Operating temperature	130 °C
Operating Pressure	6.9 E+05 N/m^2
Line size	12" (0.3239 m)
Line thickness	STD (0.00953 m)
Fluid	Steam condensate (Bulk modulus, K = 2.15806E+09 N/m^2)
Fluid velocity (V)	3.43 m/s
Fluid density	930 kg/m^3
Pipe material	A106-Gr.B (Modulus of elasticity, E = 2.07E+11 N/m^2 & Density =7833 kg/m^3)

APPROACH -2

"c" is calculated as below

$$c = \sqrt{\frac{K}{\rho + \rho\left(\frac{K}{E_{ml}}\right)\left(\frac{D_{int}}{T}\right)}}$$

$$= \sqrt{\frac{2.15806\,E{+}09}{930 + 930\left(\frac{2.15806\,E{+}09}{2.07E{+}11}\right)\left(\frac{0.30484}{0.00953}\right)}}$$

$$= 1319.15 \text{m/s}$$

Calculation of pressure rise (ΔP) $= \rho * c * \Delta V$

= 930 * 1319.15 * 3.43

= 4.2 E+06 N/m^2

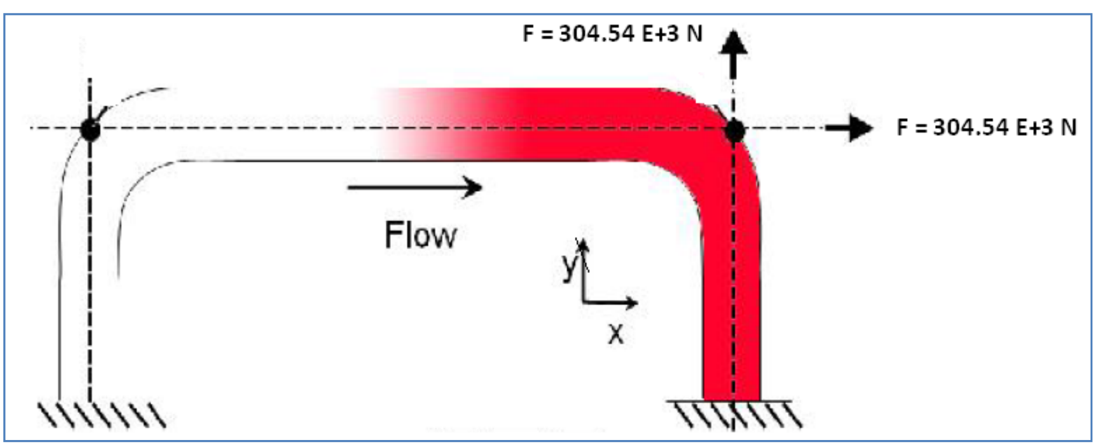
Where "ΔV" is Change in velocity = 3.43 m/s (Fluid flow to stop equal to Fluid velocity)

Calculation of unbalanced water hammer force (F) = ΔP × (Flow area)

$$= \Delta P * \left[\frac{\pi}{4} D_{int}^2\right]$$

$$= 4.2\text{ E+06} * \left[\frac{\pi}{4} 0.30484^2\right]$$

= 304.54 E+03 N



Considered both positive and negative impulse loads.

APPROACH -1

Total Pressure = P_Steady State + P_Transient(delta P)

= 6.9E+5 + 4.2E+6

= 4.59E+6 N/m2

Calculation of Total force acts on the elbow = P * A

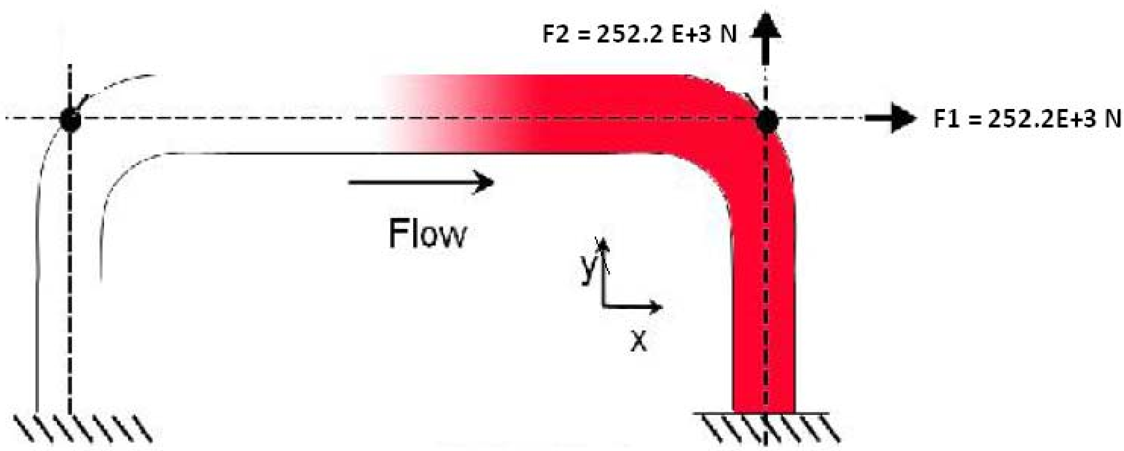
= 4.59E+6 * pi() * (0.3048^2) / 4

= 356.8E+3 N

Considering 90 deg Bend, Resolving force into two directions

F1= Sin 45 * 356.8E+3 = 0.707 * 356.8E+3 =252.25E+3 N

F2= Cos 45 * 356.8E+3 =0.707 * 356.8E+3 =252.25E+3 N



Difference In forces from approach 1 & 2 => 304.54 E+3 - 252.2 E+3 = 52340 N