A Guest's Glance
Let’s Take a PEEK at the PEAC Software

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This month, let us examine the Chlorine gas (Cl_2). For the purpose of this discussion, we will limit the discussion to the form of Cl_2 that is typically transported and used as described below.

Chorine

Formula: Cl_2

CAS NO: 7782-50-5

GUIDE 124 Gases - Toxic and/or Corrosive – Oxidizing

DOT Label: Nonflammable gas and poison

UN 1017

Chlorine is a green-yellow poisonous gas, which has a suffocating odor. At -33 degrees Celsius, it condenses to an amber liquid. Chlorine is shipped as liquefied gas under its own vapor pressure. Chlorine gas (Cl_2) is widely used and transported via rail and trucks throughout the USA. Chlorine is a very important element that, when handled, transported, and stored properly, is used safely and effectively for dozens of industrial applications. Every year, approximately 12 million tons of chlorine is produced in North America. The greatest volume of chlorine, about 35%, is used in the production of other important chemicals, including those used to make pharmaceuticals [(3)].

It is a very unique chemical, as it is used in a wide range of applications – from rocket fuels to food products. Since 1950, the largest use for Chlorine was the manufacture of ethylene oxide and glycol (antifreeze fluids).

Although Chlorine does not burn or explode, it will support combustion. Chlorine is 2.5 times heavier than air and response to leaks can be highly dependant on atmospheric and topographic conditions. When released to the air, Chlorine expands to 460 times the volume of the liquid in the container.

Chlorine gas was used in World War I as a chemical warfare agent under the name Bertholite. Currently, there is some concern that it could be utilized by adversaries under the right conditions in the future for negative consequences. Post 9/11, there has been more focus on the tracking, shipping, and storage of many hazardous chemicals (e.g. Chlorine) across the country.

Sources / Uses / Manufacture

Chlorine is produced commercially by electrolysis of brine or electrolysis of used sodium chloride and mercury using electrolyzer and decomposer reactions (eq 1.10, 1.10) oxidation of chlorides using chemical methods (eq 1.13), or an HCl oxidation process (eq 1.14). There are a number of steps for each reaction.

$$NaCl + (Hg) \longrightarrow Na(Hg) + \tfrac{1}{2}\, Cl_2 \quad (1.10)$$

$$Na(Hg) + H_20 \longrightarrow NaOH + 1/2H_2 + (Hg) \quad (1.11)$$

$$2NOCl + O_2 \longrightarrow N2O_4 + Cl_2 \quad (1.13)$$

$$4HCl + O_2 \longrightarrow 2Cl_2 + 2H_2O \quad (1.14)$$

Chlorine is used in paper and pulp, bleaching, chemical industries, in the production of plastics, household bleaches, refrigerants, metal extraction, beneficiating of ores, pharmaceuticals, cosmetics, disinfection for water and wastewater treatment, and swimming pools.[1]

Department of Transportation and Regulations

Both the Department of Transportation (DOT)[7] and the Federal Motor Carrier Safety Regulations (FMCSRs) regulate the transportation of Hazardous Materials such as Chlorine. Personnel involved in all aspects of chlorine shipping and handling should be knowledgeable of the regulatory requirements. Emergency Responders and law enforcement agencies should have a basic understanding on the hazards of this chemical given the frequency of transportation of this chemical – even in areas across the country that do not use Chlorine in the gas form.

Emergency Response

Leaks involving Chlorine may be minor, major, or catastrophic. Minor leaks may occur during a cylinder hook up or faulty valve. Major leaks may involve a broken flexible connector, a fusible plug failure or repair work while the chlorine system is under pressure. Catastrophic would involve a breach of the container (truck or rail) or a ‘blowout” of a fusible plug in the container wall.

