Let's Take A PEEK at the PEAC software

PEAC Example –Hydrogen Sulfide

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This month our example is Hydrogen Sulfide, which has a chemical formula of (H_2S). Hydrogen Sulfide is listed under the UN # (United Nations Number) by the US Department of Transportation: UN 1053. Hydrogen Sulfide CAS# is: 7783-060-4.

Persons exposed to hydrogen sulfide pose no serious risks of secondary contamination to personnel outside the Hot Zone. However, fatalities have occurred to rescuers entering the hot zone.

Hydrogen sulfide is a colorless, highly flammable and explosive gas produced naturally by decaying organic matter and by certain industrial processes. Hydrogen sulfide has a characteristic rotten-egg odor; however, olfactory fatigue may occur and consequently it may not provide adequate warning of hazardous concentrations.

Hydrogen sulfide is well absorbed through the lungs; cutaneous absorption is minimal. Exposure by any route can cause systemic effects.

Description Hydrogen sulfide is a colorless, flammable, highly toxic gas. It is shipped as a liquefied, compressed gas. It has a characteristic rotten-egg odor that is detectable at concentrations as low as 0.5 ppb.

Sources/Uses Hydrogen sulfide is produced naturally by decaying organic matter and is released from sewage sludge, liquid manure, sulfur hot springs, and natural gas. It is a by-product of many industrial processes including petroleum refining, tanning, mining, wood pulp processing, rayon manufacturing, sugar-beet processing, and hot-asphalt paving. Hydrogen sulfide is used to produce elemental sulfur, sulfuric acid, and heavy water for nuclear reactors.

Physical Properties:

Description: Colorless gas with odor of rotten eggs

Warning properties: Not dependable; characteristic rotten-egg odor detectable at about 0.5 ppb, but olfactory nerve fatigue occurs in 2 to 15 minutes at concentrations over 100 ppm

Molecular weight: 34.1 daltons

Boiling point: (760 mm Hg): -77 °F (-60.3 °C)

Vapor pressure: >760 mm Hg at 68 °F (20 °C)

Gas density: 1.2 (air = 1)

Water solubility: Slightly water soluble (0.4% at 68 °F [20 °C])

Flammability: Highly flammable and explosive between 4% and 45% (concentration in air); may travel to a source of ignition and flash back. Burns to produce a toxic gas, sulfur dioxide.

Synonyms: dihydrogen sulfide, sulfur hydride, sulfurated hydrogen, hydrosulfuric acid, "sewer gas," "swamp gas," hepatic acid, sour gas, and "stink damp."

Standards and Guidelines:

OSHA ceiling = 20 ppm

OSHA maximum peak = 50 ppm (10 minutes, once, no other exposure)

NIOSH IDLH (immediately dangerous to life or health) =100 ppm

AIHA ERPC-2 (emergency response planning guideline) (maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action) = 30 ppm.

Incompatibilities: Hydrogen sulfide reacts with strong oxidizers, strong nitric acid, and metals.

Routes of Exposure:

Inhalation Inhalation is the major route of hydrogen sulfide exposure. The gas is rapidly absorbed by the lungs. The odor threshold (0.5 ppb) is much lower than the OSHA ceiling (20 ppm). However, although its strong odor is readily identified, olfactory fatigue occurs at high concentrations and at continuous low concentrations. For this reason, **odor is not a reliable indicator of hydrogen sulfide's presence and may not provide adequate warning of hazardous concentrations.** Hydrogen sulfide is slightly heavier than air and may accumulate in enclosed, poorly ventilated, and low-lying areas.

Children exposed to the same levels of hydrogen sulfide 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 hydrogen sulfide found nearer to the ground. Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways.

Skin/Eye Contact Prolonged exposure to hydrogen sulfide, even at relatively low levels, may result in painful dermatitis and burning eyes. Direct contact with the liquefied gas can cause frostbite. Absorption through intact skin is minimal.

