

# 4.0 Health Factors, Industrial Hygiene, Medical Preparedness, First Aid and Protective Equipment

## Table of Contents

- 4.1 Health Factors
  - 4.1.1 General
  - 4.1.2 Acute Toxicity
  - 4.1.3 Chronic Toxicity
- 4.2 Industrial Hygiene
  - 4.2.1 Preventive Health Measures
  - 4.2.2 Standards for Exposure
  - 4.2.3 Air Monitoring
- 4.3 Medical Preparedness
  - 4.3.1 Medical Examinations
  - 4.3.2 Medical Treatment
- 4.4 First Aid
  - 4.4.1 Inhalation
  - 4.4.2 Contact with the Eyes, Skin or Mucous Membranes
- 4.5 Personal Protective Equipment (PPE)
  - 4.5.1 General
  - 4.5.2 Availability and Use
  - 4.5.3 Training
  - 4.5.4 Protective Clothing
  - 4.5.5 Foot Protection
  - 4.5.6 Hand Protection
  - 4.5.7 Eye Protection
  - 4.5.8 Respiratory Protection
  - 4.5.9 Head Protection
  - 4.5.10 Storage of PPE for Phosgene Service
  - 4.5.11 Maintenance of PPE for Phosgene Service
  - 4.5.12 Decontamination
  - 4.5.13 Line Breaking and/or Vessel Entry
  - 4.5.14 PPE Use During an Accidental Release
  - 4.5.15 Handling of Phosgene Badges that have Detected an Accidental Exposure

## 4. Health Factors, Industrial Hygiene, Medical Management, First Aid and Protective Equipment

### 4.1. Health Factors

#### 4.1.1 General

Phosgene is a poisonous gas at atmospheric pressure and room temperature. (It may, however, be in a liquid state under certain temperature and pressure conditions. For further information, see Section 6.2.1). The hazards of phosgene are greatly reduced if workers follow safe working procedures and are provided with proper safeguards.

The harmful effects of low-level exposure to phosgene are primarily due to irritation but this action may not be immediately apparent in a relatively mild exposure. An exposed person may even breathe the gas deeply into the lungs without being aware of the hazard. This may result in minor and brief irritation to the upper respiratory system with more serious effects in the alveolar portion of the lungs. In heavy exposures, irritation may be apparent at once but even so, because the gas causes little spasm of the air passages, immediate symptoms may subside. However, the effects to the areas of the lung where gas exchange is taking place can continue to occur over the next few hours. Pulmonary edema, indicated by excessive amounts of fluid in the lungs, may be the result of overexposure.

Phosgene exposure may also produce irritation of the eyes and headache. Nausea, vomiting and abdominal pain may occur. The important site of action is in the finer air passages of the lungs<sup>1</sup> and the pulmonary capillaries.<sup>2</sup>

**CAUTION!** Even **possible** exposure to phosgene should be reported immediately because of the potential **delayed** effect of pulmonary edema.

#### 4.1.2. Acute Toxicity

Generally, the local irritant action on the eyes, nose and throat are mild. Nausea, vomiting and abdominal pain can occur in the more serious exposures.

Although air concentrations are measured in parts per million (ppm), the total exposure over time (“dose”) measured as ppm-minutes is a better unit for expressing health effects of acute exposure. A 0.1-ppm concentration breathed for 60 minutes

equals a dose of 6 ppm-minutes. A 1-ppm concentration breathed for 6 minutes equals a dose of 6 ppm-minutes. The *total dose* is responsible for the delayed lung effects. These effects can range from no observable effects to fatal pulmonary edema.

The delayed effects of pulmonary edema can be seen relatively quickly (with greater exposures) or up to 24 hours (with less severe exposures).

A total exposure less than 25-50 ppm-minutes seldom produces lower respiratory tract problems.<sup>3</sup> Exposures greater than 50 ppm-minutes can cause chemical bronchitis (irritation of the bronchi)<sup>4</sup> and may result in pulmonary edema. Although the onset of pulmonary edema may be delayed for as long as 24 hours after exposure, it usually occurs within four to 16 hours. Pulmonary edema will often be seen on a chest X-ray within 8 hours, if it is to develop. Few or no upper respiratory symptoms may be present during the interval between phosgene exposure and the rapid development of serious pulmonary impairment.

In the event of a potentially serious exposure, it is recommended that the exposed personnel be observed and evaluated by a physician. An additional source for detailed information on phosgene toxicity and medical management can be found in the publication entitled "Information on Options for First Aid and Medical Treatment," available from the American Chemistry Council's Phosgene Panel's website at <http://www.americanchemistry.com/phosgenepanel>.

