Let's Take a PEEK at the PEAC Software

An Example Using the PEAC Software

by S. Bruce King

This month our example is Arsine, the most toxic form of arsenic, which has a chemical formula of AsH_3. Arsine is a very toxic colorless gas with a disagreeable garlic odor. It is an immediate health hazard because of its toxicity and it is extremely flammable forming mixtures with air that are flammable or explosive. Arsine may react vigorously with other oxidizing agents. Arsine is used organic chemical synthesis, as a military poison, as a doping agent for solid-state electronic components, in the manufacture of crystals for fiberoptics and computer chips. It is used infrequently in galvanizing, soldering, etching, burnishing, and lead plating. Numerous industrial processes can lead to the accidental formation and liberation of arsine fumes, including the smelting and refining of metals (zinc), plating, galvanizing, soldering, electrolytic processing of hydrogen, preparation of acetylene from calcium carbide. On exposure to light, moist arsine decomposes quickly depositing shiny black arsenic. It is normally shipped as a liquefied compressed gas.

Arsine has a melting point of -179°F and a boiling point of -81°F. Its molecular weight is 77.95, and has a relative vapor density is 2.7 (compared to air), so it will seek low areas. It has a vapor pressure of 11,000 mm of Hg (14.9 atmosphere) at a standard temperature of 70°F. The lower Explosive Limit (LEL) is 5.1%; the Upper Explosive Limit (UEL) is 78%. When heated to decomposition, it emits highly toxic fumes.

The established IDLH is 3 ppm, with a TWA: 0.002 mg/m3 as Arsenic, 15-minute ceiling. The U.S. Department of Energy (DOE) Emergency Management Advisory Committee's Subcommittee on Consequence Assessment and Protective Action (SCAPA) has developed a TEEL-(1,2,3) (*Temporary Emergency Exposure Limit*) as a temporary substitute for the ERPGs (*Emergency Response Planning Guidelines* established by the AIHA [American Industrial Hygiene Association]) through a formulaic derivation. The TEELs listing from DOE is updated every year and the current values in the PEAC database for Arsine are:

TEEL-1 = 0.15 mg/m^3,

TEEL-2 = 1.5 mg/m^3, and

TEEL-3 = 5 mg/m^3 (these are for Arsenic).

The DOE SCAPA just published the 2003 values in January, which will be released in the new version of PEAC database this spring, which are:

TEEL-1 = 0.075 mg/m^3,

TEEL-2 = 0.5 mg/m^3, and

TEEL-3 = 1.5 mg/m^3 (these are for Arsenic).

The important thing to remember when dealing with Arsine is that it is both a very flammable substance and its vapors are very toxic. Therefore if the material is released

from its container, every effort should be made to eliminate ignition sources and appropriate PPE must be worn to protect from exposure or inhalation.

Hazards and protection

Storage - Prolonged exposure of the cylinders to heat may result in the cylinders violent rupturing and rocketing. Store in areas clear of food or food products and combustible materials.

Handling - All chemicals should be considered hazardous. Avoid direct physical contact. Use appropriate, approved safety equipment. Untrained individuals should not handle this chemical or its container. Handling should occur in a chemical fume hood.

Protection - Wear appropriate protective gloves, clothing and goggles -- as recommended by the manufacturer. Always wear thermal protective clothing when handling refrigerated/cryogenic liquids.

Respirators - Wear positive pressure self-contained breathing apparatus (SCBA).

Small spills or leaks - Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Attempt to stop leak if without undue personnel hazard. Use water spray to knock-down vapors.

Incompatibilities - May react vigorously with strong oxidizers, chlorine, and nitric acid.

Hazardous Decomposition - When heated to decomposition, emits highly toxic fumes.

Other hazards - The gas is heavier than air and may travel along the ground; distant ignition possible.

Health related information

Exposure effects

Abnormally low blood pressure may occur. Headache is often an early sign of poisoning.

Ingestion - Nausea, vomiting, anorexia, and abdominal pain often develop in arsine poisoning.

Inhalation - The onset of symptoms is related to the inhaled concentration of arsine. Initial clinical manifestations generally occur 30 to 60 minutes after exposure, but may be delayed up to 2-24 hours. Symptoms include headache, nausea, vomiting, thirst, abdominal pain, shivering, hemoglobinuria. A garlicky odor of the breath may be noted.

Skin - Abnormal pigmentation may be observed. A peculiar bronze tint been described as characteristic of arsine poisoning.

Eyes - Red staining of the the mucous membrane that lines the inner surface of the eyelid and the exposed surface of the eyeball and a garlicky odor of the breath may be early signs in an arsine poisoning. Frostbite on contact with liquid.

First aid

Ingestion - Arsine is present as a gas at room temperature, so ingestion is unlikely.

