

Piping Design Loads

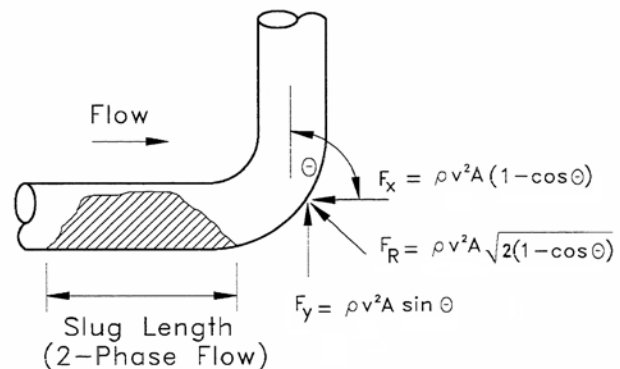
Occasional Loads (Slug Flow)

In general, when fluid changes direction in a piping system, it is balanced by the net force on the elbow. This force, shown in Figure, is equal to the change in momentum with respect to time, or:

$$F = dp / dt = \rho v^2 A \cdot \sqrt{(1 - \cos \Theta) \cdot 2}$$

Where:

- dp = change in momentum, lb-sec
- dt = change in time, sec
- ρ = fluid density, lbm/in³
- v = fluid velocity, in/sec
- A = internal area of pipe, in²
- θ = angle of the bend, degrees



- Assume rise time is set by the slug coming around the bend:
 $T_{rise} = \pi \cdot R / 2v$
- **Maximum** duration is a function of leg length (if the slug is longer than the leg, the component in the direction of the leg will be balanced by the same component on the following leg:
 $duration(Leg) = Leg/v$
- But duration is limited by slug length:
 Assume minimum slug length = 2*ID & maximum slug length = 8*ID
- Slug loads typically move through a piping system like water hammer and steam hammer loads but do not reflect from end boundary conditions.
- Slug loading on an individual elbow, therefore, is generally only a single application load that can be readily treated in mechanical piping system analysis by the application of a Dynamic Load Factor, usually equal to 2.0.
- The velocity of the slug is probably the most important mechanical design parameter. Overly conservative values produce excessively conservative forces as a function of the slug velocity squared. For this reason an accurate prediction of the slug velocity is important.
- Slugs can exist due to a number of conditions, a few of which are:
 - ✓ Steam condensate collection in low areas, and/or trap malfunction
 - ✓ Two-phase flow lines
 - ✓ Firewater pumping systems. (Firewater is pumped into an empty system.)
 - ✓ Emergency systems where liquid is evacuated rapidly into an empty line.
 - ✓ Liquid products injected into a vapor line or vice-versa.
 - ✓ Control or operation errors and incorrect shutdown and startup procedures.
 - ✓ Flare systems collecting multiple process flows.