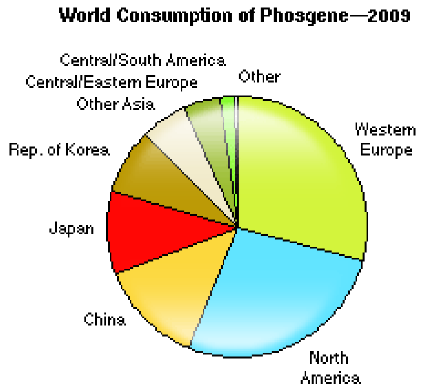
# Phosgene

Phosgene is a toxic gas once used as a chemical warfare agent during World War I and continues to be used by industry in the synthesis of plastics and other chemicals. Over one billion pounds of phosgene are used by industry in the United States annually. The gas can also be generated inadvertently during fires involving plastics and other chemicals and solvents containing chlorine, which is of concern to emergency responders. Phosgene is particularly insidious because if inhaled the person might experience initial respiratory tract irritation, feel fine later, and then die a day later of choking because of fluid buildup in the lungs (delayed onset noncardiogenic pulmonary edema).

## Industry Use



**Pie chart from Q.A. Rizvi, SRI Consulting, http://www.sriconsulting.com/CEH/Public/Reports/687.1000/**

Total industrial phosgene production numbers are not readily available and estimates differ, but a 2000 estimate (from U.S. Patent 6054107) is about 10 million tons annually worldwide. Another source (from “Phosgenations—a Handbook:, L. Cotarca and H. Eckert, Wiley-VCH publication, copyright 2003) estimated 5 to 6 million tons produced and used worldwide annually, A 2002 publication (National Academy of Sciences, subcommittee on Acute Exposure Guideline Levels) estimated about one million tons in the U.S. annually.

The reason for the difficulty in obtaining a production estimate is because phosgene is usually generated at the industrial site where the phosgene is used rather than purchased off-site and transported to the facility. In the United States, over 99% of the phosgene production is generated at the site where the chemical is used, and only one company (VanDeMark Chemical Company, Lockport NY) sells phosgene as a merchant chemical. Stockpiles of phosgene in the United States are almost “zero”. Phosgene stored has the potential to undergo change which could interfere with quality control during synthesis of resin and fine chemical products. Industry is also well aware that phosgene was used as a chemical warfare agent during World War I and the risks of accidents. Generation on site eliminates the risk of chemical release accidents during transportation. Additionally, one of the lessons learned from the 1984 methyl isocyanate release accident at Bhopal, India, is not to store large quantities of a very toxic chemical near where human populations can be exposed (see November 2009 issue of “The First Responder”). The on-site generation and limited storage of phosgene is good safety practice. Statistics on total phosgene production are somewhat difficult to estimate, and companies are unwilling to share that information. Some Chinese companies advertize their capacity for phosgene production and various commercial products in hopes of obtaining potential customers.

Phosgene is synthesized from carbon monoxide and chlorine, both of which are toxic and dangerous chemicals. Anhydrous chlorine gas is reacted with high-purity carbon monoxide in the presence of an activated carbon catalyst producing phosgene, some unwanted byproducts, and considerable heat. The production process is continuous with the raw materials carefully metered and excess heat removed. The principle unwanted byproduct is other chlorinated hydrocarbons such as carbon tetrachloride. Phosgene containing more than 150 ppm of carbon tetrachloride causes yellowing of polycarbonates (one of the commercial products manufactured from phosgene) and results in other commercial end product control issues. As a safety feature, large plants typically employ a safety absorption system where excess phosgene is destroyed by scrubbing in a recirculating caustic solution. Disposal of waste streams is an environmental concern because of the chlorinated hydrocarbons.

