2.6	2.8	3.1	3.3	3.5	3.8
16	.060	.59	.89	1.2	1.5	1.8	2.1	2.4	2.7	2.9	3.2	3.5	3.8	4.1	4.4	4.7
14	.075	.74	1.1	1.5	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.4	4.8	5.2	5.5	5.9
12	.105	1.0	1.6	2.1	2.6	3.1	3.6	4.1	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.3
11	.120	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.7	8.3	8.8	9.4
10	.135	-	2.0	2.7	3.3	4.0	4.6	5.3	6.0	6.6	7.3	8.0	8.6	9.3	10.0	10.6
-	.188	-	2.8	3.7	4.6	5.5	6.5	7.4	8.3	9.2	10.2	11.1	12.0	12.9	13.8	14.8
-	.250	-	-	4.9	6.2	7.4	8.6	9.8	11.0	12.3	13.5	14.8	16.0	17.2	18.5	19.7
-	.375	-	-	-	-	11.1	13.0	14.8	16.6	18.5	20.3	22.1	24.0	25.8	27.7	29.5
-	.500	-	-	-	-	-	17.2	19.7	22.1	24.6	27.1	29.5	32.0	34.4	36.9	39.4
-	.625	-	-	-	-	-	-	-	-	30.8	33.8	36.9	40.0	43.0	46.1	49.2
-	.750	-	-	-	-	-	-	-	-	-	-	44.3	48.0	51.7	55.4	59.0

Punching mild steel plate–shear strength of 50,000 pounds per square inch. One ton = 2,000 pounds.

General

For many years it has been common practice to use a press brake for occasional punching jobs. The Punching Tonnage Chart shown above indicates the load required to punch round holes in ordinary mild steel. The tonnage is calculated by multiplying the area being sheared times the shear strength of the material. For example, the load required to punch a 2" diameter hole in 1/4" (.250") mild steel plate:

Diameter x π = the circumference of the circle.

Thickness x circumference = the area of material being sheared.

Use 50, 000 psi (25 tons/inch $^{2)}$ for mild steel.

Punching load = 2" x π x .250 x 25 tons/inch ^{2} = 39.25 tons.

The shear strength of steel can vary between 75% to 80% of the actual tensile strength of the material. To determine the load, it is best to use 80% of the actual tensile strength of the material. If a material has a 70,000 psi minimum tensile, it is best to add 15,000 psi to obtain the probable range of tensile strengths.

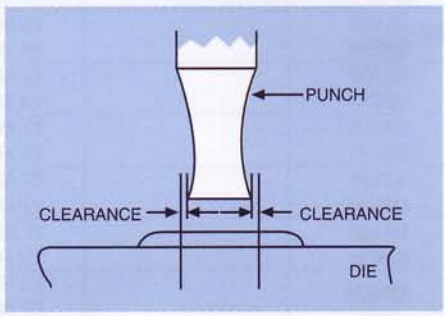


Figure 10—Clearance between punch and die

Clearance (Figure 10)

There must be clearance between the punch and die just as a shear has clearance between the upper and lower knives. The punch determines the hole size and should be made to the exact diameter that is required. The die button contains the hole diameter plus the necessary clearance. For best results on mild steel, the clearance between the punch and die at all points should be from 5% to 7% of the metal thickness. In other words, the die should be 10% to 14% of the metal thickness larger than the punch. The clearance could be different for various types of material.

Limitations of the Press Brake

Since punching consists of a shock load (rapid build up of force followed by an immediate release of the load as the material fractures) Cincinnati Incorporated recommends only using a punching load up to 2/3 of the maximum rating of the press brake when punching mild steel. This "punching" rating will normally allow sufficient safety to minimize abnormal machine maintenance.

Punching higher tensile (70,000 psi or higher) materials will require added considerations. The amount of penetration to punch a hole in high tensile steel is much less than the penetration in mild steel (e.g. mild steel = penetration of 1/3 metal thickness; higher tensile = penetration of only 15% of metal thickness). The buildup and release of the load is more rapid and has a greater shock effect on the press brake. Cincinnati Incorporated recommends limiting tonnage buildup to 1/2 of the maximum press brake capacity when high tensile steel is being punched. In punching applications where die sets are used or where special machine features (e.g. wide bed, deep throat, etc.) are required, consult Cincinnati Incorporated Engineering for an evaluation of the part involved.