Ingestion Because hydrogen sulfide is a gas at room temperature, ingestion is unlikely to occur.

Health Effects

Hydrogen sulfide is a mucous membrane and respiratory tract irritant; pulmonary edema, which may be immediate or delayed, can occur after exposure to high concentrations.

Symptoms of acute exposure include nausea, headaches, delirium, disturbed equilibrium, tremors, convulsions, and skin and eye irritation.

Inhalation of high concentrations of hydrogen sulfide can produce extremely rapid unconsciousness and death. Exposure to the liquified gas can cause frostbite injury.

Acute Exposure Hydrogen sulfide's can cause inhibition of the cytochrome oxidase enzyme system resulting in lack of oxygen use in the cells. Anaerobic metabolism causes accumulation of lactic acid leading to an acid-base imbalance. The nervous system and cardiac tissues are particularly vulnerable to the disruption of oxidative metabolism and death is often the result of respiratory arrest. Hydrogen sulfide also irritates skin, eyes, mucous membranes, and the respiratory tract. Pulmonary effects may not be apparent for up to 72 hours after exposure.

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

CNS CNS injury is immediate and significant after exposure to hydrogen sulfide. At high concentrations, only a few breaths can lead to immediate loss of consciousness, coma, respiratory paralysis, seizures, and death. CNS stimulation may precede CNS depression. Stimulation manifests as excitation, rapid breathing, and headache; depression manifests as impaired gait, dizziness, and coma, possibly progressing to respiratory paralysis and death. In addition, decreased ability to smell hydrogen sulfide occurs at concentrations greater than 100 ppm.

Respiratory Inhaled hydrogen sulfide initially affects the nose and throat. Low concentrations (50 ppm) can rapidly produce irritation of the nose, throat, and lower respiratory tract. Pulmonary manifestations include cough, shortness of breath, and bronchial or lung hemorrhage. Higher concentrations can provoke bronchitis and cause accumulation of fluid in the lungs, which may be immediate or delayed for up to 72 hours. Lack of oxygen may result in blue skin color.

Children may be more vulnerable to corrosive agents than adults because of the relatively smaller diameter of their airways. Children may also be more vulnerable to gas exposure because of increased minute ventilation per unit weight of the child and failure to evacuate an area promptly when exposed.

Cardiovascular High-dose exposures may cause insufficient cardiac output, irregular heartbeat, and conduction abnormalities.

Renal Transient renal effects include blood, casts, and protein in the urine. Renal failure as a direct result of hydrogen sulfide toxicity has not been described, although it may occur secondary to cardiovascular compromise.

Gastrointestinal Symptoms may include nausea and vomiting.

Dermal Prolonged or massive exposure may cause burning, itching, redness, and painful inflammation of the skin. Exposure to the liquified gas can cause frostbite injury.

Ocular Eye irritation may result in inflammation (i.e., keratoconjunctivitis) and clouding of the eye surface. Symptoms include blurred vision, sensitivity to light, and spasmodic blinking or involuntary closing of the eyelid.

Potential Sequelae Inflammation of the bronchi can be a late development. Survivors of severe exposure may develop psychological disturbances and permanent damage to the brain and heart. The cornea may be permanently scarred.

Chronic Exposure Hydrogen sulfide does not accumulate in the body. Nevertheless, repeated or prolonged exposure has been reported to cause low blood pressure, headache, nausea, loss of appetite, weight loss, ataxia, eye-membrane inflammation, and chronic cough. Neurologic symptoms, including psychological disorders, have been associated with chronic exposure. Chronic exposure may be more serious for children because of their potential longer latency period.

Carcinogenicity Hydrogen sulfide has not been classified for carcinogenic effects.