About 80% of the phosgene produced in the United States is used to manufacture various isocyanates which in turn are used to manufacture polyurethane resins and some pesticides. Another 10% is used to manufacture polycarbonates (a kind of plastic as in polycarbonate safety glasses). The remainder 10% is used to manufacture organic carbonates, acid chlorides from carboxylic acids, nitriles, urea-type compounds, and other chemicals. Ultimate products include pesticides, dyestuffs, pharmaceuticals (including a potent HIV-1 protease inhibitor), in metal recovery operations, aluminum chloride and boron trichloride, and a stabilizer for liquid sulfur dioxide.

## Dangers of Inhaling Phosgene

Phosgene is classified as a choking agent or a lung-damaging agent if inhaled. The boiling point of phosgene is 47°F (8 °C); below that temperature it can exist as a liquid. Phosgene has been described as an irritant pulmonary toxin that produces delayed-onset noncardiogenic pulmonary edema (from *e*-medicine, http://emedicine.medscape.com/article/832454-print). The gas slowly reacts with water producing hydrochloric acid. The gas can be inhaled deep into the lungs where it exerts its effects on the lung tissue resulting ultimately in fluid buildup in the lungs and death by choking. The damaging effects to lung tissue (including the ability to absorb oxygen from the air) are greater than what would be predicted from the hydrochloric acid alone indicating that phosgene itself damages the lung tissue membranes (the alveolar-capillary interface).

Initial exposure symptoms might be either non-existent or an irritation to the head, eyes (tearing), nausea, throat or mouth (burning sensation) or throat swelling and changes in voice (due to hydrochloric acid). This might last 3 to 30 minutes from the time of exposure. Afterwards, the exposed person might feel fine. Later, typically 4 to 24 hours from exposure, could be 30 minutes to 48 hours, the person notices respiratory problems. This typically includes a cough which is initially dry and then becomes frothy with a yellow to white sputum, and a chest tightness or chest pain or chest burning. Cardiac function is likely to be normal unless the person has another medical condition. The symptoms are present at rest but become much worse upon exertion. The time of onset of respiratory symptoms depend upon the degree of exposure. A shorter time period when symptoms occur means a more severe exposure and a poor chance of recovery. Death occurs within a few days. If the person recovers, as far as is known, the exposed person does not appear to have a greater risk towards developing cancer later in life, but could experience diminished lung capacity even a year later.

It is important to responders to determine the conditions of exposure of the injured person(s). If the temperatures were greater than the boiling point (47°F), than it is likely that the exposure was to phosgene gas, and extensive decontamination is probably not required. Any person exposed to liquid phosgene requires decontamination to protect emergency and hospital personnel. Any patient with eye exposure to phosgene must begin flushes with large amounts of saline or plain water for at least 15 minutes.

There is no specific antidote for phosgene poisoning. Care is supportive with oxygen administered upon appearance of respiratory problems, in particular chest tightness or dyspnea (labored respiration). The patient is kept dry, warm and calm (no exertion). An antibiotic might be administered as a precaution against developing a secondary bacterial infection. Ventilators are required for patients with severe pulmonary edema. Any person that might be exposed to phosgene should be transported to a medical facility for evaluation for a period (minimum 6 hours, some specialists recommend 12 or 24 hours) even if the person feels fine because of the latent period before onset of symptoms. The evaluated person should be symptom-free, normal oxygen saturation, normal chest radiograph, and have normal respiration before discharge. More details are at http://emedicine.medscape.com/article/832454-print.

## Acute Exposure Guideline Levels (AEGL)

Acute exposure guideline levels represent threshold exposure limits for the general public including infants and children for periods ranging from 10 minutes to 8 hours (10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours). They are also applicable to emergency responders. Three exposure levels are defined as follows:

- AEGL-1: This is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

- AEGL-2: This is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL-3: This is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Some susceptible subpopulations including persons with asthma and or other illnesses and the elderly could experience the effects described at concentrations below the corresponding AEGL.

