

PIPE BENDING METHODS, TOLERANCES, PROCESS AND MATERIAL REQUIREMENTS

Prepared by
Pipe Fabrication Institute Engineering Committee



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METRIC CONVERSIONS

The conversion of quantities between systems of units involves a determination of the number of significant digits to be retained. All conversions depend upon the intended precision of the original quantity and are rounded to the appropriate accuracy.

Pipe sizes together with applicable wall thicknesses are not shown with metric equivalents.

The SI (metric) values were included with the customary U.S. values in this Standard are the rounded equivalents of the U.S. values and are for reference only.

Metric units were derived utilizing the following conversion factor:

Conversion	Factor
Inches to Millimeters	25.4
Lb/in ² to Kg/cm ²	0.0703

Conversion	Factor
Deg. Fahr. to Deg. Cent.	5/9 (Deg. F. – 32)

1. Scope

- 1.1 This standard covers methods, process requirements, tolerances and acceptance criteria for shop fabricated pipe bends.
- 1.2 The bending methods described in this standard are a partial representation of commonly used processes and do not preclude the use of other methods.

2. Terminology

- 2.1 The symbols and terms defined below are used throughout this standard:

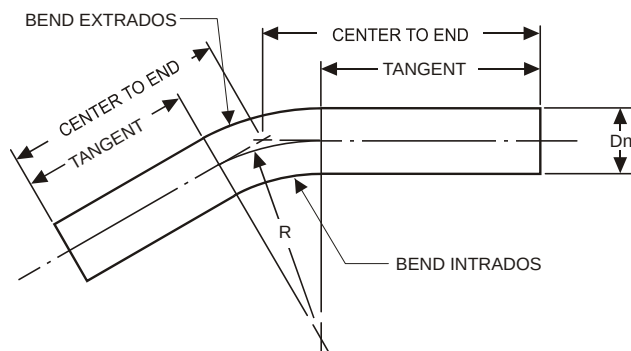


FIGURE 2.1

D = Nominal pipe size.

- Dn = Nominal outside diameter of pipe.
- tn = Nominal wall thickness of pipes.
- tm = Minimum calculated wall thickness required by the applicable code.
- T = Pipe wall thickness (measured or minimum, in accordance with purchase specification).
- R = Center line radius of bend.

3. Bending Methods

- 3.1 This standard covers bends formed by both hot and cold bending methods. For this standard, a temperature 100 degrees F below the lower critical temperature of the material is defined as being the boundary between hot and cold bending.
- 3.2 Unless otherwise specified by the governing code, the bending procedure, including the heating/cooling cycle and post bend heat treatment, is determined by the pipe material, diameter, wall thickness, bend radius and the required properties after bending. Because of the many variables involved, the bending procedure should be determined by the fabricator.

|Denotes Revision

3.3 While the bending equipment used in many of the methods is generically the same, there may be differences in bending procedures, material allowances, hold and pull legs, wall thickness, etc., between bending fabricators.

3.4 Hot bending methods

3.4.1 FURNACE BENDING:

In this method, the pipe is firmly packed with sand and then heated in a furnace to a temperature in the range of 2000 degrees F. After removing from the furnace, one end of the pipe is retained in a holding device and a bending moment is applied at the other end. The radius of the bend is controlled by dies, stops or templates as the pipe is bent. For long radius bends and/or heavy wall pipe, the sand filling operation may not be necessary.

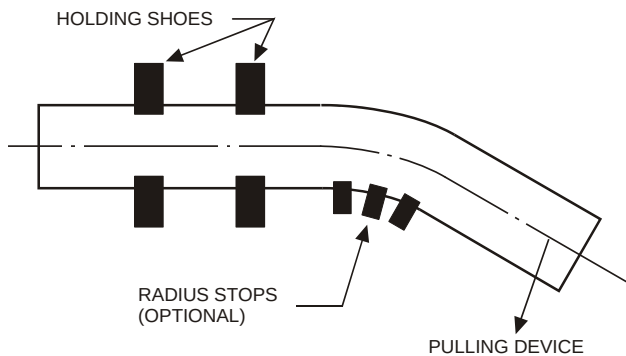


FIGURE 3.4.1
FURNACE BENDING

3.4.2 INCREMENTAL BENDING:

The incremental bending equipment is composed of an anchor box, a hydraulic cylinder, and a moveable heating device. The pipe is clamped in the anchor box and the front tangent is connected to the hydraulic cylinder. The heating device heats a narrow circumferential band on the arc to the proper bending temperature. A force is then applied by the hydraulic cylinder to bend the small increment a predetermined amount. The heating device is then moved to successive segments where the process is repeated until the required arc is attained. After bending each increment, the heated area is cooled as required by the appropriate bending procedure.

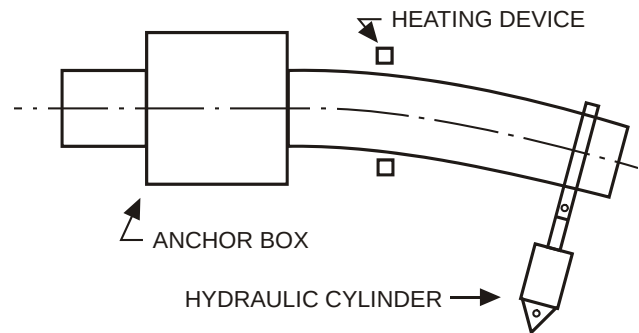


FIGURE 3.4.2
INCREMENTAL BENDING

3.4.3 INDUCTION BENDING:

The induction bending equipment is composed of three basic components consisting of a bed, a radial arm, which is set at the required radius, and an induction heating system. The pipe is placed in the bed and the front tangent is clamped to the radial arm. The induction heating system heats a narrow circumferential band around the pipe to the appropriate bending temperature. When this temperature is reached, the pipe is continuously moved through the heating coil while a bending moment is applied to the heated area. After passing through the coil, the pipe may be either forced or naturally cooled as required by the appropriate qualified bending procedure.

