Let's Take A Peek at the PEAC software

This month our example is Methylene Chloride

by S. Bruce King

This month our example is Methylene Chloride, which has a chemical formula of (CH_2Cl_2). Methylene Chloride is listed under the UN # (United Nations Number) by the US Department of Transportation: UN 1593. Methylene Chloride is listed as CAS# (Chemical Abstract Service Number) 75-09-2.

Persons exposed only to Methylene Chloride vapor do not pose risks of secondary contamination. Persons whose clothing or skin is contaminated with liquid Methylene Chloride can cause secondary contamination by direct contact or through off-gassing vapor.

Odor is not an adequate warning property for Methylene Chloride.

Methylene Chloride is a combustible liquid, but its vapor is flammable only when present in relatively high concentrations (14% to 22% in air).

Methylene Chloride is absorbed readily after inhalation and ingestion. Skin absorption is slow but may contribute to total body burden.

At room temperature, Methylene Chloride is a clear, colorless liquid with a pleasant odor. It is volatile, producing potentially toxic concentrations at room temperature. It is slightly soluble in water and miscible with most organic solvents.

Sources/Uses: Methylene Chloride is produced commercially in large volumes by direct chlorination of methane or methyl chloride. Methylene Chloride is an important solvent in paint and varnish strippers and in degreasing agents. It is used in the production of photographic films, synthetic fibers, pharmaceuticals, adhesives, inks, and printed circuit boards. It is employed as a blowing agent for polyurethane foams and as a propellant for insecticides, air fresheners, and paints.

Physical Properties:

Description: Clear, colorless liquid

Warning properties: Sweet, ether-like odor at 250 ppm; inadequate warning for hazardous exposures.

Molecular weight: 84.9 daltons

Boiling point (760 mm Hg): 104.2 °F (39.8 °C)

Freezing point: -139 °F (-95 °C)

Specific gravity: 1.33 (water = 1)

Vapor pressure: 349 mm Hg at 68 °F (20 °C)

Gas density: 2.9 (air = 1)

Water solubility: Water soluble (2% at 68 °F) (20 °C)

Flammability: Combustible liquid

Flammable range: 14% to 22% (concentration in air)

Synonyms include dichloromethane, methylene bichloride, methane dichloride, and methylene dichloride.

Incompatibilities: Methylene Chloride reacts with strong oxidizers, caustic substances, chemically active metals such as aluminum and magnesium powders, potassium, sodium, and concentrated nitric acid.

Standards and Guidelines:

OSHA PEL (permissible exposure limit) = 25 ppm (averaged over an 8-hour workshift)

OSHA STEL (short-term exposure limit) = 125 ppm (over a 15-minute time period)

NIOSH IDLH (immediately dangerous to life or health) = 2,300 ppm

AIHA ERPG-2 (maximum airborne concentration below which it is believed that nearly all persons could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action) = 750 ppm

Routes of Exposure

Inhalation Inhalation is the most important route of exposure and Methylene Chloride vapor is absorbed readily from the lungs. **Odor is not an adequate warning property for Methylene Chloride,** the odor threshold is 250 ppm, which is 10 times higher than the OSHA PEL (25 ppm). Olfactory fatigue may also occur at high concentrations. Methylene Chloride is heavier than air and may cause asphyxiation in enclosed, poorly ventilated, or low-lying areas.

Children exposed to the same levels of Methylene Chloride vapor as adults may receive larger doses because they have greater lung surface area:body weight ratios and increased minute volumes:weight ratios. In addition, they may be exposed to higher levels than adults in the same location because of their short stature and the higher levels of Methylene Chloride vapor found nearer to the ground.

Skin/Eye Contact Exposure to high levels of Methylene Chloride vapor can cause skin and eye irritation. Prolonged dermal contact with liquid Methylene Chloride may produce chemical burns. Methylene Chloride is absorbed slowly through intact skin but probably not in quantities that cause acute systemic toxicity.

Children are more vulnerable to toxicants absorbed through the skin because of their relatively larger surface area:body weight ratio.

Ingestion Acute toxic effects, including death, can result from ingestion.

Health Effects: Methylene Chloride is irritating to the skin, eyes, and respiratory tract. These effects can result from inhalation or dermal exposure to Methylene Chloride. Prolonged skin contact may cause chemical burns.

Exposure by any route can cause CNS depression. Ingestion of Methylene Chloride can cause severe gastrointestinal irritation.