Personal protective equipment (PPE) (e.g., gloves, sleeves, encapsulating A level suits) should be researched and used based on the worker's/responders potential exposure to

Chlorine. The resistance of various materials to permeation by both chlorine liquid and chlorine gas are well documented by PPE manufacturers. Response personnel should keep updated on their PPE compatibility as well as frequent inspections. Training of personnel on permeation time of PPE and routine maintenance of gear is also an essential part of preparedness. Local Hazardous Response teams typically have Chlorine repair kits on response vehicles for containing leaks for rail cars, one ton, and 150 pound cylinders. More information on response kits may be obtained from the Chlorine Institute [(2)]. Emergency Response and all other personnel involved in the use of devices and tools much are completed on a routine basis to ensure familiarity and updating with emergency kits (A, B, and C, Chlorine Institute [(2)]. Routine drills in working with the equipment and downwind scenarios are helpful.

First responders may encounter chlorine gas in one of several containers;

1)92 ton rail cars

2)2000 pound (1 ton) cylinders

a.30” diameter by 72” *

3)150 pound cylinders

a.14” by 54” *

*approximate dimensions

SPILLS AND LEAKS In the event of a spill or leak involving chlorine, any personnel without proper PPE should not be permitted to respond or be within the hot zone. At a minimum, the following steps should be undertaken following a spill or leak:

1. Notify emergency personnel. Due to the variability of leak scenarios, continuous weather assessment is essential and need to be updated to responders.

2. Remove all sources of heat and ignition.

3. Keep all combustibles (wood, paper, oil, etc.) away from the chlorine leak.

4. Ventilate potentially explosive atmospheres.

5. Evacuate the spill area for at least 50 feet in all directions. Use PEAC® and or other HAZ MAT response models to calculate evacuation distances (see example).

6. Find and stop the leak if this can be completed without risk to emergency responders. If not possible, consider moving the leaking container to an isolated area until gas has dispersed. The cylinder may be allowed to empty through a reducing agent such as sodium bisulfide and sodium bicarbonate[(2)].

7. Use water spray to reduce vapors; do not put water directly on the leak or spill area. Water applied on a leaking cylinder will enlarge the leak by creating acid.

Special Regulatory Requirements

Facilities at which use and or store greater than 100 pounds of Chlorine must comply with EPA's emergency planning requirements (40 CFR Part 355.30)[(11)]. Local Emergency Planning Committees (LEPC) should be aware of these sites at a particular area. EPA defines hazardous substance release as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. This includes the abandonment or discarding of contaminated containers of hazardous substances. If the event of a release is above the reportable quantity for that chemical, employers are required to notify the proper Federal, State, and local authorities. The reportable quantity of chlorine is 10 pounds. If an amount equal to or greater than this quantity is released within a 24-hour period in a manner that will expose persons outside the facility, employers are required to do the following: The National Response Center should be immediately notified at (800) or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6][(11)]. Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40] [(11)]. Notification of the community emergency coordinator (LEPC) or relevant local emergency response personnel of any area likely to be affected by the release is also required [40 CFR 355.40][(11)].

Risk Management Program Rule (RMPR)

A 1990 amendment to the Clean Air Act aimed to prevent accidental releases of hazardous chemical releases by risk management planning and promoting advancements. The RMPR requires any facility that stores, handles, or produces specified quantities of hazardous chemicals to file a Risk Management Plan (RMP) by June 21, 1999. The key component of the RMPR was accident prevention. Emergency Responders and Local Emergency Planning Committees are encouraged to review their specific locale to determine what facilities in their area might have users of large quantities of Chlorine. As a PEAC® user, you can use your program to evaluate possible scenarios for response as well as working with the local representatives that should have an updated RMP in place.

By working with stakeholders in any given geographical area, responders can perform table top exercises as well as full scale drills to work on pro active plans for response in case of accidental release. Communication plans are critical and each user of Chlorine should develop and practice proactive use of communication systems (e.g. public information officer) in the event of an emergency. Other key aspects of the plan include keeping an updated community contact list, and working with other stakeholders such as the LEPC.