Reproductive and Developmental Effects There is some evidence to suggest that exposure to hydrogen sulfide may be associated with an increased risk of spontaneous abortion. No information was located pertaining to placental transfer of hydrogen sulfide or to excretion of hydrogen sulfide in breast milk. There are no studies of developmental effects in humans exposed to hydrogen sulfide. However, results from animal studies suggest that hydrogen sulfide may be a developmental neurotoxicant. Hydrogen sulfide is not listed in TERIS or in *Shepard's Catalog of Teratogenic Agents.* It is also 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.

In using the PEAC application we access information for the chemical by first locating Hydrogen Sulfide in the database. The following figures show the screens displayed for chemical properties, Figure 1 for the *PEAC-WMD for Windows* application and Figure 2-5 for the *PEAC-WMD for the Pocket PC* application.

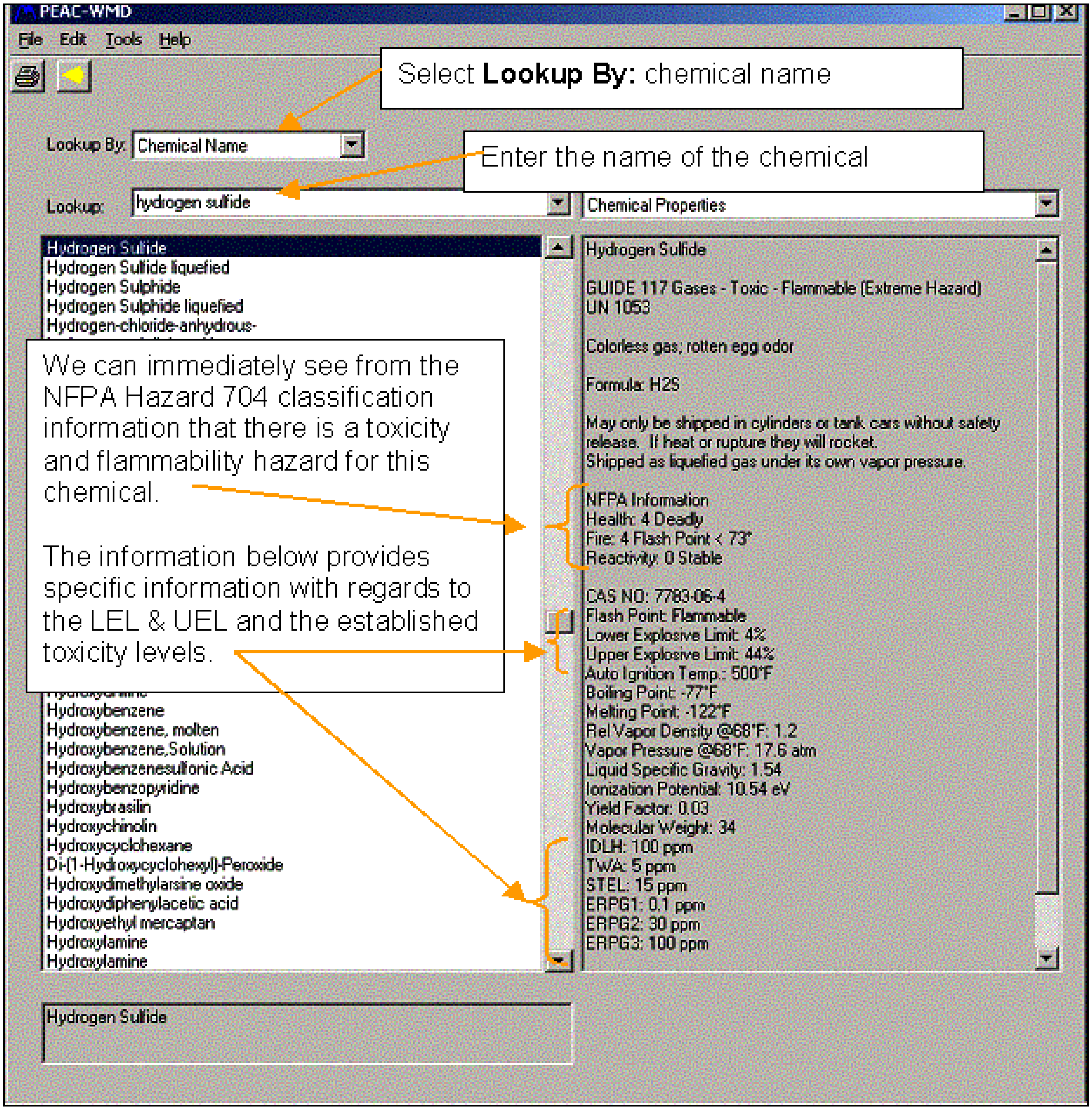