A history of the AEGL program is summarized at the U.S. Environmental Protection Agency (EPA) website, http://www.epa.gov/oppt/aegl/index.htm. The U.S. EPA interest in the program is the result of the Superfund Amendments and Reauthorization Act of 1986, in which the EPA identified about 400 extremely hazardous substances that might be released accidently based on acute lethality data for rodents. In 1991, the EPA and the Agency for Toxic Substances and Disease Registry requested that the National Research Council establish AEGLs for these extremely hazardous substances. As the program developed, the establishment of the AEGLs is a collaborate effort of private and public sectors worldwide. A list of current members of the AEGL subcommittee is at http://www.epa.gov/oppt/aegl/pubs/members.htm. A list of AEGL subcommittee members when AEGLs were developed for phosgene is at http://www.epa.gov/oppt/aegl/pubs/tsd7.pdf; this document also presents the selection process on how the phosgene levels were developed based on animal studies. The AEGLs for extremely hazardous substances is accessible at http://www.epa.gov/oppt/aegl/pubs/chemlist.htm.

Table 1. Acute Exposure Guideline Levels for Phosgene, in parts per million (ppm)

| | 10 minutes | 30 minutes | 1 hour | 4 hours | 8 hours |
|---|---|---|---|---|---|
| AEGL-1 | NR | NR | NR | NR | NR |
| AEGL-2 | 0.60 | 0.60 | 0.30 | 0.080 | 0.040 |
| AEGL-3 | 3.9 | 1.5 | 0.75 | 0.20 | 0.090 |

NR = AEGL-1 levels not recommended due to insufficient data

The AEGL subcommittee in reviewing the available literature record concluded that there was no relative human data relative to establishing AEGLs for any level nor was there any animal data relative to AEGL-1. There were many tests on a variety of animals (rats, mice, rabbits, even some monkey data) relative to AEGL-2 and AEGL-3 plus some dog, cat, sheep, and goat data for AEGL-3, but in many cases the data was of insufficient quality (test details insufficient, too small sample size). The limited data did not seem to indicate species variability. The AEGL-2 values were derived from rat nonlethal toxicity tests published in 1986 and 1989, with an additional uncertainty factors to account for susceptible populations and extrapolation from rat to man. The AEGL-3 values were also based on rat tests (published in 1990) with an additional uncertainty factor to account for susceptible populations and from rat to man.

The National Institute for Occupational Safety and Health (NIOSH) in 1976 published a report (NIOSH-76-137) summarizing the results of a study where 56 military personnel were exposed to increasing levels of phosgene until all subjects could detect an odor. The lowest detectable odor for any person was 0.4 ppm. At 1.2 ppm, 39% of the subjects detected odor. At 1.5 ppm, 50% of the subjects detected odor. The odor was described as similar to "distinctive" new-mowed hay. In addition, there was olfactory fatigue. NIOSH defined 2 ppm as the concentration level Immediately Dangerous to Life and Health.

The conclusion is that phosgene odor (new-mowed hay) is an insufficient warning signal for the presence of phosgene. Persons exposed to phosgene might inadvertently remain in a contaminated area unaware that they are in any danger.

## Phosgene Inhalation Examples

Fortunately, at least in the United States, except for a few small users, phosgene is generated at the point of use. No large inventories of the chemical are stored. However, some industrial accidents have occurred. Also if chlorinated hydrocarbons such as Freon are overheated or in a fire, some phosgene may be inadvertently generated even though the Freon itself is not combustible. Fires involving organic chemicals containing chlorine are of concern to emergency responders. Some examples of phosgene exposure follow:

- On 23 January 2010, a braided steel hose connecting a 1-ton capacity phosgene cylinder to a production unit at the DuPont chemical plant in Belle, WV, suddenly ruptured sending phosgene into the air. The hose which ruptured was one-quarter inch in diameter and 18 inches long constructed of woven stainless steel on the outside and Teflon inside. A 58-year old worker exposed to the phosgene was transported to the hospital where he died the next day. An unconfirmed source (http://www.chemistry-blog.com/2010/01/26/dupont-phosgene-death/) reported that the worker who died was earlier walking with another employee nearby and heard the hose getting ready to burst, shoved the other employee out of the way, and took the blunt of the escaping phosgene to his face and chest. The U.S. Chemical Safety Board, the independent government entity later investigating the accident, examined the hose and reported that the woven stainless steel was frayed enough that the Teflon could be seen through a small hole.