Synonyms

Chlorine, Bertholite, Chloor (Dutch), Choro (Italian), Chlore (French), Chlor (German).

Routes of Exposure

Inhalation

Inhalation is the major route of Chorine toxicity. Odor can be an indicator of chlorine; however, the olfactory glands are quickly overcome by higher concentrations. Proper Personal Protection Equipment (PPE) as well as chlorine gas detectors should always be nearby to facilitate determining chlorine leaks. Respiratory Protection Programs [8] are an important aspect of employee screening when using Self Contained Breathing Apparatus (SCBA).

Skin/Eye Contact

Chlorine is a server irritant causing irritation to the eyes, nose, and throat. Burning of the mouth, vomiting, headaches, dizziness, muscle weakness, pneumonia, respiratory distress, and pulmonary edema can also occur with exposure. Contact with compressed liquid Chlorine can cause frostbite and/or chemical burns to the eyes and skin.

Physical Properties

Chemical Abstract Service (CAS) NO: 7782-50-5

Flash Point: Non-Combustible

Boiling Point: -29°F

Melting Point: -150°F

Rel Vapor Density @68°F: 2.5

Vapor Pressure @68°F: 6.8 atm

Liquid Specific Gravity: 1.42

Ionization Potential: 11.48 eV

Atomic Number: 17

Atomic Weight: 35.453

Molecular Weight: 70.9

Occupational Exposure Limits

IDLH: 10 ppm

TWA: 0.5 ppm

STEL: 1 ppm

ERPG1: 1 ppm

ERPG2: 3 ppm

ERPG3: 20 ppm

TEEL1: 3 mg/m^3

TEEL2: 7.5 mg/m^3

TEEL3: 60 mg/m^3

Concentration Cl_2	**Reported Response in Humans**
0.2-3.5 ppm	Odor detection (some tolerance develops)
1-3 ppm	Mild mucous membrane irritationthat can be tolerated up to1 hour
3 ppm	Extremely irritating to the eyes and respiratory tract
5 ppm	Severe irritation of eyes, nose, and respiratory tract; intolerable after a few minutes
14-21 ppm	Immediate irritation of the throat, Dangerous if exposed 30-60 minutes
15 ppm	Irritation of the throat
30 ppm	Moderate irritation of the upper respiratory tract; immediate chest pain, vomiting, dyspnea, cough

Table 1 [10]

Incompatibilities

Chlorine will react with many compounds to form explosive compounds. Examples include, but are not limited to: acetylene, ammonia, fuel gas, hydrogen, metals, ether, and turpentine.

Standards and Guidelines

In 1973, NIOSH estimated that 15,000 workers had potential occupational exposure to Chlorine. Excellent references can be accessed through the Center for Disease Control[12], NIOSH [6], and ATSDR [13, 14].

Health Effects[10] Acute Exposure

Chlorine gas is a respiratory irritant. The distinctive odor similar to household bleach is detectable easily at very low concentrations, e.g., 0.2-0.4 parts per million (ppm) – the "odor threshold." For example, the concentration over a laundry tub where bleach is being used is around one part chlorine per one million parts of air. Most people can smell it very readily at that level. Chlorine concentrations above five parts per million (ppm) are irritating to the nose, throat, and eyes. In concentrations around the 1-3 ppm, chlorine causes mild eye and respiratory-tract irritation after several hours. and excess salivation. The very young, the elderly, and people with other health problems are most susceptible to the effects of chlorine exposure.

If a person is trapped for a long period in a high chlorine-concentration atmosphere, loss of consciousness and possibly death can result. It is important during a chlorine emergency to leave the contaminated area if possible. If that is not possible, sheltering in place can reduce considerably the chlorine exposure level.