Carbon monoxide, a metabolite of Methylene Chloride, may contribute to delayed toxic effects. The fetus and neonates are particularly vulnerable to poisoning with carbon monoxide.

Acute Exposure: Adverse health effects of Methylene Chloride are due both to the parent compound and carbon monoxide which is a metabolite of Methylene Chloride. The mechanism of neurotoxic effects of the parent compound is unknown but may be related to the lipophilic properties of the compound. Carbon monoxide induces the formation of carboxyhemoglobin, thus depriving the brain from normal oxygen delivery and utilization. Signs and symptoms of exposure to very high levels (>750 ppm) of Methylene Chloride may be evident within minutes of exposure onset. Less pronounced exposures may induce adverse signs and symptoms within hours.

Children do not always respond to chemicals in the same way that adults do. Different protocols for managing their care may be needed.

Central Nervous System (CNS) Methylene Chloride exposure causes dose-related CNS depression. Typical acute symptoms (within minutes to hours) include headache, drowsiness, lightheadedness, slurred speech, decreased alertness, slowed reaction times, irritability, impaired gait, and stupor. Rapid loss of consciousness, coma, seizures, and death have been reported.

Metabolic Methylene Chloride is metabolized in the liver, in part to carbon monoxide, which will produce elevated carboxyhemoglobin levels and decrease the oxygen-carrying capacity of the blood. Carboxyhemoglobin levels may continue to rise for several hours after exposure has ceased. The fetus is particularly vulnerable to poisoning with carbon monoxide.

Because of their relatively higher metabolic rate, children may be more vulnerable to toxicants interfering with basic metabolism.

Cardiovascular Methylene Chloride may cause electrocardiographic changes resembling those of carbon monoxide poisoning. Elevated carboxyhemoglobin and carboxymyoglobin levels may cause insufficient oxygen supply to the heart in persons who have preexisting coronary disease. Angina, myocardial infarction, and cardiac arrest associated with Methylene Chloride inhalation was reported in one patient, but no adverse cardiovascular effects from Methylene Chloride have been reported for occupationally exposed workers.

Respiratory Victims of acute, high-level inhalation exposures may suffer airway irritation, inflammation of the lungs, and accumulation of fluid in the lungs. Children may be more vulnerable because of relatively increased minute ventilation per kg and failure to evacuate an area promptly when exposed. Hydrocarbon pneumonitis may be a problem in children.

Gastrointestinal Nausea, vomiting, gastrointestinal ulceration and bleeding have been reported after ingestion.

Hepatic Liver dysfunction may result from acute, high-level exposure to Methylene Chloride.

Dermal Methylene Chloride causes skin irritation and blistering. Prolonged dermal contact may result in second- and third-degree chemical burns. Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

Ocular High concentrations of Methylene Chloride vapor may cause eye irritation and tearing. When splashed in the eye, Methylene Chloride can cause burning pain, inflammation of the eye surface, and inflammation of the iris.

Potential Sequelae Survivors of severe, acute exposure (e.g., cases of coma, seizures, or respiratory arrest) may suffer brain or heart damage from lack of oxygen to these organs. Exposure to high levels of Methylene Chloride, which may lead to the formation of high amounts of the metabolite carbon monoxide, may lead to permanent sequelae, including mental deterioration, urinary and fecal incontinence, and gait disturbance. However, most cases of delayed neurologic sequelae are associated with loss of consciousness in the acute phase of intoxication.

Chronic Exposure: Cardiovascular effects have been documented in case reports but have not been demonstrated in epidemiologic studies of workers exposed to Methylene Chloride. Irritant contact dermatitis manifested by inflammation and hives has been noted in workers who have chronic skin exposure.

Chronic exposure may be more serious for children because of their potential longer latency period.

Carcinogenicity The DHHS (Department of Health and Human Services) has determined that Methylene Chloride may be reasonably anticipated to be a human carcinogen based on adequate evidence in experimental animals.

Reproductive and Developmental Effects In experimental animals, Methylene Chloride did not produce structural abnormalities but produced behavioral alterations and retarded development in offspring. The levels used in these studies were greater than 1,000 ppm. Whether these effects would have occurred in the absence of maternal toxicity is not clear. Embryotoxic effects have not been documented in humans. Methylene Chloride is not included in *Reproductive and Developmental Toxicants*, a 1991 report published by the U.S. General Accounting Office (GAO) that lists 30 chemicals of concern because of widely acknowledged reproductive and developmental consequences.