- A 43-year-old worker was using a hot welding torch to cut through a refrigeration pipe which contained Freon (chlorodifluoromethane) at a United Kingdom location, and was exposed to a musty smelling gas. He experienced lacrimation (tearing), a burning sensation in his mouth, and nausea. Later he experienced difficulty breathing and chest pain. On arrival to the local hospital, he had symptoms of pulmonary edema, and was placed on oxygen. Chest radiograph was normal. The patient had been exposed to phosgene which had been formed due to heating of chlorodifluoromethane during welding. The patient slowly recovered, complaining of lethargy and continued difficulty breathing for weeks after the accident. [reference: *Journal of Accident and Emergency Medicine*, 12 pp212-213 (1995), available on the Internet]
- A case of a presumed worker phosgene poisoning death occurred at a dry cleaning facility which used trichloroethylene. A concentration of 488 ppm trichloroethylene was measured in the room where he worked. The worker was also a heavy smoker smoking 40 cigarettes a day. He left work, collapsed and died 90 minutes later. Chest x-ray films confirmed pulmonary edema. The phosgene was believed to be generated by decomposition of trichloroethylene as the result of contact with the hot tip of his lighted cigarette [example cited in a NIOSH Criteria Document, referenced at http://www.lindane.org/chemicals/phosgene.htm., more examples of worker phosgene deaths presented at this website].
- The EPA AEGL document [http://www.epa.gov/oppt/aegl/pubs/tsd7.pdf] cites an early accident on 20 May 1928 at Hamberg, Germany, where 11 metric tons of phosgene was released outdoors from a storage tank on a warm, dry, slightly windy day. Within a few hours, people as far away as six miles began reporting to hospitals complaining of headaches, nausea, irritant cough, and sickening-sweet taste in their mouths. This was followed by a latent period and then pulmonary symptoms. Autopsies on six of the people who died showed pulmonary effects in all cases. There were about 300 people who reported to the local hospital within a few days, and 10 known deaths.
- A probable inhalation of phosgene in December 1958 is published in *Thorax* (a medical journal), vol 16, pp 91-93 (1961) and is available in the Internet at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1018609/pdf/thorax00061-0105.pdf. The phosgene is believed to be generated from carbon tetrachloride from a fire extinguisher which was used by a 16-year-old woman to fight a fire that was destroying her small home. Today, the hazards of carbon tetrachloride are recognized, but 50 and 60 years ago this was not so, and the chemical was widely used as a safe, non-flammable solvent easily purchased in drug and hardware stores and used in fire extinguishers. The heat from the fire caused phosgene to be generated from the carbon tetrachloride. She complained of a dry cough; her doctor initially diagnosed bronchitis and found her general condition good. Several hours later her condition deteriorated

considerably; when she was admitted to the hospital she was almost breathless and deeply cyanosed (bluish color from oxygen starvation). Chest x-rays (photos in medical journal) showed pulmonary edema. Treatment with oxygen was started. She began to recover after several days, but if oxygen treatment was stopped cyanosis returned. After 6 months, she apparently recovered completely. Another study cited in the same journal article uncovered 15 fatal cases using carbon tetrachloride extinguishers to fight fires which at the time of death were attributed to "smoke poisoning".

