CURVED STEEL

A GUIDE FOR SPECIFIERS

AISC ASSOCIATE

There's always a solution in steel.

Developed by AISC's Committee on Bending and Rolling, this guide helps clarify terminology and geometry for specifying curved structural steel members. Being able to specifiy a curved piece of steel—and knowing that a detailer, fabricator, and bender-roller will be able to create that piece—is one step towards a successful curved steel project.

BENDING TERMS

	SECTION
Angles Leg Out	Inside Dia.
Angles Leg In	Outside Dia.
Flat Bar the Hard Way	Inside Dia.
Flat Bar the Easy Way	Inside Dia.
Square Bar	Inside Dia.
Beam the Easy Way (Y-Y Axis)	Mean Dia.
Beam the Hard Way (X-X Axis)	Inside Dia.
Channel Flanges In	Outside Dia.
Channel Flanges Out	Inside Dia.
Channel the Hard Way (X-X Axis)	Inside Dia.
Tee Stem In	Outside Dia.
Tee Stem Out	Inside Dia.
Tee Stem Up	Mean Dia.
Angle Heel In	Inside Dia.
Angle Heel Out	Outside Dia.
Square & Rectangular Tube	Inside Dia.
Round Tube & Pipe	Mean Dia.
Round Bar	Mean Dia.
Round Ball In	Outside Dia.
Round Ball Out	Inside Dia.
Round Ball Up	Mean Dia.

SPECIAL TYPES OF BENDING

Complex or special bends require special treatment when specifying dimensional components.

Off-axis bends, where material is rotated out of square in cross section, require the same basic dimensional components to be specified as simple bends with one additional requirement: a cross sectional or end view of the member showing a rotation in relation to the bend plane. This rotation can be specified by degree of rotation, or triangulated dimensioning to indicate rotation.

Multiple-axis bends, where material is bent in two planes (i.e. hard way and easy way) should be specified like simple bends with dimensional components for each plane of bend addressed separately.

S-curves, where bends occur in the same plane, but in opposite directions, should be specified with the same components as simple bends. Each curve in the member needs to have dimensional components specific to that curve separately addressed.

Spirals, where bend occurs in plan view with rise in elevation view, require dimensional components from both plan and elevation views. At a minimum the following components are required: radius in plan view, degree/angle of arc or arc length in plan view, degree of pitch in elevation view, and direction of rotation (i.e. clockwise or counter clockwise as member rises in elevation). These minimum components can be represented with other dimensions, but the bender-roller must be able to arrive at these minimums.

BENDING GEOMETRY

The graphic to the right depicts a simple single line drawing of the circular geometry components that relate to most bending applications. When specifying and detailing curved steel, there are a minimum number of components of this circular geometry that must be dimensionally specified. These components can be specified in different minimum combinations that will allow the bender-roller to generate other required information for processing. Some examples of the combinations are as follows:

Radius and Arc: The most basic information required for a bender-roller to curve steel.

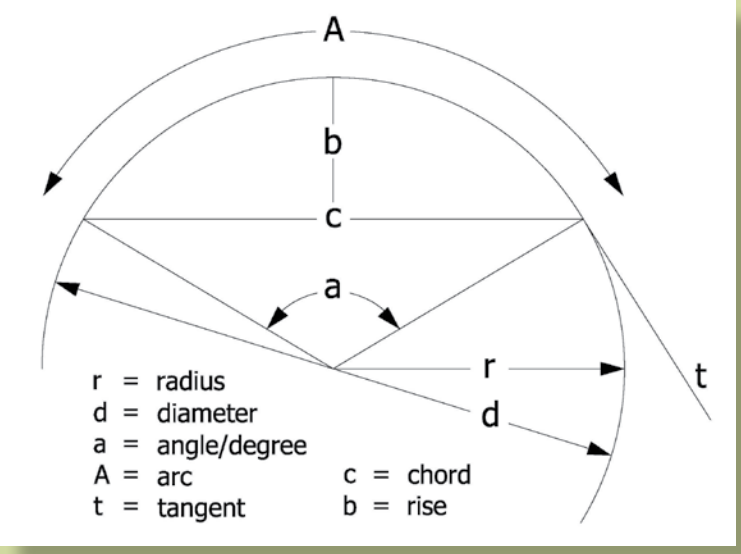
Chord and Rise: Both dimensions, taken from the same work points, allow the bender-roller to calculate radius and arc.