Inhalation - Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. If massive exposure is suspected or if the patient is hypotensive, ensure adequate hydration by infusing intravenous saline or lactated Ringer's solution. For adults, bolus 1,000 mL/hour if blood pressure is under 80 mm Hg; if systolic pressure is over 90 mm Hg, an infusion rate of 150 to 200 mL/hour is sufficient. For children with compromised perfusion administer a 20 mL/kg bolus of normal saline over 10 to 20 minutes, then infuse at 2 to3 mL/kg/hour. Monitor fluid balance and avoid fluid overload if renal failure supervenes; monitor plasma electrolytes to detect disturbances (particularly hyperkalemia) as early as possible. Monitor hematocrit. Because of possible severe hemolysis ensure adequate oxygenation by arterial blood gas measurement or pulse oxygenation monitoring. The use of diuretics such as furosimide to maintain urinary flow is an important consideration and should be performed under medical base control.

Skin - Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician should examine the area if irritation or pain persists.

Eyes - Irrigate exposed eyes with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

In using the PEAC application we access information for the chemical by first locating Arsine in the database. The following figures show the screens displayed for chemical properties, Figure 2 for the *PEAC-WMD for Windows* application and Figure 3-6 for the *PEAC-WMD for the Pocket PC* application.

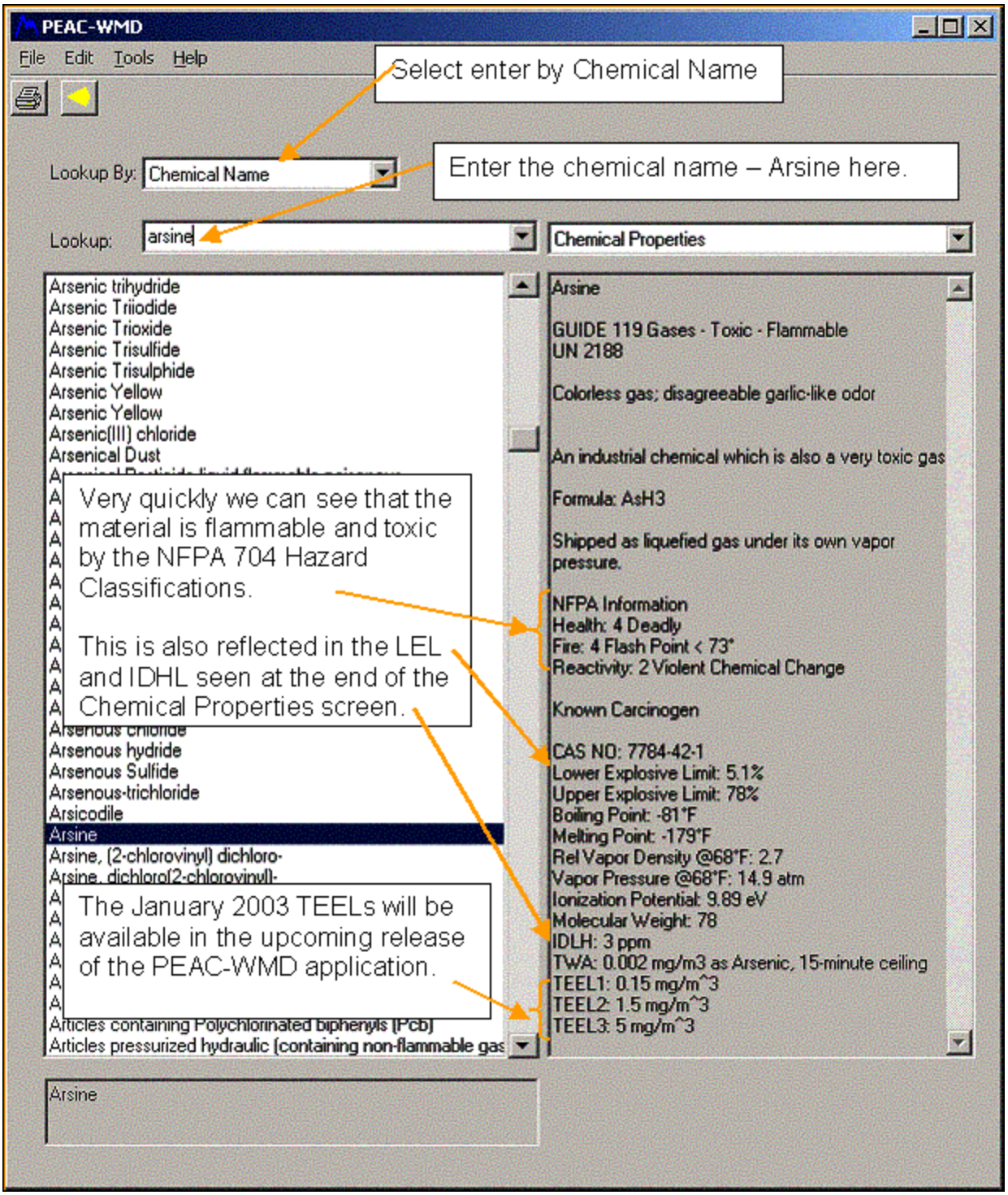

Figure 2- Using the Lookup By: Name for Arsine using the PEAC-WMD for Windows application