To receive a lethal exposure, a person would have to remain near a leak source, within a chlorine cloud, Chronic Exposure

Most studies indicate no significant connection between chronic exposure to low concentrations of chlorine and adverse health effects. A 1983 Finnish study did show an increase in chronic coughs and a tendency for hyper-secretion of mucous among workers. However, these workers showed no abnormal pulmonary function in tests or chest x-rays.

One of the most comprehensive studies, involving 300 chlorine plant workers chronically exposed to 0.006 to 1.42 ppm, showed no statistically significant increase in abnormal chest x-rays, electrocardiograms, or pulmonary function tests.

Other studies of workers in the chlor-alkali industry have resulted in similar observations. *No significant effects have been indicated for chlorine levels normally found in work places where chlorine is handled.* Those levels typically are well below one ppm.

As for the air breathed by the general population, chlorine levels in ambient air are so low that they are either unmeasurable or of no toxicological importance.

Safety

National Fire Protection Association (NFPA) Information[4]

Health: 4 Deadly

Fire: 0 Will not burn

Reactivity: 0 Stable

Special: Oxidizer

FIRST AID

Call 911 or emergency medical service. Incidents involving Chlorine may involve multiple resources due to weather and topographic variables. Move victim to fresh air. Have MSDS[9] ready for EMS personnel. Apply artificial respiration if victim is not breathing. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves while responding and administering aid. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Clothing frozen to the skin should be thawed before being removed. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Keep victim warm and quiet. Keep victim under observation. Effects of contact or inhalation may be delayed themselves. Incidents involving chlorine may require removal of contaminated clothing as Cl_2 may produce further skin irritation if not removed. Finally, any incident involving Chlorine requires the expertise of professional medical advice for specific exposures or assessments.

Chlorine response and emergencies should be handled only by those with specific training. The supplier should be contacted in the event of any leak. Help can also be obtained by contacting CHLOREP. This can be activated by contacting CHEMTREC in the USA by calling 1-800-424-9300 or CANUTEC in Canada 1-613-996-6666. In the event of leak and the responder finds victims make sure that you have adequate PPE to approach the area. The PEAC-WMD application will greatly aid the responder with appropriate response information (Figure 1). Due to the many variables regarding any response, it is essential that medical personnel be briefed on the hazards of Chlorine. Depending on the release, decontamination may be required on scene.