Methylene Chloride has been shown to cross the placenta in animals and has been found in human breast milk. The fetus and neonates are more susceptible to carbon

monoxide, a Methylene Chloride metabolite, poisoning. Acute, nonlethal maternal intoxication with carbon monoxide may result in fetal death or permanent neurologic sequelae.

Using the PEAC tool

In using the PEAC application we access information for the chemical by first locating Methylene Chloride in the database. The following figures show the screens displayed for chemical properties, Figure 1 for the *PEAC-WMD v5 for Windows* application which is being released this month. For those individuals familiar with the previous version, you'll notice some changes in this new release. The Pocket PC version should be released shortly after the in-house testing is complete.

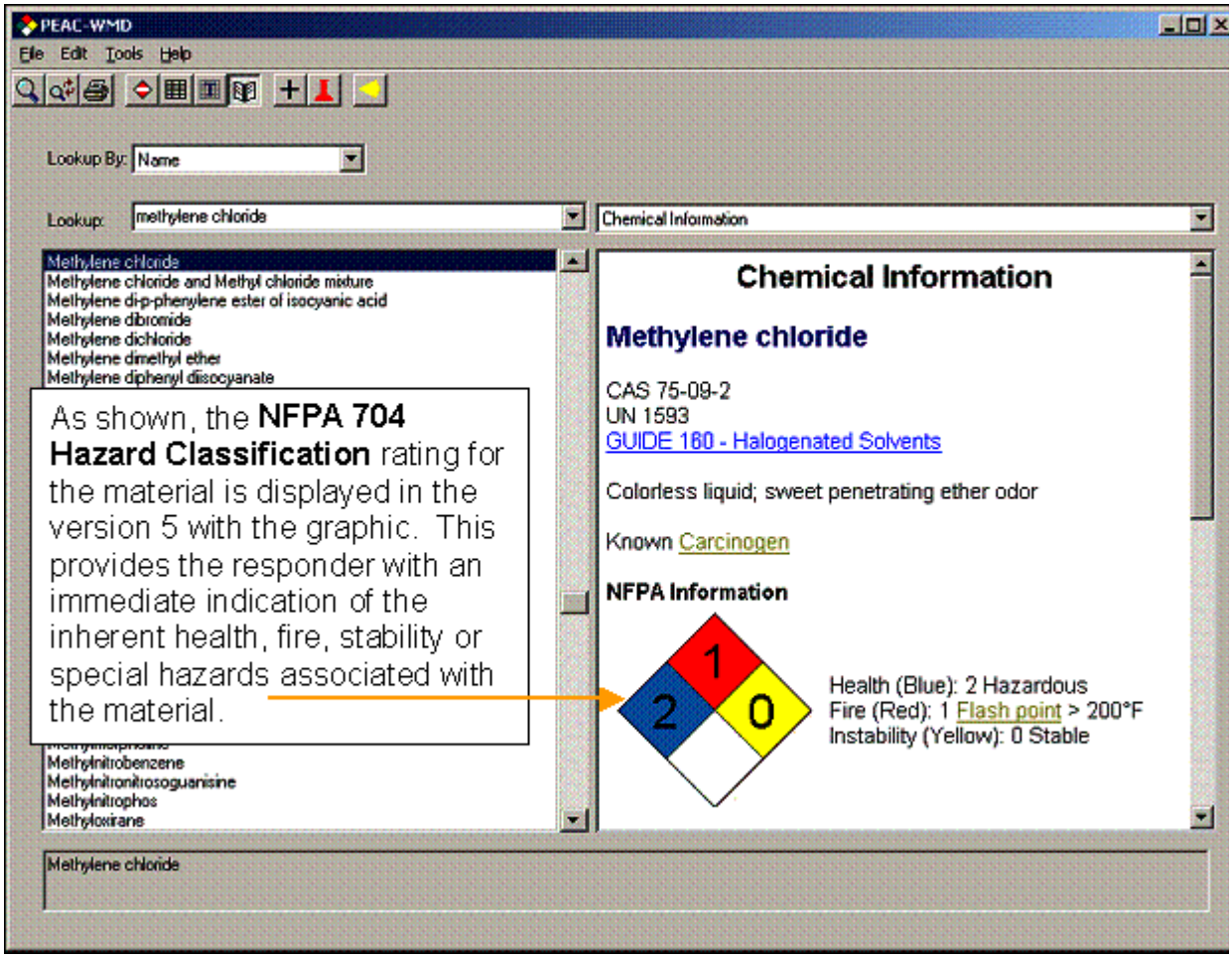


Figure 1 - Using the Lookup By: Name for Methylene Chloride using the PEAC-WMD v5 for Windows application (top of the Chemical Information screen)

Review of the information displayed in the chemical properties screen whether in Figure 1 (above) or Figure 2 (below), show chemical information values discussed earlier in this discussion.

