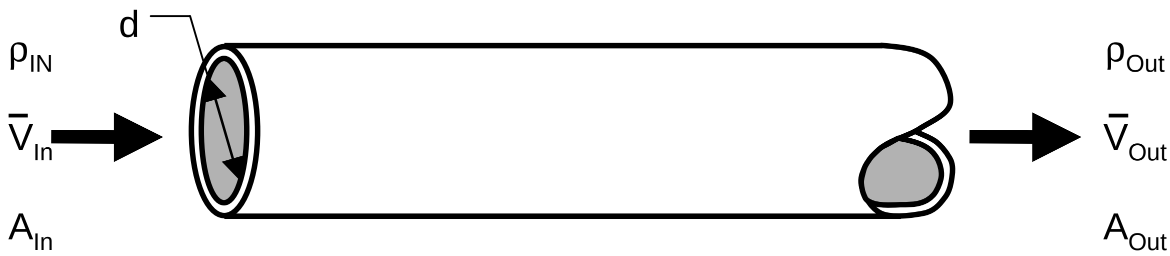
Reynolds Number & Pipe Flow



$$Re = \frac{\rho \bar{V} d}{\mu} = \frac{\rho \left(\frac{Q}{A}\right) d}{\mu} = \textbf{Unitless Number}$$

$$= \frac{\rho \bar{V} d}{\mu} = \frac{\left(\frac{\dot{m}}{Q}\right) \bar{V}\ d}{\mu} = \frac{\left(\frac{\dot{m}}{A \bar{V}}\right) \bar{V} d}{\mu} = \frac{\left(\frac{\dot{m}}{A}\right) d}{\mu}$$

The Reynolds (Re) number is a quantity which engineers use to estimate if a fluid flow is laminar or turbulent. This is important, because increased mixing and shearing occur in turbulent flow. This results in increased viscous losses which affects the efficiency of hydraulic machines.

A good example of laminar and turbulent flow is the rising smoke from a cigarette. The smoke initially travels in smooth, straight lines (laminar flow) then starts to “wave” back and forth (transition flow) and finally seems to randomly mix (turbulent flow). These ranges are discussed below.

RANGE 1: Laminar Flow (see diagram below)
Generally, a fluid flow is laminar from Re = 0 to some critical value at which transition flow begins.

RANGE 2: Transition Flow (see diagram below)
Flows in this range may fluctuate between laminar and turbulent flow. The fluid flow is on the verge of becoming turbulent.

RANGE 3: Turbulent Flow (see diagram below)
The fluid flow has become unstable. In turbulent flow, there is increased mixing that results in viscous losses which are generally much higher than in those in laminar flow.

NOTE: The Re at which turbulent flow begins depends on the geometry of the fluid flow. The value is different for pipe flow and external flow (i.e. over/outside and object). Since we are studying fluid flow in hydraulic systems, WE WILL CONSIDER ONLY INTERNAL FLOWS (PIPE FLOWS).

Streamlines In Laminar, Transition, and Turbulent Flow Regimes In Pipe Flow:

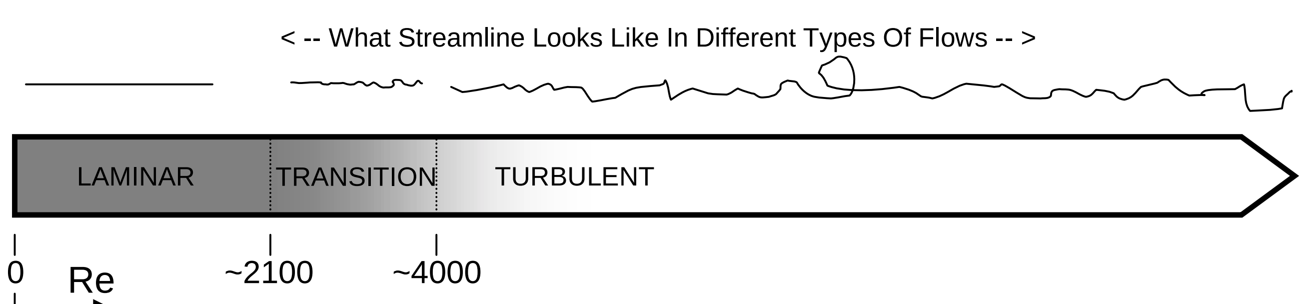


Diagram of Flow Regimes in Pipe Flow