

**Advanced Topic:**  
**Filament Environment**

It is desirable to operate the filament at a high temperature, but the evaporation of the tungsten must be minimized to increase the lifetime of the filament and to prevent deposits of tungsten on the inside of the bulb, which darkens the bulb. Recall that evaporation is caused by some molecules of a substance having greater energies than others, thus enabling them to break away from the surface. This process can be hindered by placing molecules of another substance near the surface. This effect also causes water to boil at lower temperatures at high altitudes where the air pressure is lower, where the density of air molecules is lower, making evaporation easier. The evaporation from a tungsten filament can be reduced by filling the lamp bulb with an inert gas that will not cause oxidation of the filament. Typically, a mixture of nitrogen and argon is used.

The filling gas conducts some heat away from the filament, causing a reduction in efficiency. Most lamps above 25 W operate in a gas, because the lower rate of filament evaporation offsets the heat loss caused by the gas. Most lamps 25 W and below operate in a vacuum because the reduced heat loss offsets the higher rate of filament evaporation.

The filling gas is introduced into the lamps at slightly less than atmospheric pressure. When the lamp operates, the pressure rises to about atmospheric pressure, in accord with the ideal gas law. For a 100 W lamp operating in the vertical position, the temperature of the bulb surface is about 230 C at the top, 100 C at the center and 50 C at the base.