Limitations on the Use of the Bernoulli Equation

1. **Steady flow** The Bernoulli equation is applicable to *steady flow*.
2. **Frictionless flow** Every flow involves some friction, no matter how small, and *frictional effects* may or may not be negligible.
3. **No shaft work** The Bernoulli equation is not applicable in a flow section that involves a pump, turbine, fan, or any other machine or impeller since such devices destroy the streamlines and carry out energy interactions with the fluid particles. When these devices exist, the energy equation should be used instead.
4. **Incompressible flow** Density is taken constant in the derivation of the Bernoulli equation. The flow is incompressible for liquids and also by gases at Mach numbers less than about 0.3.
5. **No heat transfer** The density of a gas is inversely proportional to temperature, and thus the Bernoulli equation should not be used for flow sections that involve significant temperature change such as heating or cooling sections.
6. **Flow along a streamline** Strictly speaking, the Bernoulli equation is applicable along a streamline. However, when a region of the flow is *irrotational* and there is negligibly small *vorticity* in the flow field, the Bernoulli equation becomes applicable *across* streamlines as well.

Hydraulic Grade Line (HGL) and Energy Grade Line (EGL)

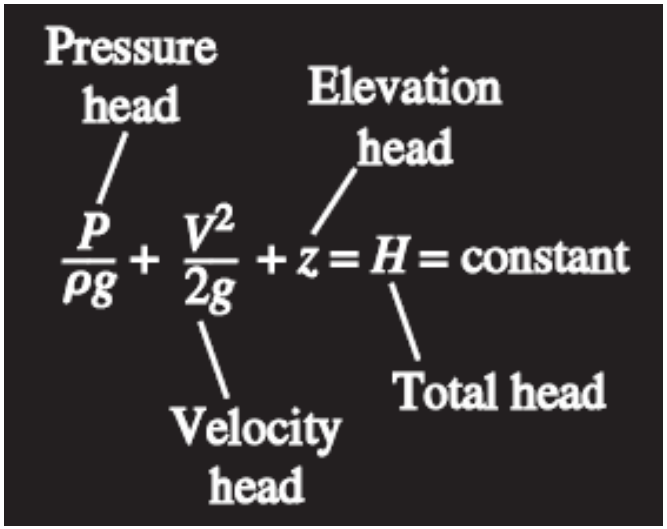
It is often convenient to represent the level of mechanical energy graphically using *heights* to facilitate visualization of the various terms of the Bernoulli equation. Dividing each term of the Bernoulli equation by g gives

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = H = \text{constant} \qquad \text{(along a streamline)}$$

***P*/ρ*g* is the pressure head;** it represents the height of a fluid column that produces the static pressure P.

***V*²/2*g* is the velocity head;** it represents the elevation needed for a fluid to reach the velocity V during frictionless free fall.

***z* is the elevation head;** it represents the potential energy of the fluid.



An alternative form of the Bernoulli equation is expressed in terms of heads as: ***The sum of the pressure, velocity, and elevation heads is constant along a streamline*.**