Figure 1 - Using the Lookup By: Name for Hydrogen Sulfide using the PEAC-WMD for Windows application

Review of the information displayed in the chemical properties screen whether in Figure 1 (above) or Figures 2-5 (below), show chemical properties values discussed earlier at the top of this discussion. As you can see below, 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 as the Level of Concern when we develop the Protective Action Distance (PAD) a little later.

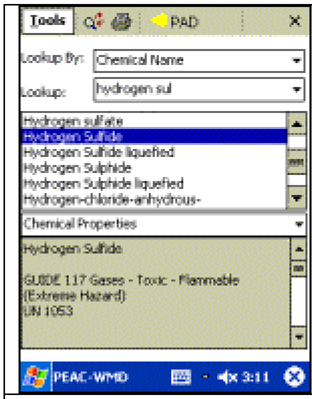


Figure 2 – Selecting Hydrogen Sulfide using the PEAC-WMD for Pocket PC application

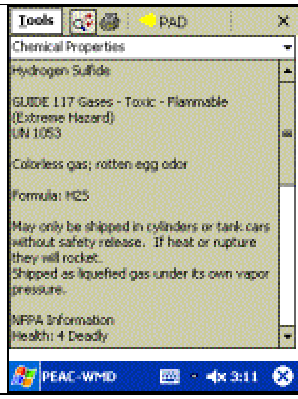


Figure 3 – The top portion of the Chemical Properties Data Display Screen

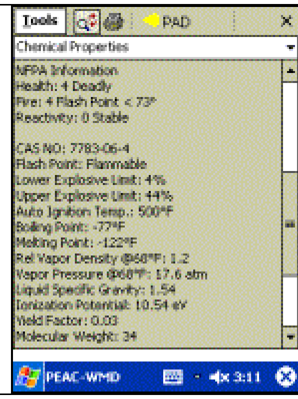


Figure 4 – The middle portion of the Chemical Properties Data Display Screen

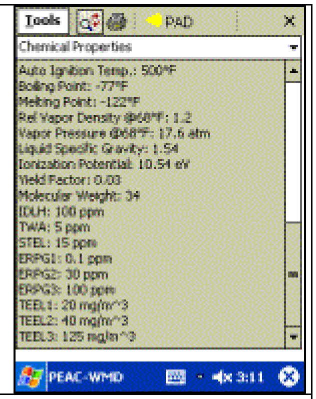


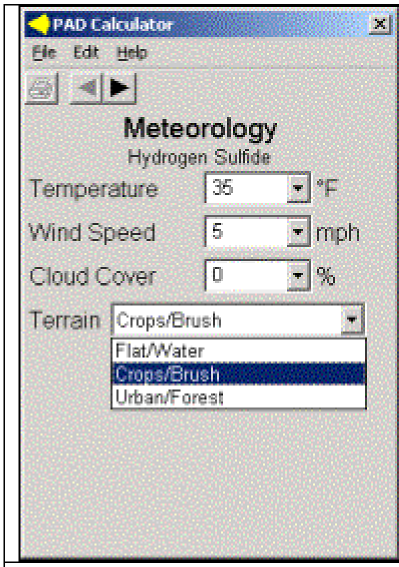
Figure 5– The bottom portion of the Chemical Properties Data Display Screen

