

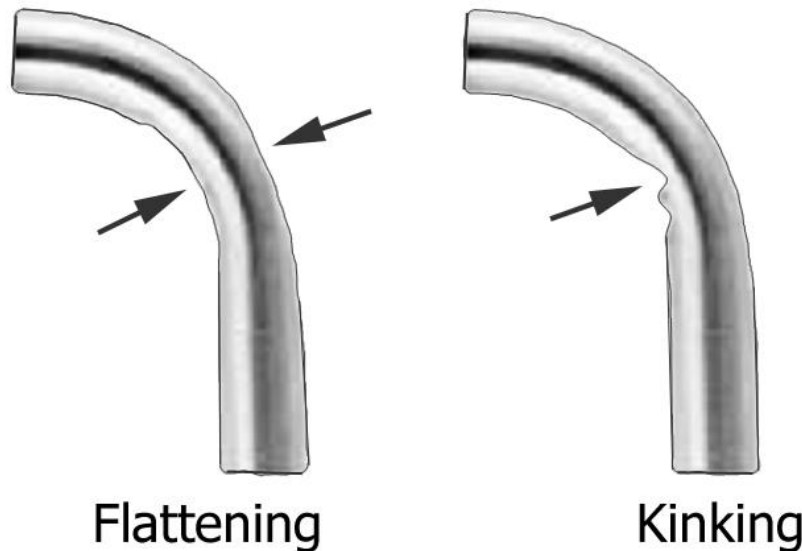
Tube Bending for Baja SAE

04-Jan-2020

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B.3.2 - Roll Cage Structure

The roll cage must be a space frame of tubular steel. The following section outlines the requirements of the physical members and joining methods of the roll cage. Roll cage and Frame Members must be fully welded, and welds must not be ground, sanded or modified so as to prevent inspection. **Roll Cage Members that are bent must not exhibit any wrinkles, kinks or any detrimental deformation to the cross-section.**



Contents:

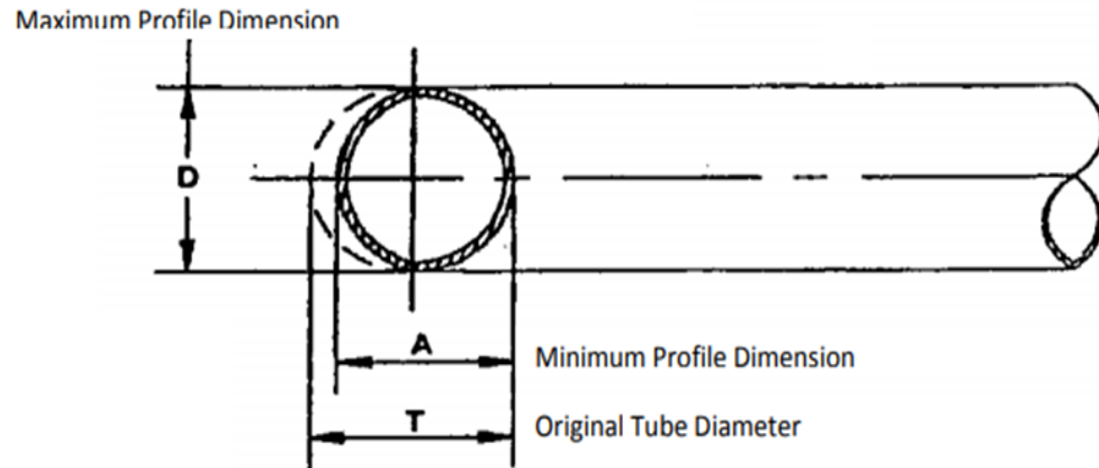
1. Ovality
2. Kinks
3. Humps
4. Wrinkles
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The purpose of this document is to provide guidance on allowable defects in bent members

1. Ovality

When bending, the outside diameter tends to pull toward the centerline, causing the tube to flatten around the bend. Excessive flattening, or ovality, should not occur.

$$\frac{\phi_{MAX} - \phi_{MIN}}{Nominal \phi} \leq 10\%$$



Possible Solution: Use a larger bend radius. CLR should exceed 4x the tube OD.

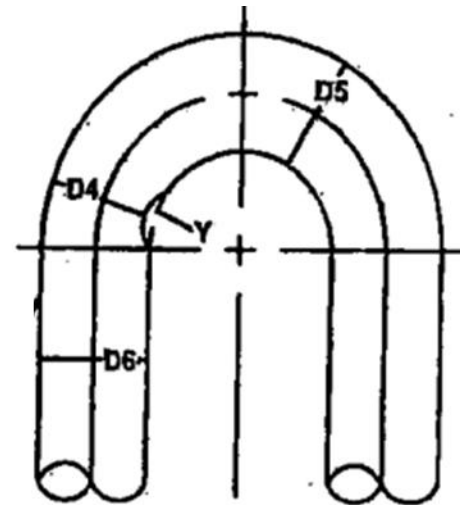
Ovality, or flattening, of a bend should not exceed 10%

2. Kinks

If a tube buckles, or kinks, on the inside of the bend, the material is unable to support the compression loads during bending. This is typically an indication of poor support for the bend, die slippage or an inappropriately adjusted wiper die.