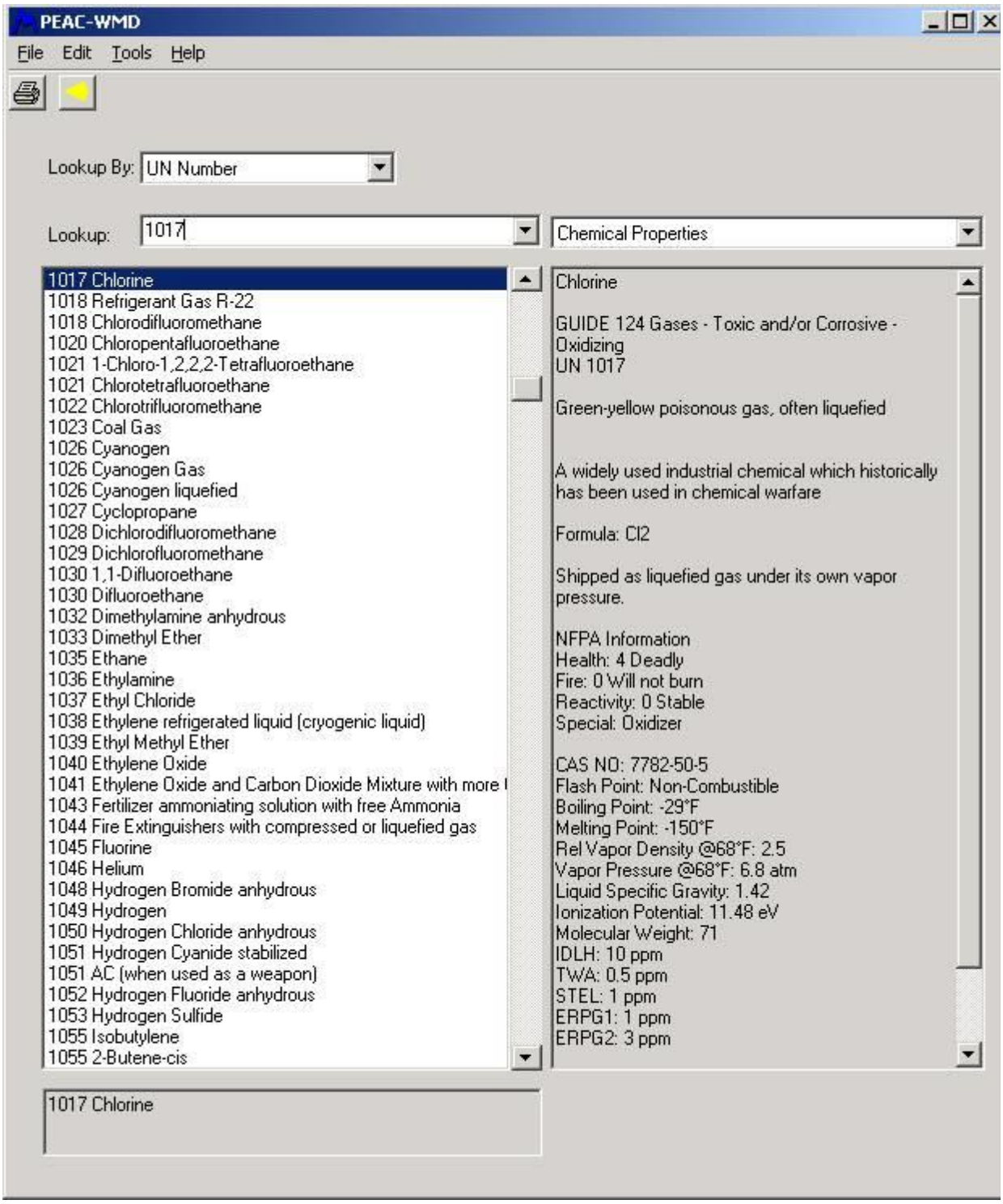

Figure 1 – PEAC-WMD system Chemical Information screen for Chlorine

PEAC® Application

You are a firefighter in Rawlins WY on October 1st and receive a call that a railroad car has derailed outside a rural town. Upon arriving to the scene, the engine company notes a few victims down next to the railroad. As the engine arrives closer, you detect a very pungent odor at which time you change

directions to get upwind from the scene. Using binoculars, you see one of the rail cars has the designation of UN 1017. Confirming your suspicion, you look up the code in the NIOSH reference.[5] It is determined to be Chlorine. The leak appears to be small originating at the capped valve assembly area, which is turned on its side.

Responding units are notified to stay outside the initial isolation zone and adequate PPE is being requested. The area is hilly and the humidity is 83%. The winds are NE at 15 mph, the skies are partly cloudy, the temperature is 68 degrees F, and the time is 1834 hours.

Once Incident Command (IC) is set up, calls are made and you start your PEAC® software. What is the initial isolation zone for a large spill? How will ICS advise evacuation for downwind ranches and farms? Very quickly, the DOT ERG2000 evacuation recommendations for chlorine, GUIDE 124 Gases - Toxic and/or Corrosive – Oxidizing (Figure 2) provides some quick recommendations.

To refine these using the patented PEAC vapor dispersion model, the user can click on the PAD icon and select values as shown in Figure 3-5 to compute a Protective Action Distance.