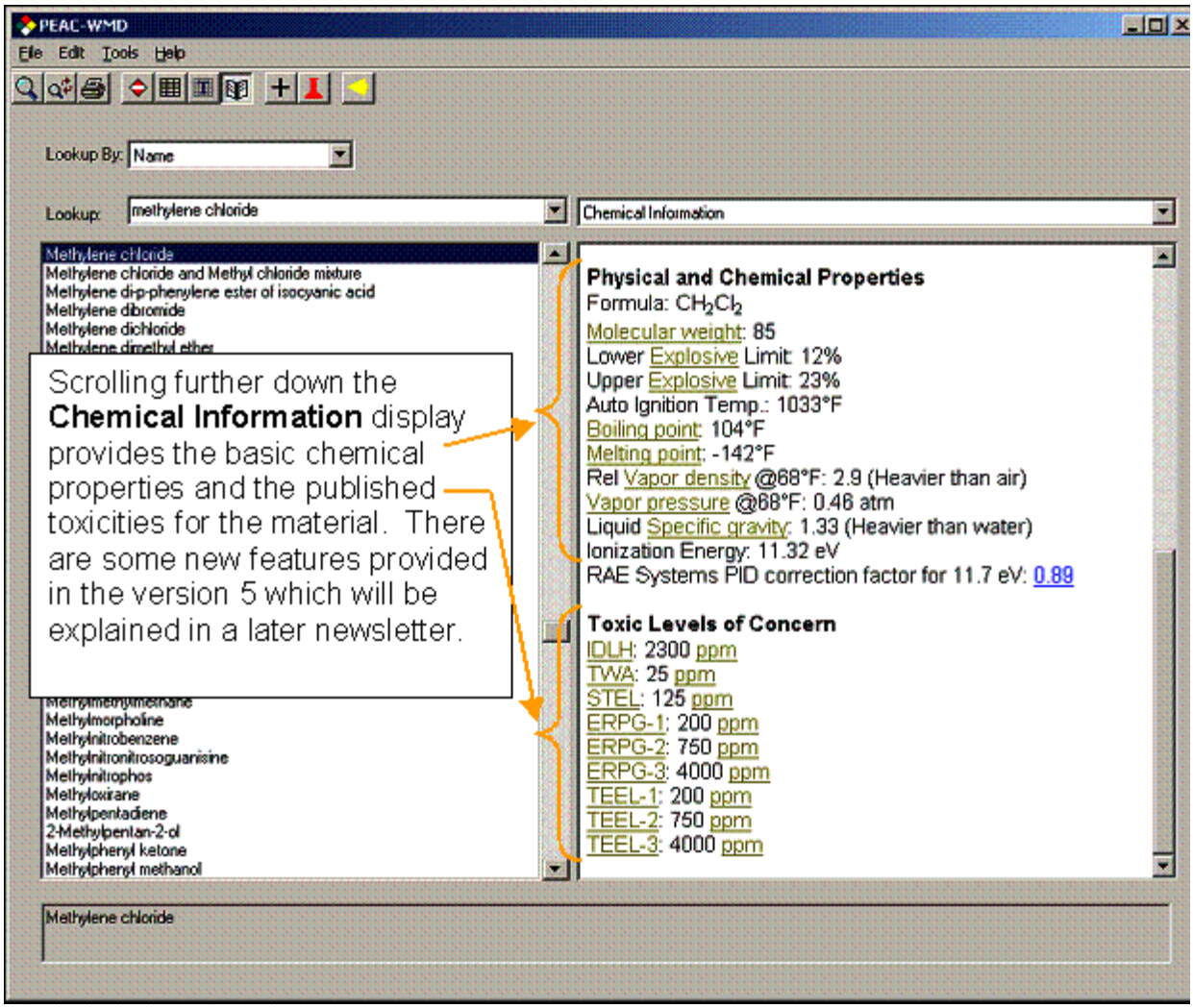


Figure 2 - Using the Lookup By: Name for Methylene Chloride using the PEAC-WMD v5 for Windows application (bottom of the Chemical Information screen)

As you can see above, the published toxicity values, e.g., IDLH, ERPGs, and the TEELs (Temporary Emergency Exposure Limits) published by Department of Energy are provided. We will use the IDLH and the ERPG-2 as the Level of Concerns when we develop the Protective Action Distance (PAD) a little later.