Review of the information displayed in the chemical properties screen whether in Figure 2 (above) or Figures 3-5 (below), show chemical properties values discussed earlier at the top of this discussion. As you can see, the published toxicity values, e.g., IDLH, and TEELs

(Temporary Emergency Exposure Limits) published by Department of Energy are provided. We will use the IDLH as the Level of Concern when we develop the PAD a little later.

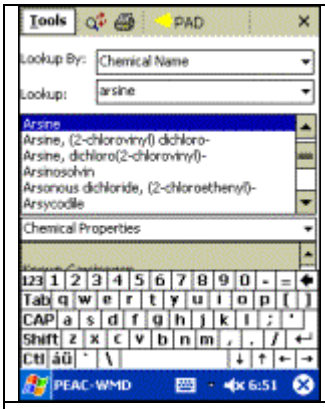

Figure 3– Selecting Arsine using the PEAC-WMD for Pocket PC application

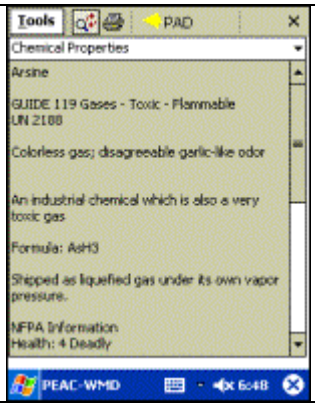

Figure 4– The top portion of the Chemical Properties Data Display Screen

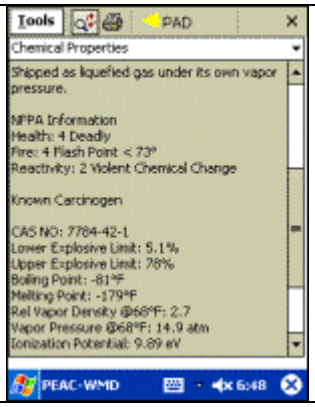

Figure 5– The middle portion of the Chemical Properties Data Display Screen

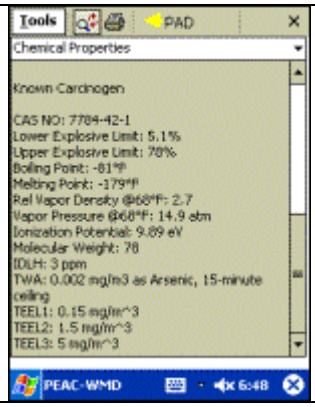

Figure 6– The middle portion of the Chemical Properties Data Display Screen

A benefit of using the PEAC tool is assistance in the development of an evacuation zone for those chemicals that produce a toxic vapor cloud. Arsine has a very high vapor pressure (11,000 mm Hg) at room temperature, so if the chemical is released from a container it will exit as a vapor. As with all of our examples, AristaTek creates a scenario for a spill or release of the specific chemical, and then we work through the development of a PAD (Protective Action Distance) to demonstrate how the PEAC system works. For our scenario using Arsine as the spilled chemical we'll set the location to San Jose, CA and the time as 9:00 AM on March 13th. A transport truck with 40 cylinders of Arsine has been involved in an accident on US Highway 101 close to the center of the city. At least one of the cylinders has the valve cover knocked off the cylinder and is leaking vapor very rapidly. The temperature is about 80°F, the winds are about 5 mph, and it's a clear day (no clouds).

As seen at the top of the data display screens, there is a yellow icon displayed; this is the PEAC icon for notifying the user that a Protective Action Distance can be calculated. Clicking or tapping on the PAD icon will display a screen as shown in Figure 7. Following through the screens, we provide information on the Meteorology, Container Size, and Type of Release (Source). The last screen displays the PAD based on the provided information. If you decide to follow along on this example, remember to change the location to San Jose and the time to 9:00 AM, March 13th.