$D6 - D4 = \text{Depth of Kink}$

$$\frac{D6 - D4}{D5} \leq 15\% \text{ of Nominal OD}$$



Possible Solutions:

- Adjust the pressure die closer to the tube or increase pressure on clamping device.
- The wiper die should be within 1/8 in. of the tangent, slightly raked away at the back.
- Check the tube wall thickness, variations occur, otherwise increase the thickness.

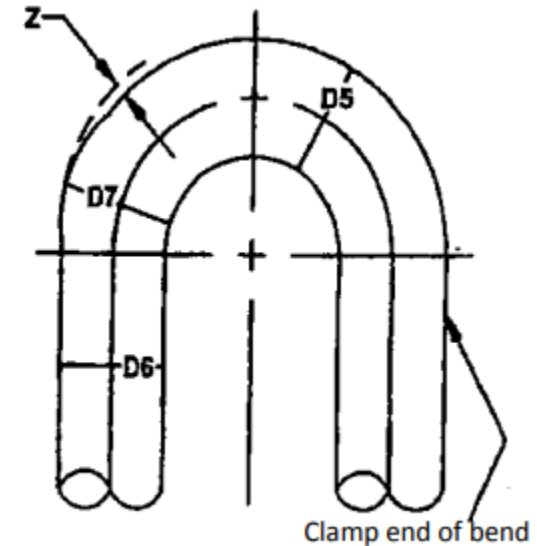
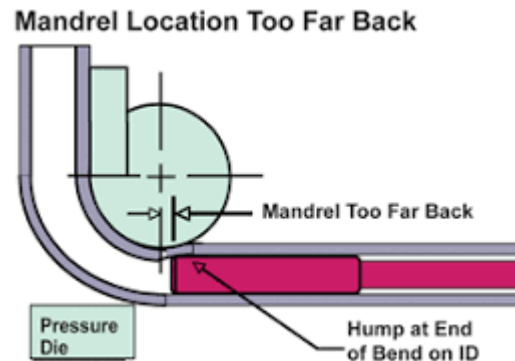
The depth of a kink should not exceed 15% of the nominal OD

3. Humps

Tube humps, or outward bulging of the tube near the tangent of the bend, can occur on the inside or outside of the bend. This is typically the result of poor mandrel positioning.

$$D7 - D6 = \text{Height of Hump}$$

$$\frac{D7 - D6}{D5} \leq 10\% \text{ of Nominal OD}$$



Possible Solutions:

- Bring the mandrel forward if the hump occurs on the inside of the bend. A straight portion of the mandrel should be at or just forward of the tangent.
- If the mandrel is too far forward, a hump will appear on the outside of the bend, near the end; move the mandrel farther back.

Hump height should not exceed 10% of the nominal OD

4. Wrinkles

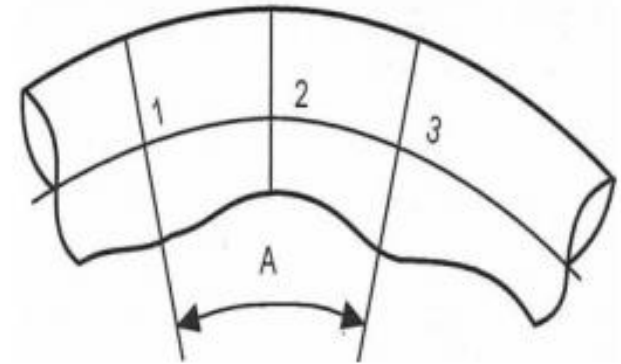
Wrinkles are caused by high levels of compressive force on the inside of a pipe or tube with thin wall thickness, coupled with insufficient support of the bending dies.

Average Depth =

$$\frac{1 + 3}{2} \leq 3\% \text{ of Nominal OD}$$

Distance between wrinkles:

$$A \geq 12 * \text{Average Depth}$$



Possible Solutions:

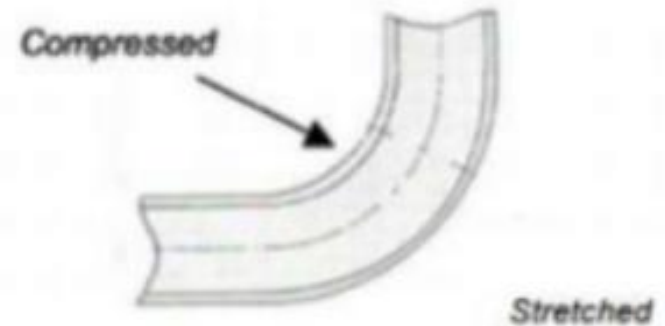
- Increase the clamping pressure in the dies.
- Reduce the clearance between the mandrel and the tube.
- Use less lubrication.

Wrinkling height should not exceed 3% of the nominal OD

5. Thinning

Bending operations put the outside of the bend in tension and the inside in compression. As a result, the outside of a bend tends to thin. Wall thinning is directly related to bend centerline radius. Smaller radii produce higher stresses and more thinning.

C.L.R.	Tube OD	
	1.00	1.25
3	14%	18%
5	9%	11%
8	6%	7%



CLR < 4 results in excessive thinning

Possible Solutions:

- Use a larger bend centerline radius. CLR should exceed 4x the tube OD.
- Support the inside diameter, using a mandrel.

**Thinning is expected, but should not exceed the metric above.
(Approximately <11%)**