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. If transported as a compressed liquefied vapor, it will be released from a container as a vapor or aerosol or a liquid that will rapidly vaporize. 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 Hydrogen Sulfide as the involved chemical we'll set the location to be a natural gas processing facility located just outside Evanston, WY. The date is January 14, 2004, about 4:45 PM with a temperature of 35°F, a wind speed of 5 mph with a clear sky. The release involves a low-pressure gas line that contains hydrogen sulfide that runs from the scrubbing unit to a flare, and a 1-inch valve has been knocked off. To provide some additional information, we'll specify the pipeline is a 6-inch diameter line about 500 feet long. 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 Evanston, WY (Salt Lake City is pretty close and is in the list of locations built into the PEAC locations list) and set the date and time to the proper values, otherwise you'll compute different values. We'll use a terrain type of crops/brush since most of the surrounding vegetation is probably sagebrush for a gas processing facility in Wyoming.

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 6. 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.

<table>
<tr>
<td>
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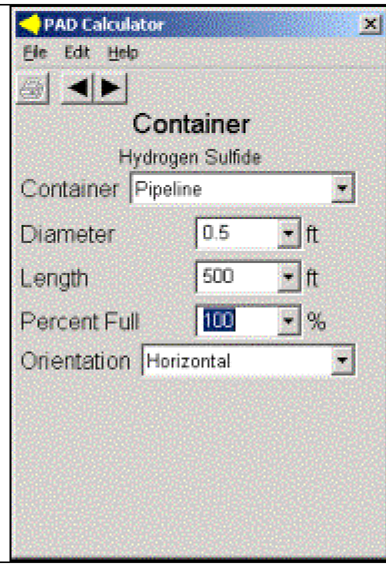
<td>
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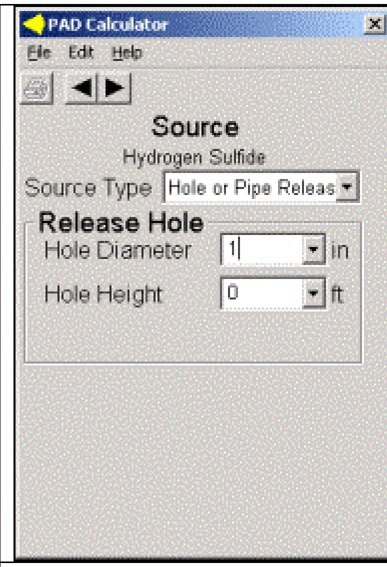
<td>
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<tr>
<td>Meteorology

It’s Wyoming in December and the temperature about 35°, wind is set for 2 mph, clear skies and the terrain is Crops/Brush since it’s an outdoor setting around a gas processing facility.</td>
<td>Container

We have selected from our list of container sizes the Pipeline selection with a 6” line (0.5’ diameter) and a 500’ length. This gets us a quick estimate of how much material might be involved.</td>
<td>Source

We have selected a Hole or Pipe Release for the type of release with a 1” Hole Diameter. This is the size of the valve knocked off the flare line.</td>
</tr>
</table>

Figure 6 – Calculating a PAD using the PEAC-WMD System for January 14th

By pressing the right arrow at the top of the screen, the PEAC system will display a screen as shown in Figure 7. This calculates a **PAD** (Protective Action Distance) based on the default **Level of Concern** the IDLH of 100 ppm. This evacuation or standoff distance is based on the toxicity of Hydrogen Sulfide, **<u>not</u>** the flammability.