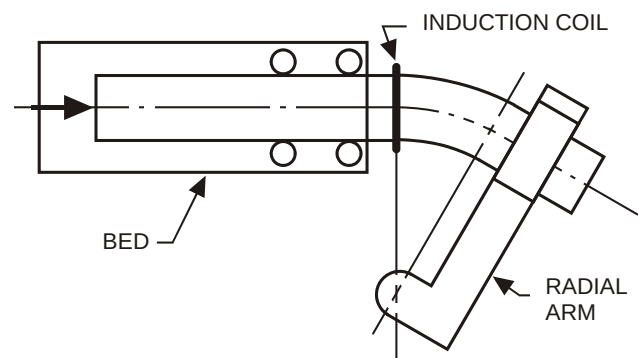


FIGURE 3.4.3
INDUCTION BENDING

3.5 Cold bending methods

3.5.1 ROTARY DRAW BENDING:

In this method, the pipe is secured to a bending die by a clamping die. As the bending die rotates, it draws the pipe against the pressure die and, if necessary to prevent wall collapse, over an internal mandrel. The pressure die may remain fixed or move with the pipe.

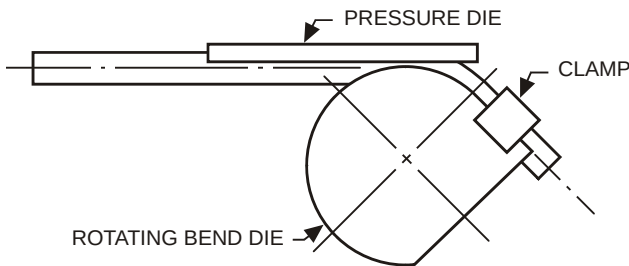


**FIGURE 3.5.1
ROTARY DRAW BENDING**

3.5.2 RAM BENDING:

In ram bending, the pipe is held by two supporting dies and a force is applied by means of a hydraulic ram to a forming shoe located at the center of the workpiece. The supporting dies rotate on their mounting pins so that they follow the pipe and maintain external support throughout the operation.

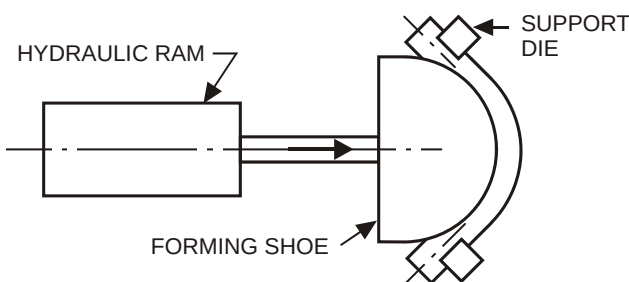


**FIGURE 3.5.2
RAM BENDING**

3.5.3 ROLL BENDING:

In roll bending, three forming rolls of approximately the same diameter arranged in a pyramid are used. The two fixed rolls oppose the adjustable center roll. The pipe is passed through the rolls with the position of the adjustable roll controlling the bend radius.

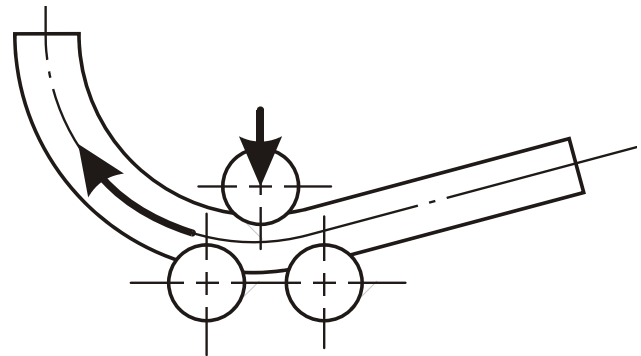


**FIGURE 3.5.3
ROLL BENDING**

4. Welds in Bends

4.1 In some instances it is not practical to utilize pipe of sufficient length to satisfy the required arc length of the bend. When it becomes necessary to join lengths of pipe resulting in a circumferential butt weld in the arc of a pipe bend, the following practices should be considered:

- 4.1.1 Pipes to be welded should be selected to provide the best uniformity possible at the mating ends. Pipe wall thickness shall not be less than the design minimum plus bend thinning allowance (see section 7.0).
- 4.1.2 End preparation for welding shall be in accordance with the qualified welding procedure to be used. Internal counterboring should be avoided wherever possible. During fit-up of the joint, the pipes should be rotated or aligned as necessary to provide the least amount of I.D. and/or O.D. mismatch and the best transition across the weld.
- 4.1.3 The welding procedure must be qualified in accordance with the governing Code for the thermal exposures, (if any) excepted in bending and heat treatment.
- 4.1.4 After completion of the circumferential butt weld, but before bending, the O.D. and I.D. (where accessible) of the weld should be ground to remove excess weld reinforcement and blended smoothly into the base metal.
- 4.1.5 It is good practice to examine the circumferential butt weld by radiography prior to and after bending, whether or not such radiography is required by the applicable Code.