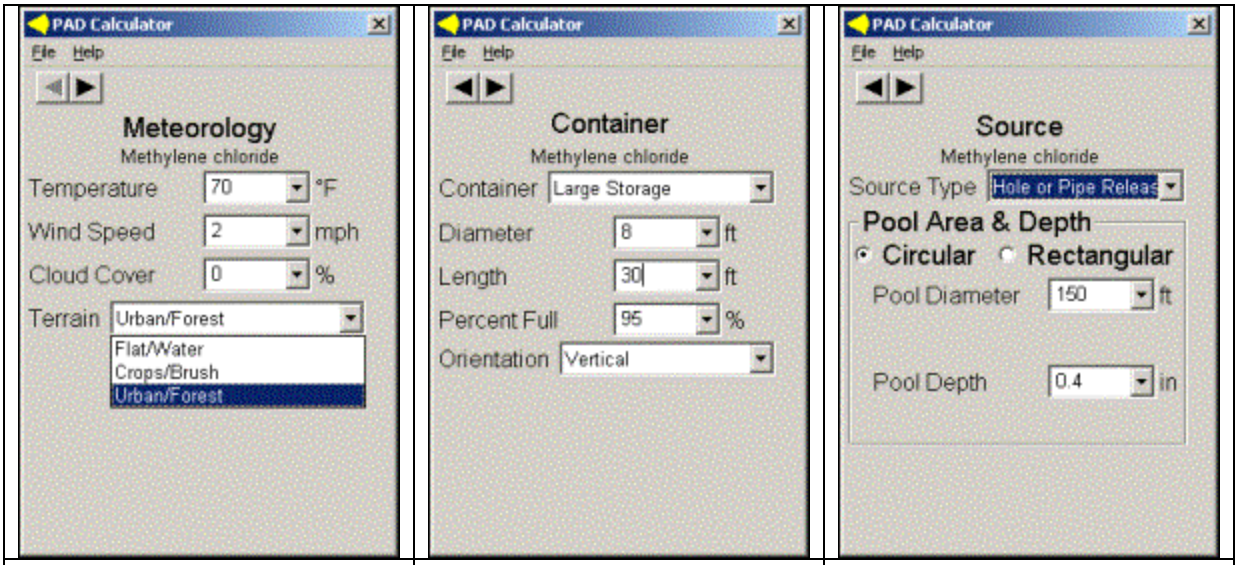
A benefit of using the PEAC tool is assistance in the development of an evacuation zone for those chemicals that produce a toxic or flammable vapor cloud. As with most of our examples, AristaTek creates a scenario for a spill or release of the specific chemical, and then we work through the development of a PAD (Protective Action Distance) to demonstrate how the PEAC system works.

For our hypothetical scenario using Methylene Chloride as the involved chemical we'll set the location to be a paint and coatings manufacturing facility located outside Baton Rouge, LA. The date is October 11, 2004, at 5:00 AM with a temperature of 70°F, wind speed of 2 mph and a clear sky. The hypothetical release involves a storage tank (8' x 30') that contains Methylene Chloride, and a front-end loader has accidentally run into the tank creating a large hole or gash in the side of the tank. Liquid is flowing from the tank and has

created a liquid pool. The PEAC tool can provide guidance with regards to toxic vapor cloud that is released.

If you decide to follow along as we proceed through these examples, remember to set the location to Baton Rouge and set the date and time to the proper values, otherwise you'll compute different values. We'll use a terrain type of urban/forest since this is a manufacturing facility and has buildings and processing equipment in the immediate area.

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 3. Following through the screens, we provide information on the Meteorology, Container Size, and Type of Release (Source). The following figures demonstrate how we would work through our scenario to see what our Protective Action Distance should be.



Meteorology	**Container**	**Source**
It's early morning (5AM) in Baton Rouge in October and the temperature about 70°, wind is set for 2 mph, clear skies and the terrain is **Urban/Forest** since it's a processing facility setting.	We have selected from our list of container sizes the **Large Storage** selection and filled in some dimensions. This gets us a quick estimate of how much material might be involved.	We have selected a **Hole or Pipe Release**, and since the Methylene Chloride will form a liquid pool, the size of the pool is required.

