Technical Tidbit

This month we thought we would address those chemicals that have a vapor density less than air. Quite often the First Responder will hear the term to describe a material’s vapor as being “heavier-than-air” or that the vapor density is greater than 1. This relates to comparing the weight of a fixed volume of the vapor, at standard pressure and temperature, to that of air. Air is composed of a mixture of gases listed below (these are exclusive of water vapor):

- Nitrogen - 78.084%
- Oxygen - 20.946%
- Argon - 0.934%
- CO_2 (Carbon Dioxide) - .033%
- Others - < 0.003%

Using the molecular weight of each of these components multiplied by the volume percent of each component, gives us a “molecular weight” of air to be 28.9 amu (atomic mass units). To compute a material's vapor density we simply divide the molecular weight of the material by the molecular weight of air. This will provide a value that can be compared to air's value of one. As you have learned in HAZMAT classes and now understand, if a material has a vapor density greater than 1.0 or its vapor is “heavier-than-air”, the material will seek or accumulate in low areas. It therefore can add an additional element of danger if the material’s vapor is toxic, since the material may now have increased risk in low areas where the concentration may be greater since the material collects in these low areas. Even materials not considered to be “toxic” or at least aren’t toxic at low concentrations may have a greater danger if they collect in low areas and displace “normal” air or specifically displace the oxygen in the “normal” air.

There are a limited number of materials that have vapor densities less than air. For instance hydrogen fluoride (HF) - to compare its molecular weight (20 amu) to that of air, we see that the vapor density is less than air or 20/28.9 = 0.69. Another such material is ammonia (NH_3), with a molecular weight of 17 it has a vapor density of 17/28.9 = 0.59. These material’s vapor clouds will actual “lift-off” when released to the atmosphere, i.e., the resulting vapor cloud will rise into the surrounding air. There is one important point to remember, this all assumes the material is the same temperature as the surrounding air. If the material is released from a container that is refrigerated or the material is stored pressurized under its own vapor pressure, when it is released it will be cooler than the surrounding air and will “behave” as if it was denser or heavier-than-air until it warms up. Then the vapor cloud will have a tendency to “lift-off” as described earlier. The rate of warming is controlled by many factors and is not a simple computation. As we described last week in the example of using PEAC, HF when released will form an aerosol cloud. This aerosol takes much longer to warm, primarily because the aerosol or droplets require heat to evaporate, as they absorb heat from the surrounding air, the resulting cloud tends to cool and it takes longer for the cloud to warm up. Vapor clouds containing aerosols tend to persist longer and therefore don’t disperse as rapidly as simple vapor clouds.

As mentioned earlier, there are a limited number of hazardous gases that have molecular weights less than air. The following list makes up the hazardous gases with vapor densities less than air (this does not include materials such as Helium or Neon that are considered asphyxiates):

Material	**Formula**	**Molecular Wt.**	**Vapor Density**
Hydrogen	H_2	2	0.069
Methane	CH_4	16	0.554
Ammonia	NH_3	17	0.588
Hydrogen Fluoride	HF	20	0.692
Acetylene	C_2H_2	26	0.900
Diborane	B_2H_6	27.6	0.956
Carbon Monoxide	CO	28	0.969
Ethylene	C_2H_4	28	0.969

As discussed above, even some of these gases if sufficiently chilled could initially sink and be considered heavier-than-air. As we can see, there are a very limited number of hazardous materials that are lighter than air, thus the corollary is that all the other hazardous materials are "heavier-than-air" or have vapor densities equal to or greater than air and should always be considered as potentially collecting or accumulating in low areas.