- Another death due to probable phosgene poisoning was cited by NIOSH (see http://www.cdc.gov/niosh/pdfs/76-137c.pdf). The situation involved use of chlorinated hydrocarbon solvents (methylene chloride) in a poorly ventilated area heated by a portable kerosene stove. A 53-year-old man noticed respiratory irritation soon after beginning work but continued to work for several hours. After about 5 hours later, his breathing became labored. He developed pulmonary edema and died within a few hours. Autopsy showed extensive degenerative changes in his lungs and trachea. A second person, a 38-year-old pregnant woman was exposed in a similar manner for three hours in the afternoon. The next day the woman was hospitalized with pulmonary edema. She was released after 8 days hospitalization even though her chest x-ray did not show a complete recovery to normal. She gave birth to a healthy child 2 months later.
- Another death, also cited by the same NIOSH website, involved trichloroethylene vapor escaping from a chlorinated solvent degreaser and contacting the firebox of nearby space heater. Normally perchloroethylene was used in the degreaser, but trichloroethylene was inadvertently used on the day of the incident. The worker was found dead 3.5 hours after exposure began, and one hour after he reported that vapor was escaping from the degreaser. The cause of death was consistent with phosgene exposure. The circumstances of the situation were later artificially recreated, with concentrations of 15 ppm phosgene being measured in the breathing zone where the deceased worker had worked.
- A combination tank explosion and toxic gas release caused 10 firemen deaths plus 22 firemen and 3 policemen injured responding to an incident on 28 October 1954 at a textile finishing firm in Philadelphia. (see http://www.facebook.com/topic.php?uid=144290795635&topic=11704 for details). Firefighters were responding to smoke coming from a 4000-gallon capacity aluminum alloy tank containing a mixture of the chlorinated organic solvents o-dichlorobenzene, propylene dichloride, and ethylene dichloride. The tank previously had been used for storage of coconut oil and was steam-cleaned before filling with the organic solvents. The steam cleaning apparently caused residual oil to vaporize and condense in the tank vent blocking the vent. Residual moisture left in the tank reacted with the organic

> solvents and aluminum and increased the temperature inside the tank. The tank exploded killing two firemen instantly from the blast (a third firefighter died from the blast shortly afterwards). The exploding tank released a combination of toxic gases (the original chlorinated hydrocarbons plus hydrogen chloride, aluminum chlorate, and an unknown amount of phosgene generated from the heat). There were more deaths due to inhalation of the toxic gas mixture.

Phosgene can be generated as the result of incomplete combustion or overheating of chlorinated hydrocarbons. These chlorinated hydrocarbons are found in many commercial and industrial products including vinyl materials, pesticides, refrigerants, paint strippers, and organic degreaser solvents, and even PVC piping. In the case of fire, the chlorine part of the chemical is released. If combustion is complete, the chlorine might appear as chlorides in the ash residue and as hydrogen chloride (hydrochloric acid). John Nordin (the writer of this report) once measured the relative amounts of chlorides in the ash and hydrochloric acid escaping up a stack during a controlled incineration burn of medical waste containing chlorinated plastics for an industrial client, and found that most of the chlorine was captured in the ash and a lesser amount escaping as hydrogen chloride. Under the test conditions, the incinerator was fitted with an afterburner operating under excess air conditions.

Under air-starved conditions of real-world fires, some phosgene can potentially form along with carbon monoxide and hydrogen cyanide. This is of concern to firefighters.

### Chemical Warfare

The Germans first used phosgene as a chemical warfare agent during World War I. On 19 December 1915, 4000 cylinders of phosgene gas and phosgene and chlorine combination were released against the British at Ypres. Phosgene was also later used by French, American, and British forces responding to the World War I attack. After World War I, some countries began to secretly stockpile the chemical. It was used by the Imperial Japanese Army against the Chinese during the Second Sino-Japanese War in 1938. More details are in the references cited by Wikipedia (see http://en.wikipedia.org/wiki/Phosgene). Australia also admits to stockpiling but not using phosgene during World War II, with some buried weapons only recently discovered (see also http://www.dailytelegraph.com.au/news/nsw-act/top-secret-war-bombs-in-lithgow/story-e6freuzi-1111117545423).