Figure 3 – Calculating a PAD using the PEAC-WMD System for October 11th

By pressing the right arrow at the top of the screen, the PEAC system will display a screen as shown in Figure 4. This calculates a **PAD** (Protective Action Distance) based on the default **Level of Concern** the IDLH of 2,300 ppm. This evacuation or standoff distance is based on the toxicity of Methylene Chloride, **not** the flammability.

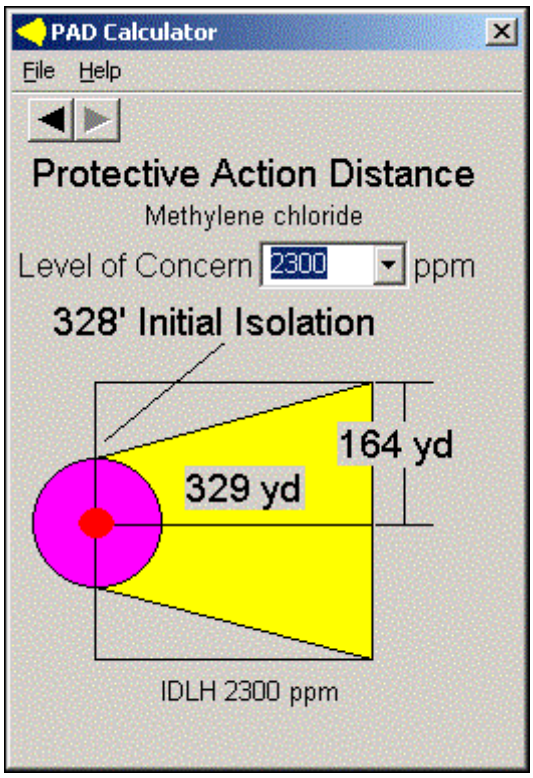


Figure 4 – Default PAD for Methylene Chloride using the IDLH of 150 ppm

If we want to calculate a PAD based on a toxicity level other than the IDLH, we can enter a value in the field for **Level of Concern** or we can select a value from our list of toxicity values shown in Figure 5. In this figure we select the ERPG-2 value or 750 ppm.

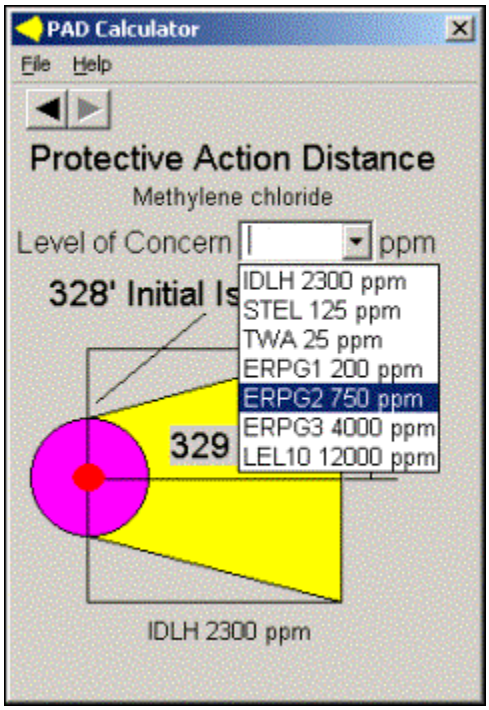


Figure 5 – Selecting another Level of Concern

The calculated PAD will be displayed, see Figure 6.

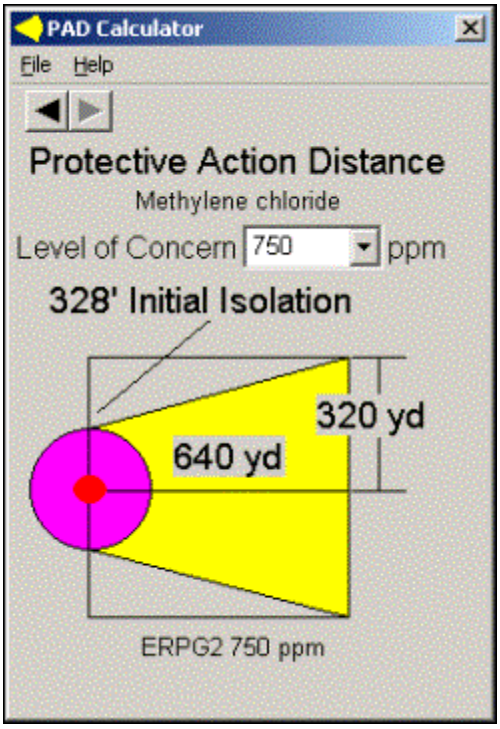


Figure 6 – Calculated PAD using the ERPG-2 Level of Concern

In addition to the toxicity of the released material, the user should also remember the flammability issue with Methylene Chloride and eliminate all ignition sources.