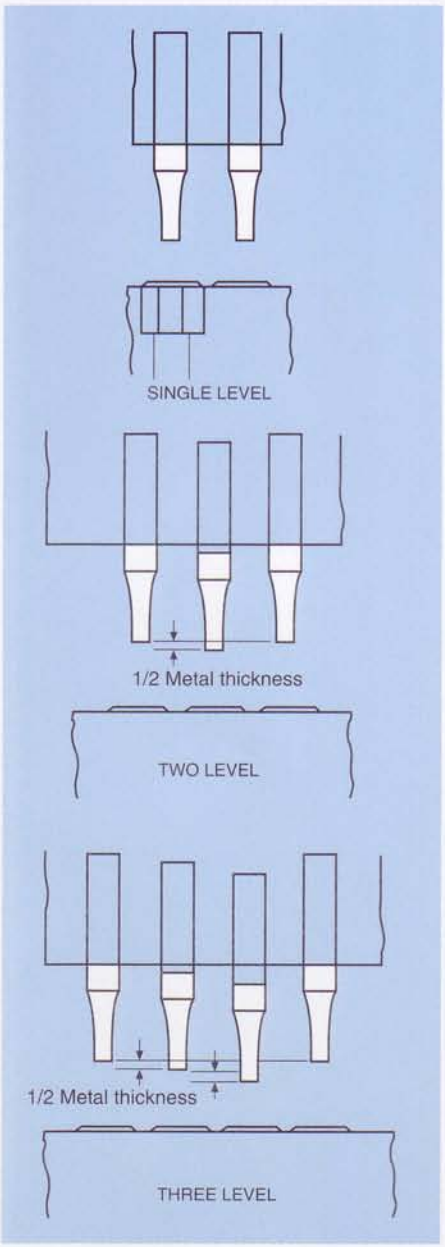


Figure 11—Stepping of punches

Stepping of Punches (Figure 11)

It has been found that if the number of holes to be punched results in the recommended punching rating of the press brake being exceeded, punches in the die set can be "stepped." If punches hit the metal at two levels, approximately 1/2 metal thickness apart, a maximum punching load can be built up, released, and a second load built up and released in the same stroke without damage to the press brake.

Stepping of the punches can be accomplished by making the punches different lengths, shimming under the punches, or making steps in the die set. The punching load must continue to be symmetrical.

Stripping the Metal from the Punches (Figure 12)

It is normal for sheet metal being punched to stick tightly to the punch as it moves upward after the hole is punched.

Note: *The punch must move downward through the metal to ensure the slug is pushed through the hole. Springs, metal hooks, polyurethane or rubber are normally used to strip the metal off the punch. This force takes from 2% to 5% of the punching force.*

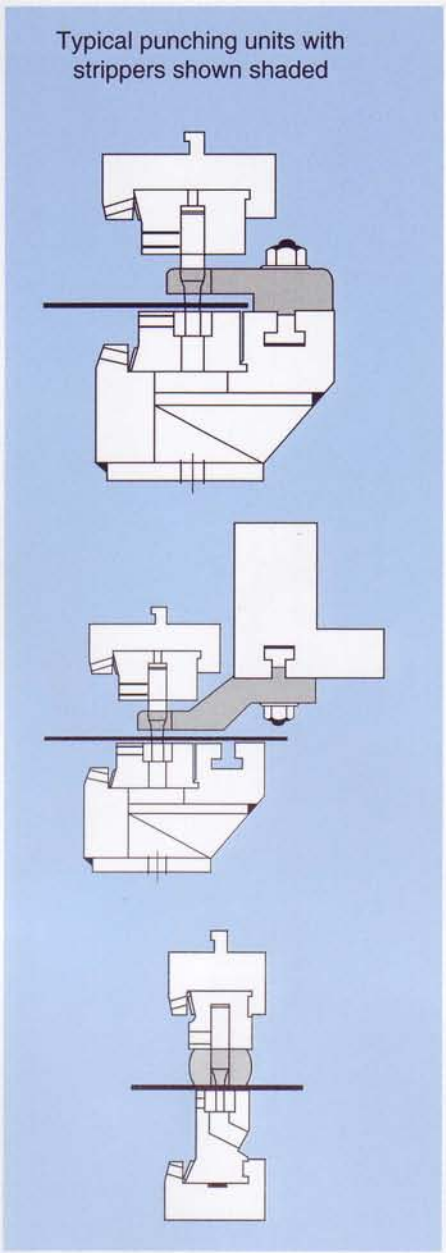


Figure 12—Stripping metal from the punches

The maximum stripping load of a press brake is limited to 10% of the punching capacity. Normally this is not a problem unless "stepping" is used. Then, all of the holes being punched in one stroke are stripped from the punches during the upstroke of the press brake. The stripping load will be a percentage of the entire punching load.

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