Forces Due To Pipe Bends

The momentum change and the unbalanced internal pressure of the water leads to forces on the pipes.

The force diagram in figure is a convenient method for finding the resultant force on a bend. The forces can be resolved into X and Y components to find the magnitude and direction of the resultant force on the pipe.

\[ V_1 = \text{velocity before change in size of pipe, ft/s (m/s)} \]
\[ V_2 = \text{velocity after change in size of pipe, ft/s (m/s)} \]
\[ p_1 = \text{pressure before bend or size change in pipe, lb/ft}^2 \text{ (kPa)} \]
\[ p_2 = \text{pressure after bend or size change in pipe, lb/ft}^2 \text{ (kPa)} \]
\[ A_1 = \text{area before size change in pipe, ft}^2 \text{ (m}^2) \]
\[ A_2 = \text{area after size change in pipe, ft}^2 \text{ (m}^2) \]
\[ F_{2m} = \text{force due to momentum of water in section 2 } V_2 Q \frac{w}{g} \]
\[ F_{1m} = \text{force due to momentum of water in section 1 } V_1 Q \frac{w}{g} \]
\[ P_2 = \text{pressure of water in section 2 times area of section 2 } p_1 A_1 \]
\[ P_1 = \text{pressure of water in section 1 times area of section 1 } p_1 A_1 \]
\[ w = \text{unit weight of liquid, lb/ft}^3 \text{ (kg/m}^3) \]
\[ Q = \text{discharge, ft}^3/\text{s (m}^3/\text{s)} \]
If the pressure loss in the bend is neglected and there is no change in magnitude of velocity around the bend, then

\[ R = 2A[(wV^2/g) + p] \cos \text{ of angle between pipes} \]

where \( R \) resultant force on bend, lb (N)

\[ p = \text{pressure, lb/ft}^2 (\text{kPa}) \]
\[ w = \text{unit weight of water, 62.4 lb/ft}^3 (998.4 \text{ kg/m}^3) \]
\[ V = \text{velocity of flow, ft/s (m/s)} \]
\[ g = \text{acceleration due to gravity, 32.2 ft/s}^2 (9.81 \text{ m/s}^2) \]
\[ A = \text{area of pipe, ft}^2 (\text{m}^2) \]

Source: http://www.engineeringcivil.com/forces-due-to-pipe-bends.html