Another feature of the PEAC-WMD v5 release is the automatic display of the results file that has always been created and retained each time a PAD was calculated. Now the **PAD Results** are displayed in the **Data Display Box** and can easily be recalled and printed for review after an incident. Figures 7 and 8 provide an example of how the results appear when recalled.

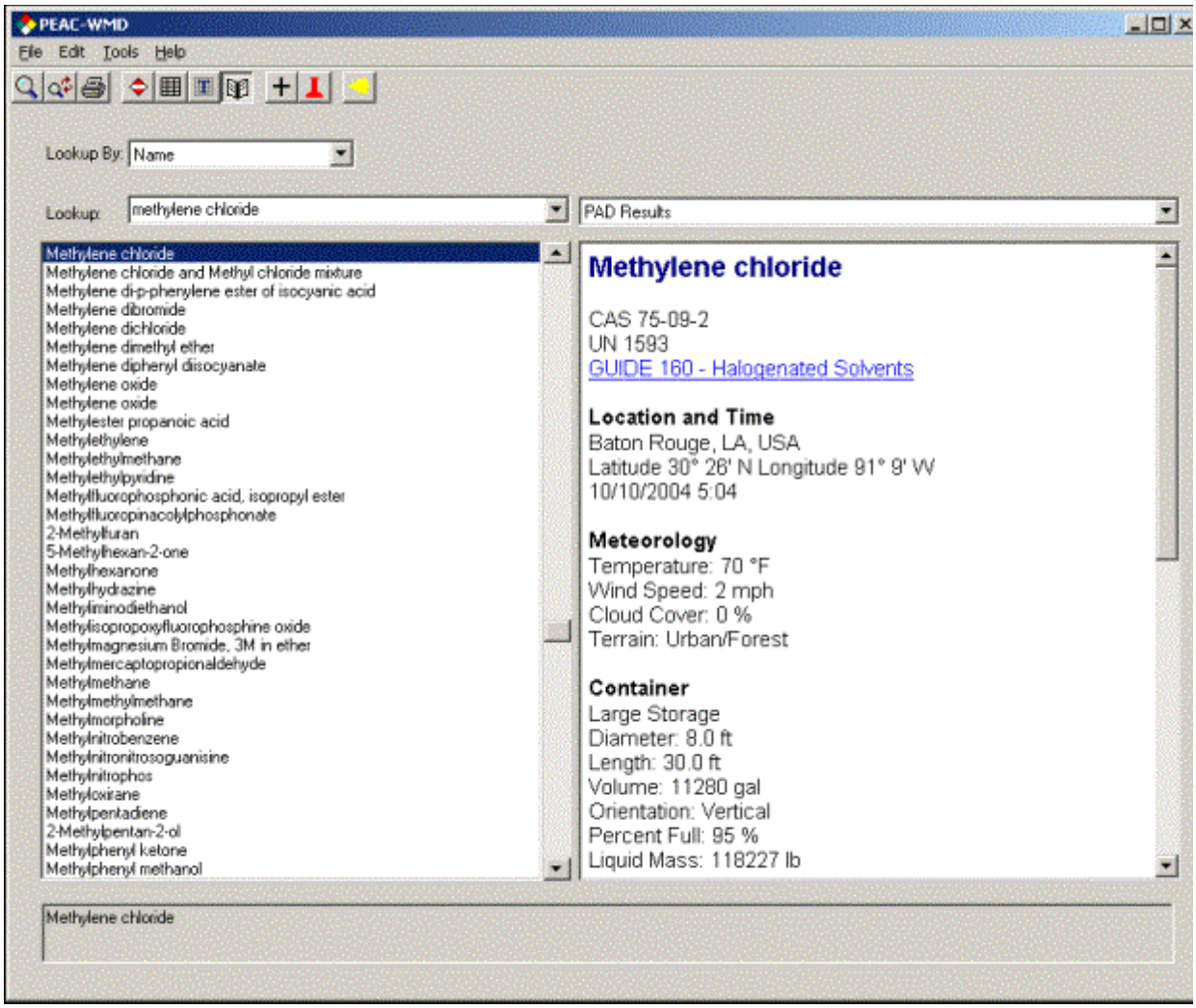


Figure 7 – The PAD Results file is automatically displayed when the PAD Calculation is completed (this is the top portion of the PAD Result)