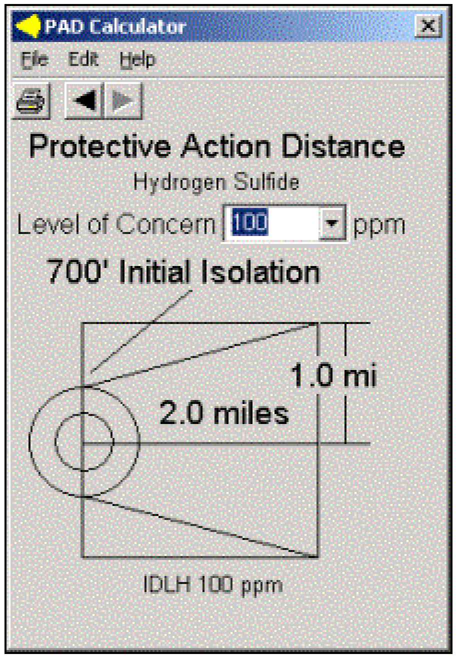

Figure 7 – Default PAD for Hydrogen Sulfide using the IDLH of 100 ppm

With a wind speed of 5 mph the downwind evacuation or PAD extends about 2 mile. If the wind speed was slower so that stable atmospheric conditions were established, the downwind evacuation distance will be impacted. To see the effect, click on the left arrow [◂] at the top of the screen until you return to the meteorological input screen. As shown in Figure 8, select a wind speed of 2 mph rather than 5 mph.

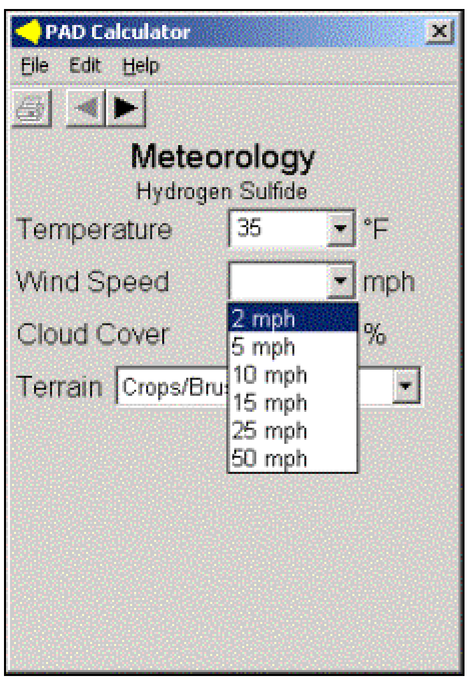

Figure 8 – Change the wind speed to 2 MPH

Then click on the right arrows [⏵] at the top of the screen until a new PAD screen is displayed. The results of the new calculations are shown in Figure 9.

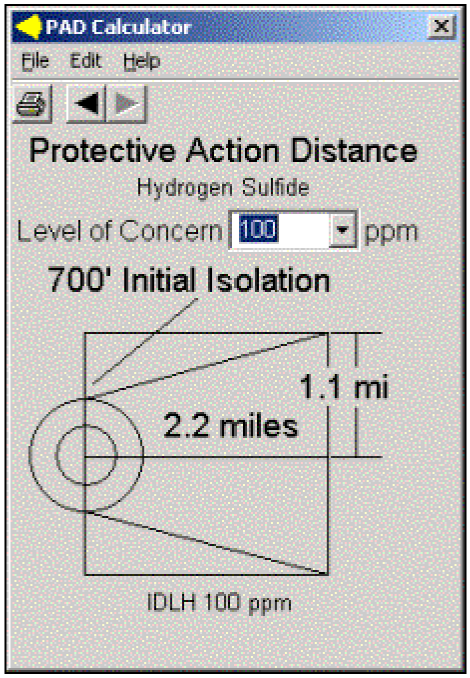

Figure 9 – PAD under stable conditions

As can be seen in Figure 9, the evacuation distance has increased when stable atmospheric conditions are present, hence the term "worst case" conditions.

The user should be aware that stable atmospheric conditions may exist during night with low wind; this is a "worst case" condition. These conditions can present serious problems with respect to toxic clouds and their behavior.

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/.