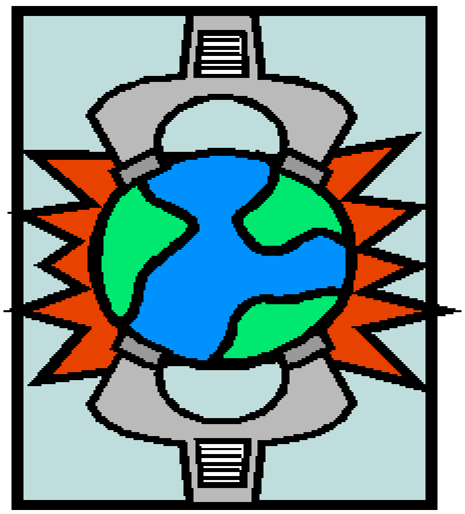
Technical Tidbit
Vapor pressure units of measure

On more than one occasion AristaTek has been asked the question, "Why do you display the vapor pressure of chemicals in units of atmospheres (atm) rather than mm of Hg or inches of water or pounds per square inch?"

It's a good question and deserves an explanation, which we'll address. To begin the explanation we first look at the definition of vapor pressure as provided in the PEAC-WMD 2002 User's Guide.



Vapor pressure The pressure exerted when a solid or liquid is in equilibrium with its own vapor. Higher values indicate greater volatility or evaporation rate. If 1 atmosphere and 68°F are considered standard conditions, a substance that has a boiling point less than 68°F will have a vapor pressure greater than 1 atmosphere. Substances with high vapor pressures are typically stored under pressure and are sometimes referred to as condensed or liquefied compressed gases. If released into the atmosphere, they will rapidly produce vapor and sometimes aerosols.

The first part of this definition is the technical description of what vapor pressure represents, i.e., that all liquids and some solids have a vapor pressure, (for all practical purposes vapor pressures for most solids are so low as to be considered non-existent). This vapor pressure is what causes a liquid to evaporate when released from its container or causes a solid to sublime.

Chemicals in the liquid state will exert their vapor pressure whether or not they are in their containers. When in a container, they reach a state of equilibrium where some of the molecules change from the liquid phase to the vapor phase and other molecules go from the vapor phase to the liquid phase. When the chemical is outside of the container the molecules that go from the liquid phase to the vapor phase simply mix with the atmosphere and over time will move away from the surface of the liquid. As the molecules move to the vapor phase the liquid evaporates and in time will be depleted. Faster air movement across the liquid surface and high temperatures will increase the rate of evaporation. The ***rough rule of thumb*** is the greater the vapor pressure the greater the tendency a material has to become a gas or vapor and the faster it will evaporate. There are other factors besides vapor pressure that dictate or control the evaporation rate.

The second portion of the definition provides an explanation as to how a material will behave depending on their vapor pressure and what is considered standard conditions. Standard conditions usually relate to the "standard temperature and pressure". The typical standard conditions are a temperature of 68°F (20°C) and a barometric pressure of 1 atmosphere at sea level or 14.696 pounds per square inch (psi). It's this last part of the standard conditions, the pressure and the units that sometimes cause problems or confusion.

When the PEAC tool was first developed it was debated what units were best or most appropriate for displaying the vapor pressure. It became obvious in discussions and inquires made with different responders that there didn't seem to be a consistent unit of measurement used for vapor pressure. The decision was made to use atmospheres (atm) since this was probably the easiest method to describe to a responder how the chemical being displayed behaved when released from its container.

Chemicals whose vapor pressure is greater than 1 atmosphere must be stored under pressure at standard conditions or under refrigeration, or both. Refrigeration reduces the temperature, which lowers the vapor pressure and allows the material to be stored at a lower pressure.

A chemical whose vapor pressure is less than 1 atmosphere will still evaporate or sublime when removed from its container. Using the ***rough rule of thumb***, the nearer the material's vapor pressure is to 1 atm the faster it would evaporate. The lowest value used for storing vapor pressures in the PEAC database is 0.01 atm. This corresponds to a vapor pressure of 0.14696 psi or 7.6 mm of Hg or 10.33 inches of water.

For "real-world" comparison, water has a vapor pressure of 17.535 mm of Hg at 68°F (20°C). This corresponds to 0.0231 atm or 0.3391 psi or 23.84 inches of water. If a chemical has a vapor pressure less than 0.01 atm the ***rough rule of thumb*** would suggest the material is going to evaporate slower than water. Conversely if the chemical's vapor pressure is much higher than this, the material will probably evaporate quicker than water and if toxic, may present a hazard from the standpoint of creating a toxic vapor cloud. A common example used when demonstrating the PEAC PAD calculator is to look at Bromine. Bromine has a boiling point of 139°F and its vapor pressure is 0.23 atm at 69°F. It will evaporate faster than water and with an IDLH of 3 ppm, it presents a hazard with regards to a toxic vapor cloud.

Knowledge of a chemical's vapor pressure is essential when dealing with a chemical spill. If a hypothetical chemical has a vapor pressure of 0.01 atm at 68°F, with sufficient chemical present in a closed room, i.e., where there is no air exchange with the outside air, the chemical would evaporate until it reached equilibrium and potentially reach a concentration of 10,000 ppm or 1% by volume.

For reference the following conversions factors are provided:

1 atm = 14.696 psi = 1033.26 inches of water = 760 mm of Hg = 33.8995 feet of water

1 psi = 0.06805 atm = 70.309 inches of water = 51. 715 mm of Hg = 2.3067 feet of water

1 mm of Hg = 0.001316 atm = 0.01934 psi = 1.3596 inches of water = 0.0446 feet of water

1 foot of water = 0.02945 atm = 0.4335 psi = 30.480 inches of water = 22.419 mm of Hg

The following table provides some conversions at different pressures

atm	psi	mm of Hg	in of water	ft of water
0.01	0.146	7.6	10.33	0.338
0.05	0.734	38	51.66	1.694
0.10	1.469	76	103.32	3.389
0.50	7.348	380	516.63	16.949
0.70	10.287	532	723.28	23.729
1.00	14.696	760	1033.26	33.899
2.00	29.392	1520	2066.52	67.799
5.00	73.48	3800	5166.3	169.497
10.00	146.96	7600	10332.6	338.995
20.00	293.92	15200	20665.2	677.99
50.00	734.80	38000	51663.0	1694.975
80.00	1175.68	60800	82660.8	2711.96