Welcome to the Wall Chart. Scroll down to view the chart or go to a specific topic by clicking on the corresponding page icon on the left OR click on the button of another piece of literature you’d like to view.

Capabilities Brochure

Tooling and Techniques Guide

Tube and Pipe Bending Manual

Wall Chart

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THE DESIGN AND SET UP OF TOOLING

Typical Example:
2.0” O.D. x .065 Wall on 4” Centerline
Wall Factor 30 - 2 x “D” of Bend

1. **Bend Die**
   - Hardened tool steel or alloy steel, heat-treated and nitrided
   - Clamp insert is secured with cap screws and dowel pins
   - Drive key must be parallel to clamp insert
   - Bore should have a slip fit over centering ring or spindle
   - Note: Bend dies may have special tube grooves with captive lip or Empty-Bending®
   - Reference: TFB’s Tool Catalog

2. **Clamp Die**
   - Hardened tool steel or alloy steel, heat-treated and nitrided
   - Preferable length is 3½ x tube O.D.
   - Tube groove is grit blasted or may be serrated if less than preferred length
   - With tube held in bend die, advance clamp die and adjust for vertical alignment
   - Adjust for parallel contact with entire length of clamp
   - Adjust for pressure

3. **Pressure Die**
   - Alloy steel and nitrided
   - Tube groove must be parallel to back of die
   - If follower type pressure die is used, length equals 180° + 2 O.D.
   - If a boosted system is used, groove should be grit blasted
   - With tube clamped to bend die, advance pressure die and adjust for vertical alignment
   - Start with minimum pressure and increase as required in small increments

4. **Mandrel**
   - Type of mandrel and number of balls indicated by Tooling Selection Guide which is on back of this wall chart.
   - Aluminum/bronze, chrome, or Kro-Lon® mandrels for ferrous tubing.
   - Only chrome mandrels for non-ferrous materials
   - Gain best results with most mandrels when shank projects a small amount past tangent (bend & try)
   - Lube I.D. of each tube

5. **Wiper Die**
   - The Tooling Selection Guide (on back of this wall chart) indicates when a wiper may be required
   - Push tube over properly located mandrel and bring clamp and pressure dies up to bending position
   - Slide wiper along tube as far as possible into bend die then secure to holder
   - Unclamp pressure and clamp dies, tip of wiper should be “very close” to tangent
   - Adjust for rake and vertical alignment
   - Lube each tube and the wiper

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Mandrel Selection Guide on other side
**CORRECTIONS FOR POORLY BENT TUBES**

After the initial tooling set-up has been made, study the bent part to determine what tools to adjust to make a better bend. Keep in mind the basic bending principle of stretching the material on the outside radius of bend and compressing the material on the inside of bend. Make only one adjustment for each trial bend unless the second adjustment is very obviously needed. Avoid the tendency to first increase pressure die force rather than adjust the wiper die or mandrel location. Start with a clean, deburred and lubed tube with the elongation properties sufficient to produce the bend.

Note: There are certainly other corrections that could be made for the following problems. These illustrations are a few examples of how to “read” a bend and improve the tooling set-up.

1. **Problem**
   - Hump at end of bend.
   - **Correction**
     1) Adjust mandrel slightly back from tangent until hump is barely visible. This is also a good system to find the best location for the mandrel.
     2) Increase force on pressure die assist.

2. **Problem**
   - Tool marks on centerline of bend in clamp and pressure die area.
   - **Correction**
     1) Reduce pressure and clamp die forces.
     2) Oversized tube or undersized tube groove from bad tooling source.

3. **Problem**
   - Wrinkling throughout bend, even extending into wiper die area.
   - **Correction**
     1) Advance wiper die closer to tangent.
     2) Decrease rake of wiper die.
     3) Recut worn wiper by TFB.

4. **Problem**
   - Bad mark at start of bend and over bend for 90°.
   - **Correction**
     1) Removeable clamping portion of bend die not matched properly to round part of bend die.
     2) Clamping portion of bend die not parallel to the key way.

5. **Problem**
   - Wrinkles throughout bend area with wiper and mandrel in known proper position.
   - **Correction**
     1) Check for undersized mandrel.
     2) Increase pressure die force only after checking wiper fit and mandrel location.
     3) Reduce force on pressure die advance.

6. **Problem**
   - Excessive collapse with or without wrinkling throughout entire bend.
   - **Correction**
     1) Advance mandrel toward tangency until slight hump occurs (most mandrels must project somewhat past tangent).
     2) Need more balls on mandrel.

7. **Problem**
   - Mandrel ball humps.
   - **Correction**
     1) Too much drag on tube; back off pressure die force — increase wiper die rake.
     2) May require closer pitch mandrel ball assembly.
     3) Tubing material too soft.
     4) Increase force on pressure die assist.

8. **Problem**
   - Deep scratches throughout the bend and in wiper die area.
   - **Correction**
     1) Increase rake.
     2) Check for undersized mandrel.
     3) Increase pressure die force only after checking wiper fit and mandrel location.
     4) Reduce force on pressure die advance.
     5) Use more and/or a better lube.
     6) Recut galled tube groove at TFB.

9. **Problem**
   - Heavy wrinkles through bend area only and linear scratches in grip area indicating clamp slippage.
   - **Correction**
     1) Reduce pressure die force.
     2) Check location (and lube) of mandrel and wiper die.
     3) Increase pressure on clamp die.
     4) Use serrated or carbide spray in tube groove of clamp die.
### Tooling Selection Guide

**“D” of Bend =**

\[
\frac{\text{centerline radius}}{\text{tube outside diameter}}
\]

(2.0 C.L.R. ÷ 1.0” O.D. = 2 x D)

**Wall Factor =**  tube outside diameter / wall of tube

**NOTE:**
1. The Empty-Bending system (without a mandrel or wiper die) is recommended for applications above the dotted line.
2. A wiper die is recommended for applications below the dotted line.
4. All mandrels are available with lube holes and grooves and finished in chrome, Kro-Lon, AMPCO bronze.

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**KEY**
- P-Plug or Empty-Bending
- RP-Regular Pitch
- CP-Close Pitch
- UCP-Ultra Close Pitch
- No. indicates suggested number of balls

**NOTE**
- Wall Factor = tube outside diameter / wall of tube
- “D” of Bend = centerline radius / tube outside diameter

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