Radius and Degree/Angle: Degree/angle, in conjunction with bend radius, allows the bender-roller to calculate arc.

Radius and Chord: Both dimensions, taken from the same work points, allow the bender-roller to calculate degree/angle or arc.

Radius and Rise: Both dimensions, taken from the same work points, allow the bender-roller to calculate degree/angle or arc.

Additional information for bending may be required for processing depending on fabricated member requirements. For example, if tangents are required, the length of tangents needs to be provided separately from other dimensional components.



GLOSSARY OF BENDING TERMS

A

Arc: The curved portion of a bend.

Arc Length: The length of a bent/rolled surface.

B

Bend Radius: The arc of the bend itself, usually taken at the centerline. The distance from the center of curvature to the centerline (axis) of the pipe, expressed as a number multiplied by the pipe or tube size. For example, the bend radius of a 5 × D bend for a 2-inch nominal pipe size (NPS) pipe or a 2-inch tube is 10 inches (see **centerline radius**).

C

Center to Center: The distance between the theoretical or calculated centers of two adjoining bends on the same plane. Also used for diametric measurement between the centerlines of two tangent points of a bend (i.e. 180° bend, for which the center to center distance will be equal to twice the centerline radius).

Centerline Radius: The distance from the center of the curvature to the centerline (axis) of the pipe.

Chord: The straight distance measured between the centerline points of any two points of a bend.

Cold Bending ("Pyramid" Rolling): A steel member is placed in a machine and curved between three rolls.

D

Degree of Bend: The angle to which the bend is formed.

Diameter: A straight line passing through the center of a circle.

Distortion: A change from original shape and dimension. Note: Occurs in every rolled part to some degree.

Ductility: The ability of the material to deform without fracture. This is measured by elongation of reduction of area in a tensile test.

H

Hot Bending: Bending is achieved by applying heat directly to material by internal or external flame, or heating in a furnace.

I

Induction Bending: An electric coil heats a short section of a structural member, and then it is drawn through a process similar to rotary-draw and cooled with water directly after.

O

Off-Axis: Material rotated out of square in a cross sectional view.

Ovality: The distortion of the cross section of pipe or tube from its normal (round) shape usually expressed as a percentage of the difference between major and minor axis.

P

Point Bending/Gag Pressing: Bending is achieved by applying a select number of point loads at varying increments along the length of the steel member.

R

Radius: A line segment that joins the center of a circle with any point on the materials circumference (see **centerline radius**).

Rise/Mid Ordinate: The distance of offset between the mid point of a chord and an arc, perpendicular to the chord.

Rotary-Draw Bending: The structural material is clamped into a die and then drawn around the die and over a mandrel until the bend is formed.

S

S-Curve: Bends occur in the same plane, but in opposite directions.

Slope: Calculated as the rise over the run of a segment.

Spirals: Bends occurs in a plan view with rise in elevation view.

Synchronized Incremental Cold Bending: Performed by applying pressure in a highly synchronized fashion at several locations along the steel member.

T

Tangent: Straight section of material on either side of the bend or arc. May be any length. In order to make the bend itself, there has to be sufficient material at each end during the bending process. Excess may be trimmed after.

Tangent Point: The point at which the bend is started or ended.

W

Wall: The thickness of tubular material, usually expressed as "nominal" or "minimum."

Wall Thickness: The thickness of the material.

Wrinkles: Definite folds, creases or ripples formed on the surface of the pipe during bending operation.

Y

Yield Point: The point at which material will deform permanently during bending.

Yield Strength: The stress at which a material exhibits a specified deviation.

Do you have more questions about bending-rolling? Detailed questions regarding the visual appearance of a specific member with a specific bend and cost implications for a given configuration are best handled by contacting an AISC Associate Member bender-roller.

To find a bender-roller in your area, visit **www.aisc.org/benders** or call AISC's Steel Solutions Center at **866.ASK.AISC**.

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