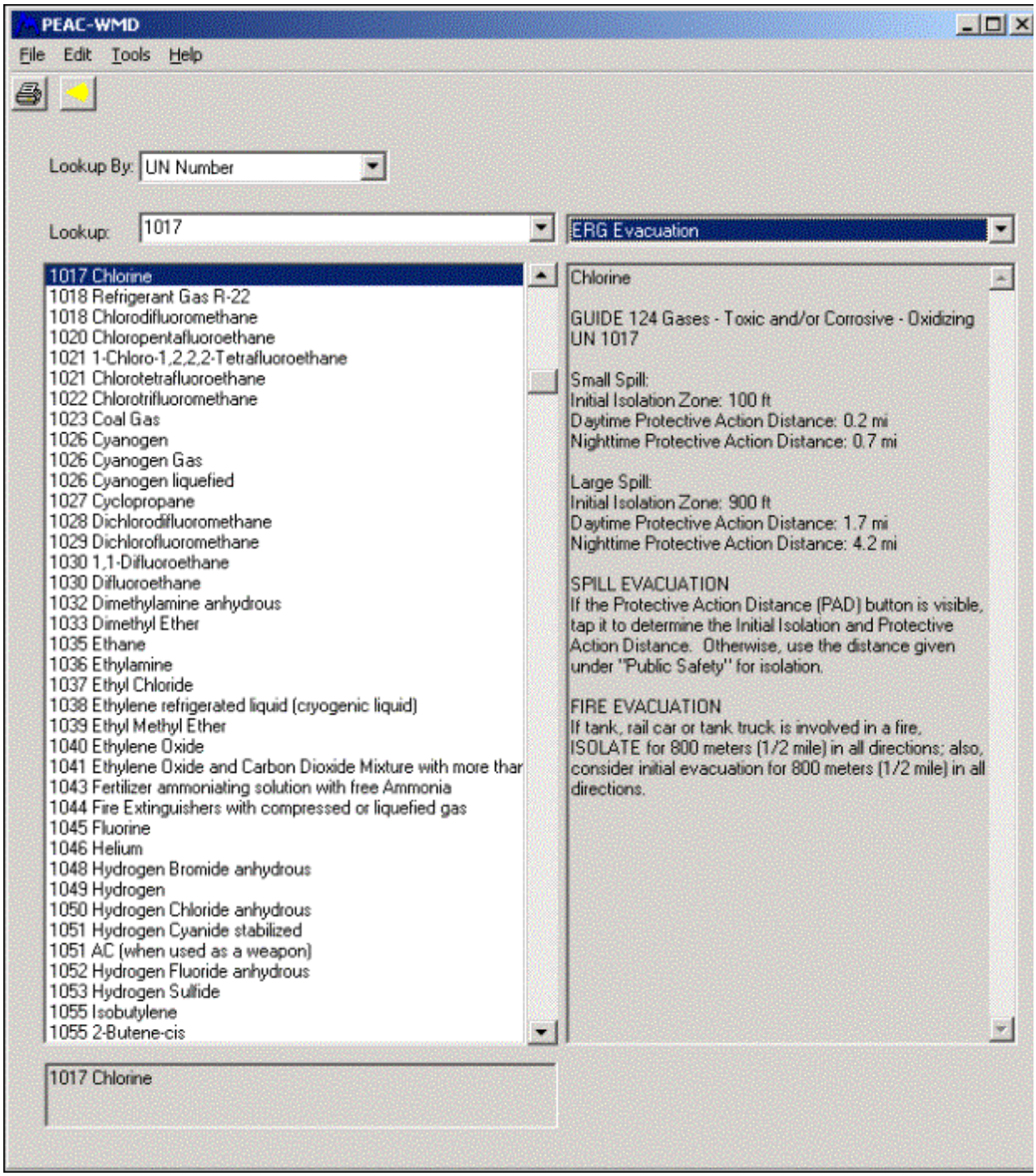

Figure 2 – The PEAC display screen for the DOT ERG Evacuation information

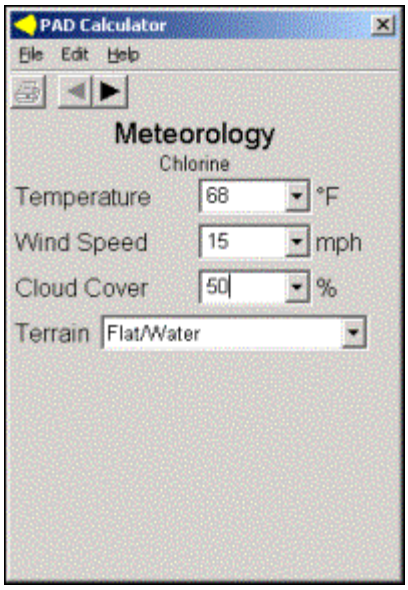

Figure 3 - Meteorology

It's late in the afternoon outside Rawlins WY in early October and the temperature about 68°, wind is set for 15 mph, partly cloudy skies and the terrain is **Flat/Water,** since it's an open setting with no major structures or large vegetation around.

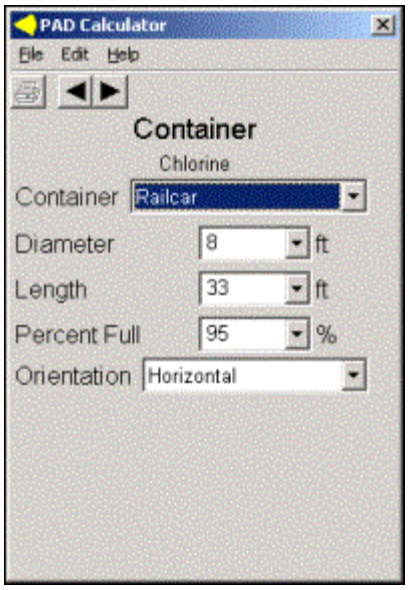

Figure 4 - Container

We have selected from our list of container sizes the **Railcar** selection. This gets us a quick estimate of how much material might be involved.

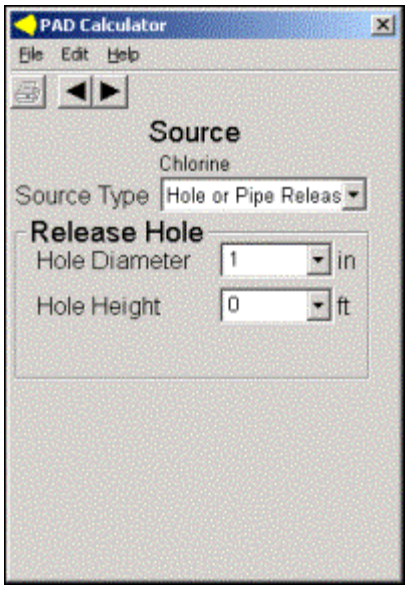

Figure 5 - Source