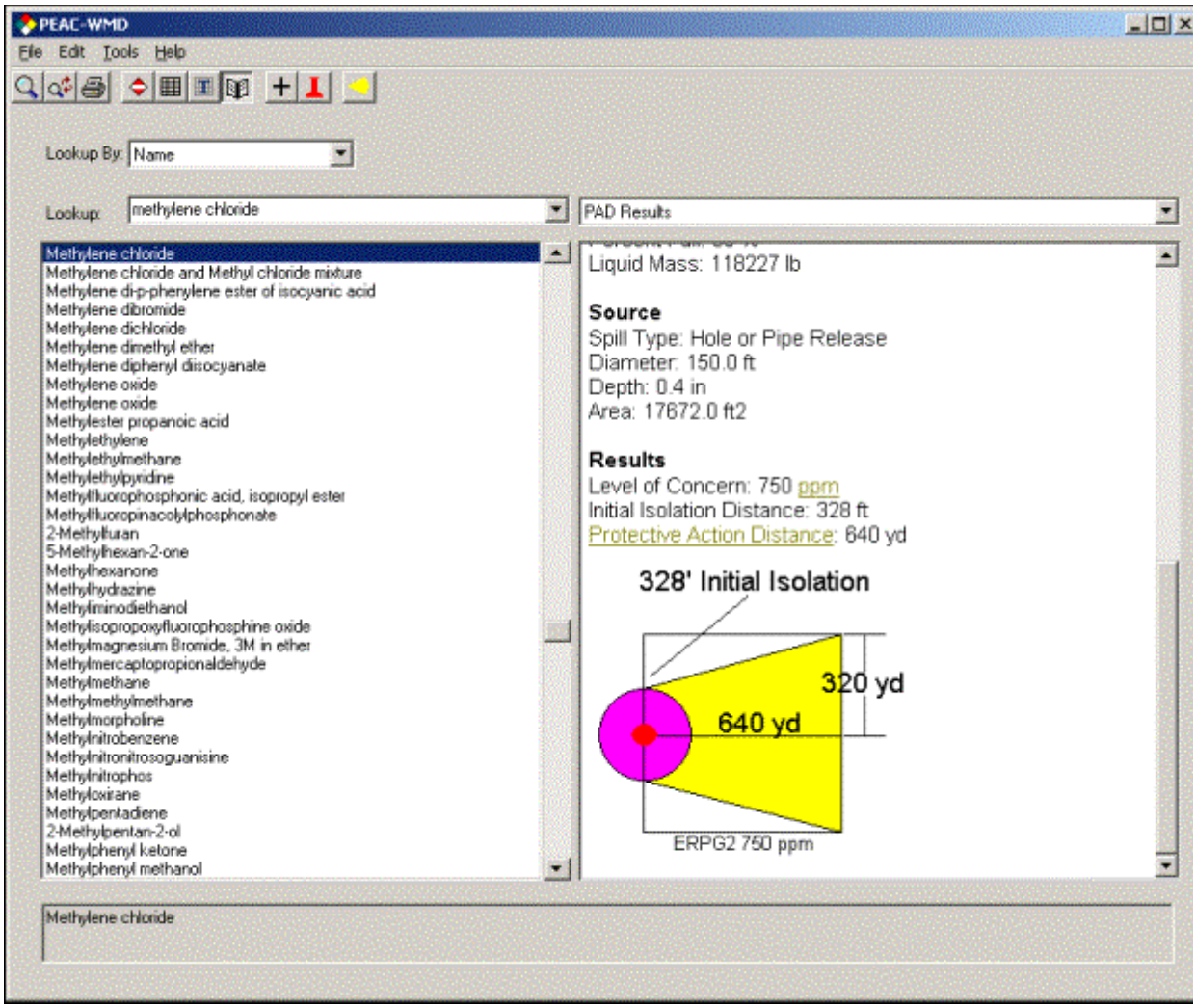


Figure 8 – The PAD Results file is automatically displayed when the PAD Calculation is completed (this is the bottom portion of the PAD Result)

Substantial portions of this discussion were adapted from the Agency for Toxic Substances and Disease Registry (ATSDR) Web site for Medical Management Guidelines at: http://www.atsdr.cdc.gov/.