After World War II there have been only isolated, small-scale incidents. An example is a Japanese 1994 incident cited at http://emedicine.medscape.com/article/832454-print, where an extremist cult attacked a journalist reporting on the cult activities by introducing phosgene into her apartment through a mail slot while she slept.

The Chemical Weapons Convention of 1997 bans chemical weapons and requires destruction of within a certain length of time of chemical weapons with no commercial use. Details are at http://www.armscontrol.org/factsheets/cwcglance. It is much more comprehensive than the 1925 Geneva Protocol which only outlaws the use of chemical weapons. Phosgene is classified as a Schedule 3 substance, which applies to chemicals which have been produced, stockpiled, or used as a chemical weapon but are also produced in large commercial quantities not prohibited by the Chemical Weapons Convention. Plants that manufacture more than 30 metric tonnes per year of phosgene must declare this and can be inspected at any time, and there are restrictions on export to countries which are not Chemical Weapons Convention signers.

**Use of PEAC Tool**

Emergency responders encounter many different hazardous situations. There are many thousands of different chemicals and mixtures that are used commercially or could be used by terrorists; the PEAC tool contains about 100,000 listings. Pocket guides such as the 2008 Emergency Response Guidebook and NIOSH Pocket Guide lists basic information for a shortened list of chemicals. With the PEAC tool, the user can look up the chemical, find information about the hazards, estimate a protective action distance for public evacuation in case of a spill, respiratory protection, and look at protocols for basic and advanced life support. The following represents part of the PEAC tool display:

# Chemical Information

## Phosgene

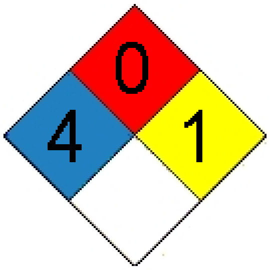
CAS 75-44-5
UN 1076
GUIDE 125 - GASES - CORROSIVE

Low boiling, colorless liquid; pungent odor, causes severe pulmonary edema

May only be shipped in cylinders or tank cars without safety release. If heat or rupture they will rocket.

Shipped as liquefied gas under its own vapor pressure.

**NFPA Information**



Health (Blue): 4 Deadly
Fire (Red): 0 Will not burn
Instability (Yellow): 1 Unstable if heated

**Physical and Chemical Properties**
Formula: $CoCl_2$
Molecular Weight: 99
Boiling Point: 47°F
Melting Point: -198°F
Rel Vapor Density @68°F: 3.4 (Heavier than air)
Vapor Pressure @68°F: 1.6 atm
Liquid Specific Gravity: 1.43 (Heavier than water)
Ionization Energy: 11.55 eV
RAE Systems PID correction factor for 11.7 eV: 8.5

**Toxic Levels of Concern**
IDLH: 2 ppm (8.1 mg/$m^3$)
TWA: 0.1 ppm (0.4 mg/$m^3$)
ERPG-2: 0.2 ppm (0.81 mg/$m^3$)
ERPG-3: 1 ppm (4.05 mg/$m^3$)
TEEL-1: 0.1 ppm (0.4 mg/$m^3$)
TEEL-2: 0.3 ppm (1.21 mg/$m^3$)
TEEL-3: 0.75 ppm (3.04 mg/$m^3$)

**Acute Exposure Guideline Levels** (Status: Final)

Ten Minute AEGL-1: Not recommended due to insufficient data.
Thirty Minute AEGL-1: Not recommended due to insufficient data.
One Hour AEGL-1: Not recommended due to insufficient data.
Four Hour AEGL-1: Not recommended due to insufficient data.
Eight Hour AEGL-1: Not recommended due to insufficient data.