We have selected a **Hole or Pipe Release**, and set the hole or orifice size to 1.0".

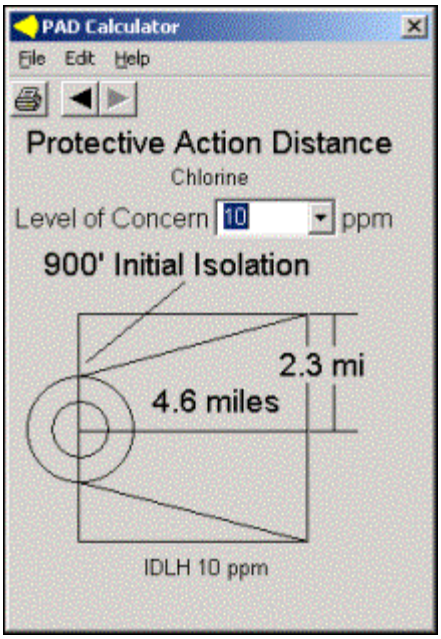

Figure 6 – The PEAC Protective Action Distance (PAD) for Chlorine based on the IDLH of 10 ppm

The Protective Action Distance (PAD) shown in Figure 6 is created using the IDLH as the default Level of Concern (LOC) which is a value of 10 ppm. Remembering that IDLH is a 30-minute exposure before irreversible health effects can occur, it may be more appropriate to use a lower or more conservative LOC. As shown in Figure 7, the operator has chosen the ERPG-2, or 3 ppm LOC. The ERPG-2 (Emergency Response Exposure Guideline) is established by the American Industrial Hygiene Association.