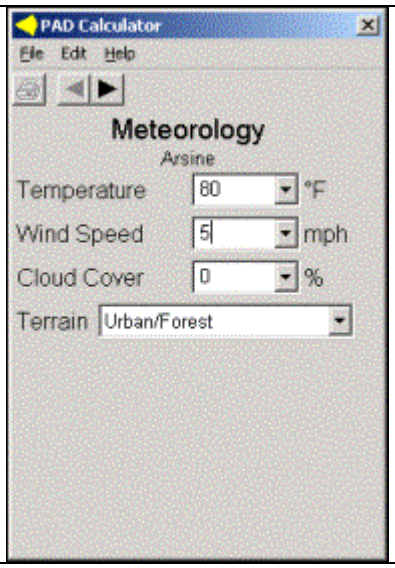	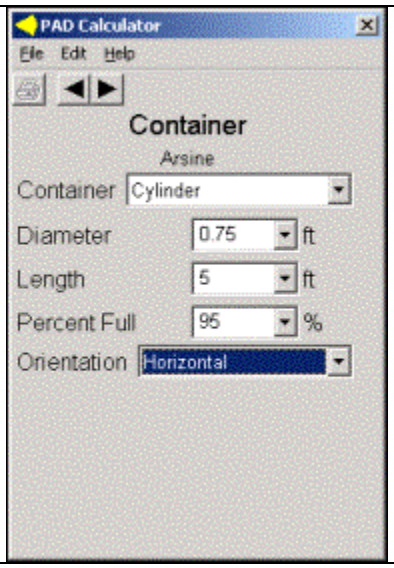	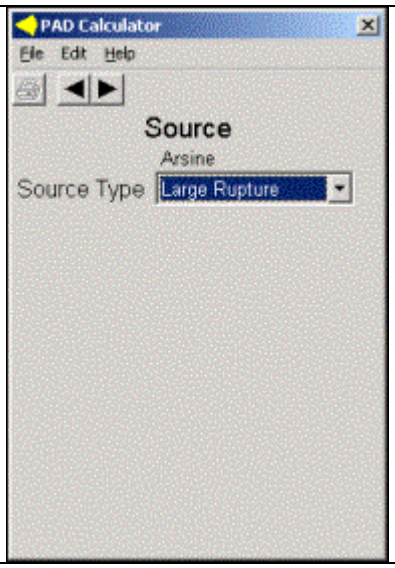
Meteorology It's San Jose in March and the temperature about 80°, light wind is set for 5 mph, clear sky so we'll set cloud cover to 0%, and the terrain is Urban/Forest since it's an urban setting.	**Container** We have selected from our list of container sizes the **Cylinder** selection. This provides us with a default size that should get us pretty close to the actual size.	**Source** Since the scenario has the valve cover knocked off we've assumed a worst-case scenario, we've selected a **Large Rupture** as the **Source** type of release.

Figure 7– Calculating a PAD using the PEAC System

By pressing the right arrow at the top of the screen, the PEAC system will display a screen as shown in Figure 8. This calculates a **PAD** (Protective Action Distance) based on the default **Level of Concern** the IDLH of 3 ppm. This evacuation or standoff distance is based on the toxicity of Arsine, not its flammability. Since it is so flammable, extreme care needs to be given to ignition sources in the immediate vicinity of the release.

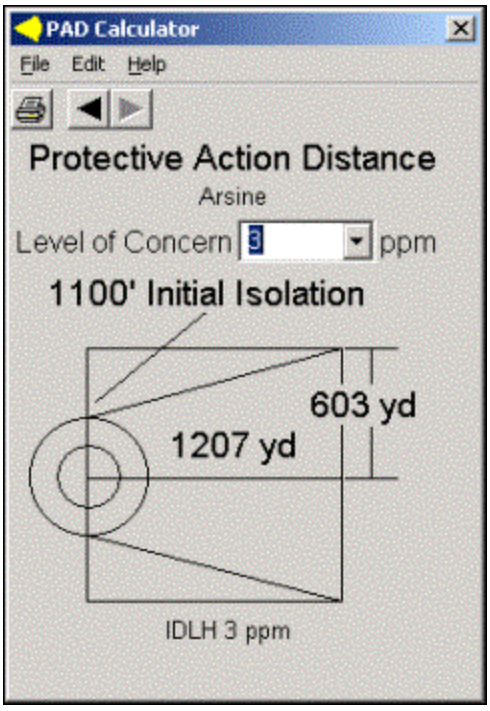

Figure 8– Default PAD for Arsine using the IDLH of 3 ppm

Portions of this discussion were adapted from the WEB site supported by the Hardy Research Group, Department of Chemistry, The University of Akron: http://ull.chemistry.uakron.edu/. Additional information was adapted from the web site provided by International Programme on Chemical Safety (IPCS) INCHEM site located at: http://www.inchem.org/. Additional information was also adapted from the National Occupational Health & Safety Commission web site: http://www.nohsc.gov.au/, provided by the Commonwealth of Australia. Additional information was also adapted from the Agency for Toxic Substances and Disease Registry (ATSDR) Web site for Medical Management Guidelines at: http://www.atsdr.cdc.gov/.