Ten Minute AEGL-2: 0.6 ppm
Thirty Minute AEGL-2: 0.6 ppm
One Hour AEGL-2: 0.3 ppm
Four Hour AEGL-2: 0.08 ppm
Eight Hour AEGL-2: 0.04 ppm

Ten Minute AEGL-3: 3.6 ppm
Thirty Minute AEGL-3: 1.5 ppm
One Hour AEGL-3: 0.75 ppm
Four Hour AEGL-3: 0.2 ppm
Eight Hour AEGL-3: 0.09 ppm

**Definitions**

AEGL-1: The airborne concentration of a substance at or above which it is predicted that the general population, including "susceptible" individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2: The airborne concentration of a substance above which it is predicted that the general population, including "susceptible" individuals could experience irreversible or other serious, long-lasting health effects or impaired ability to escape.

AEGL-3: The airborne concentration of a substance at or above which it is predicted that the general population including "susceptible" individuals could experience life-threatening health effects or death.

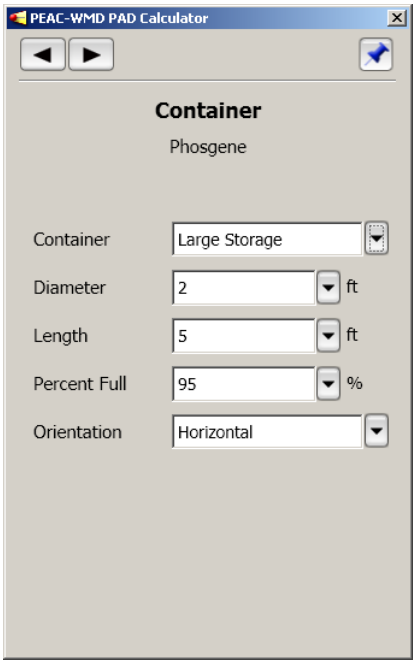
"Susceptible" individuals may include persons in the 40 to 65 age bracket, smokers, or people who use alcohol; but not hyper-susceptible or hypersensitive individuals.

The AEGL-1 and AEGL-2 levels are also evaluated to ensure that the chemicals do not pose a greater than 0.0001 increased risk for cancer.

**AEGL Source**

United States Environment Protection Agency

The following is an example from the PEAC tool for a release and development of a PAD. The user selects the circumstances of the release, for example, a sudden rupture of a 2 foot diameter 5 foot long cylinder containing phosgene at a plant as in the case of a daytime terrorist attack on a sunny day, urban location, wind speed 10 miles per hour, and a protective action distance based on a conservative AEGL-2 level concentration a 30 minute exposure (0.6 ppm). A one-ton capacity cylinder appears to be the largest-size container shipped in the U.S., at least as far as we are able to find.