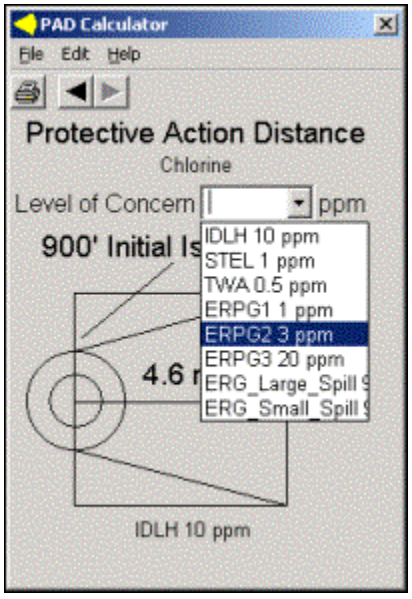

Figure 7 – Selecting a new LOC

After the new LOC is selected, the PEAC application will calculate a new PAD using the new information and display the PAD with dimensions (Figure 8).

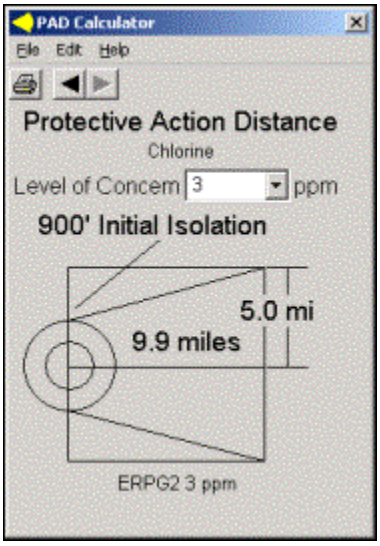

Figure 8 – The PEAC Protective Action Distance (PAD) for Chlorine using the ERPG-2 Level of Concern

References

1) The Chlorine Story, Chlorine Chemistry Council., Web Site: http://www.c3.org/chlorines_everyday_uses/index.html

2) The Chlorine Institute. Web Site: http://www.cl2.com/

3) American Chemistry Council

Web Site: http://www.americanchemistry.com/

4) National Fire Protection Association

Web Site: http://www.nfpa.org/

5) NISOSH Pocket Guide to Chemical Hazards

Web Site: www.cdc.gov/niosh/homepage.html

6) NIOSH [1995]. Registry of toxic effects of chemical substances: Chlorine. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Standards Development and Technology Transfer, Technical Information Branch.

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8) Occupational Safety and Health Administration (OSHA) Web Site: http://www.osha.gov/SLTC/respiratoryprotection/index.html

9) Material Safety Data Sheet., Chlorine., DPC Industries Inc. Houston, TX 77229-4600. Web Site: www.dxgroup.com

10) Chlorine: Effects on Health and the Environment. 3rd Edition The Chlorine Institute. Web Site: http://www.cl2.com/

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12) Center for Disease Control, Emergency Response Guidelines, Web site: http://www.cdc.gov/niosh/topics/emres/default.html

13) Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services, Public Health Service. Web Site: http://www.cdc.gov/niosh/topics/emres/default.html

14) Agency for Toxic Substances and Disease Registry (ATSDR). 2002. Managing Hazardous Materials Incidents. Volume III – Medical Management Guidelines for Acute Chemical Exposures: Chlorine. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.