In general, the minimum bending radii should not be less than:

- 25 D for pipe NPS of less than 8”
- 30 D for pipe NPS of 8” to 16”
- 40 D for pipe NPS of over 16”

Pipe outer diameter

$$D := 16\ \text{in} = 0.4064\ \text{m}$$

Degrees in (θ)D

$$\theta := 60\ \text{deg}$$

Step length per dgree (S)

$$S := \left| \theta \cdot D \right| = 0.4256\ \text{m}$$

Step length per 1/2 degree (s, 1/2 deg)

$$S_{.5} := \frac{S}{2} = 0.2128\ \text{m}$$

Degrees of bending

$$Degree := 90\ \text{deg}$$

Bend length needed

$$B := S \cdot \frac{Degree}{1\ \text{deg}} = 38.3023\ \text{m}$$

Length of the pipe

$$L_p := 11.750\ \text{m}$$

Spool Length

$$Spool := L_p - 2\ \text{m} - 2\ \text{m} = 7.75\ \text{m}$$

Number of steps

$$DPP := \frac{Spool}{S} = 18.2104$$

Number of pipes

$$NOP := \frac{B}{Spool} = 4.9422$$

Round number of pipes to a natural number

$$\text{round}\left(NOP,\ 0 \right) = 5$$

Bend thinning calculations shall be performed. Recommended formula for calculating bend thinning is as below.

bend thinning % = 50/(n+1)%

t_b = (1-bend thinning) x t

where,

t= nominal thickness.

n= inner bend radius/pipe outer diameter.

t_b = pipe wall thickness after bending.

ε: Bending strain in outer fibre

$$\varepsilon := \frac{D}{\frac{2 \cdot \theta \cdot D}{\text{deg}}} = 0.0083$$

t: nominal thickness

$$t := 10.5 \text{ mm}$$

Inner bend radius

$$R_i := \frac{\left(\theta \cdot D\right)}{1 \text{ deg}} - \frac{D}{2} = 24.1808 \text{ m}$$

Ratio

$$n := \frac{R_i}{D} = 59.5$$

Bend thinning percentage

$$BT := \frac{50}{\left(n + 1\right)} = 0.8264$$

Pipe wall thickness after bending

$$t_b := \left(1 - \frac{BT}{100}\right) \cdot t = 10.4132 \text{ mm}$$

Diffrence between original thickness and thickness after bending at expansion

$$\Delta t := t - t_b = 0.0868 \text{ mm}$$

Inner diameter

$$ID := D - 2 \cdot t = 385.4 \text{ mm}$$

Guaging plate diameter

$$GPD := 97.5 \text{ \%} \cdot ID = 375.765 \text{ mm}$$