**Container**

Phosgene

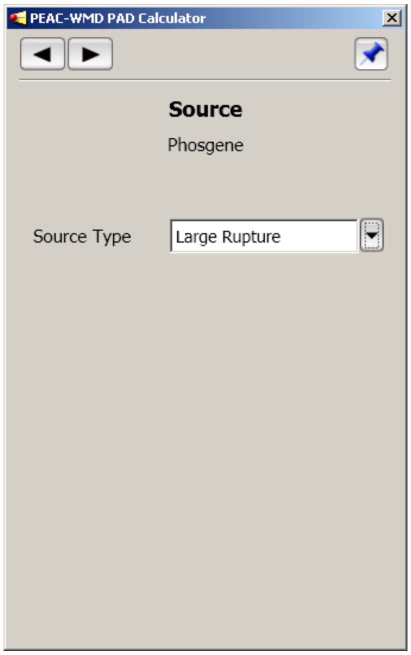
Container: Large Storage

Diameter: 2 ft

Length: 5 ft

Percent Full: 95 %

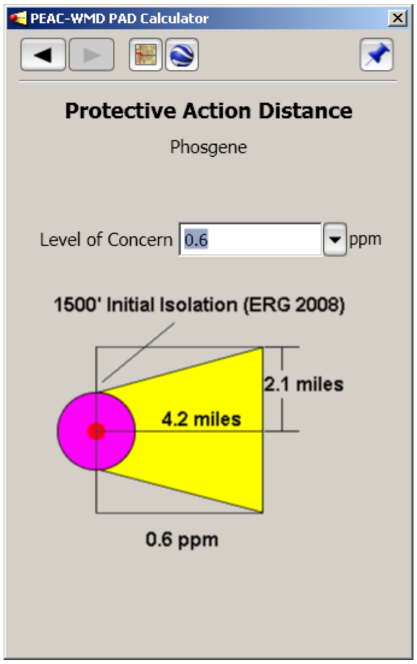
Orientation: Horizontal



**Source**

Phosgene

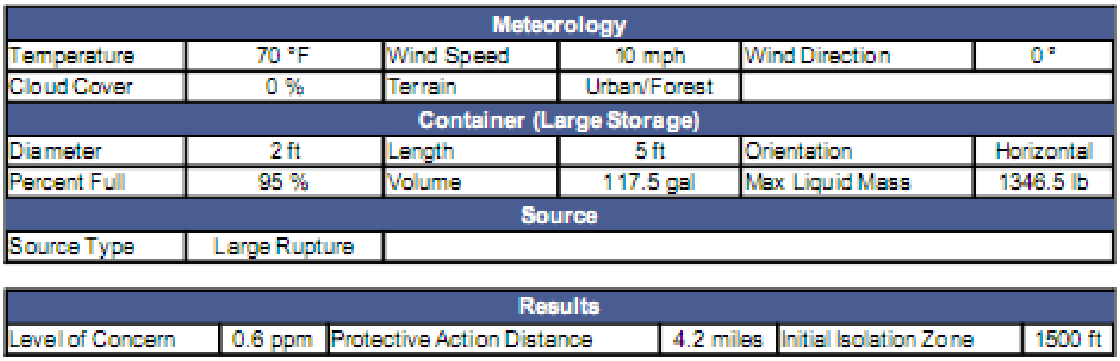
Source Type: Large Rupture



**Protective Action Distance**

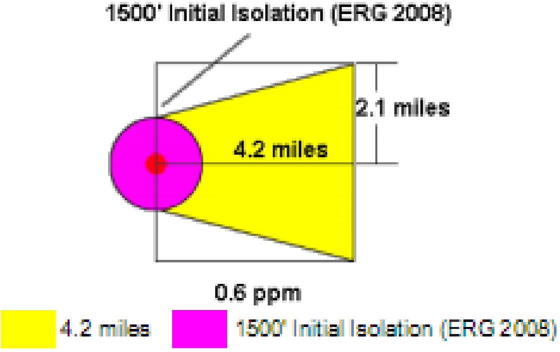
Phosgene

Level of Concern: 0.6 ppm



| Meteorology | | | | | |
|---|---|---|---|---|---|
| Temperature | 70 °F | Wind Speed | 10 mph | Wind Direction | 0 ° |
| Cloud Cover | 0 % | Terrain | Urban/Forest | | |
| **Container (Large Storage)** | | | | | |
| Diameter | 2 ft | Length | 5 ft | Orientation | Horizontal |
| Percent Full | 95 % | Volume | 117.5 gal | Max Liquid Mass | 1346.5 lb |
| **Source** | | | | | |
| Source Type | Large Rupture | | | | |

| Results | | | | | |
|---|---|---|---|---|---|
| Level of Concern | 0.6 ppm | Protective Action Distance | 4.2 miles | Initial Isolation Zone | 1500 ft |



The PEAC tool display can be overlaid on an area map for printout by selecting a location of the incident.

## Additional Newsletter Articles

This article on phosgene is part of a series where AristaTek reviews toxic chemicals used in Industry, including accidents and unintentional releases. Previous articles have appeared on anhydrous ammonia, chlorine, propane, hydrofluoric acid and fluorine, oleum and sulfuric acid, and methyl isocyanate. More are planned.