*Exposure doses below 25ppm-min. can be regarded as harmless (Phosgene Induced Edema: Diagnosis and Therapeutic Countermeasures).*

#### **4.1.3. Chronic Toxicity**

To the best of the Panel's knowledge, no chronic (i.e., long term) effects from exposure to phosgene alone in the workplace have been reported in the literature. EPA has written a review of phosgene toxicology (EPA/635/R-06/001, [www.epa.gov/iris](http://www.epa.gov/iris)) which may be consulted for detailed information.

### **4.2. Industrial Hygiene**

#### **4.2.1. Preventive Health Measures**

**CAUTION!** It is important that odor not be relied upon to give adequate indication of the presence of phosgene.

Based on a review of existing information, odor references cited in the literature were all rejected or the source was unable to be located.<sup>5</sup> Aside from this, since the reported odor ranges (0.12 - 5.7 ppm) are above the threshold limit value (TLV) (see Section 4.2.2), odor does not provide adequate warning. Additionally, personnel working with phosgene can lose their ability to detect low concentrations by conditioning or deadening of the sense of smell. Exposure assessment programs based on colorimetric indicators (badges) have been developed to identify employees with exposure.

Workers with potential for exposure to phosgene can benefit from receiving instruction periodically in the hazards of the chemical and in safe handling procedures. The development and utilization of control measures helps reduce potential risks.

#### **4.2.2. Standards for Exposure**

The threshold limit value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for phosgene is 0.1 ppm (volume/volume).<sup>6</sup> The TLV refers to the airborne concentration and represents the condition under which it is currently believed that nearly all workers may be repeatedly exposed day after day without adverse health effect. It is a time-weighted average (TWA) concentration for an 8-hour workday and 40-hour workweek. It only serves as a guide in the control of health hazards, and not as a fine line to distinguish between safe and dangerous concentrations. Engineering control measures can be used to maintain very low phosgene exposure concentrations, so that routine exposure to near 0.1 ppm does not occur. Control measures serve a critical function towards eliminating phosgene concentrations in the work place.

The Occupational Safety and Health Administration (OSHA) sets a limit of 0.1 ppm, 8-hour, time-weighted average. Although the TLV and Permissible Exposure Limit (PEL) are currently the same value, OSHA's position has been to embrace the limit that is most restrictive and protective of employees and to use it in conjunction with the general duty clause in its enforcement role.

Based on the ACGIH TLV's for Chemical Substances and Physical Agents (revised annually), limited excursions above the TLV are permitted for short periods of time. While there is no guidance for a STEL or ceiling, ACGIH provides that excursions

in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday, but under no circumstances should they exceed 5 times the TLV-TWA.

The National Institute of Occupational Safety and Health (NIOSH) gives an additional recommendation for short-term excursions. The NIOSH REL (Recommended Exposure Limit) for phosgene excursions above the TLV is 0.2 ppm for 15 minutes.<sup>7</sup> TLV's, REL's and PEL's are subject to change by their associated peer review groups. As with other references in the manual, users must check the current reference for up-to-date information.

It is important to note that the concept of an established time weighted average exposure limit for phosgene implies that a background level of phosgene in the work place could be considered an acceptable practice. Member companies do not operate their plants where background concentrations and time weighted average exposures to phosgene are allowed.

#### 4.2.3. Air Monitoring

Early methods for the detection of phosgene utilized absorption into a solution which changes color (25% 4(4'-nitrobenzyl pyridine) and stabilizes the color (0.5% N-phenylbenzene).<sup>8</sup> The absorbance was then read on a spectrophotometer. Sampling efficiency was excellent but the use of an impinger had drawbacks. Another method developed by OSHA to provide a simpler, convenient and precise means to monitor occupational exposure to phosgene utilizes sampling tubes containing XAD-2 adsorbent coated with 2-(hydroxymethyl)piperidine. The samples are desorbed with toluene and then analyzed by gas chromatography using a nitrogen selective detector.<sup>9</sup> The early colorimetric methods gave rise to development of diffusion badges.

Badges that change color upon exposure to phosgene are commercially available. Color change is from white to pink (red) or white to blue. Extremely high concentrations (percent not ppm levels) may cause the color to change *back* to white again. Badge readings may vary depending on the manufacturer of the badge, the reader of the badge, and other conditions and factors. Manufacturers may provide additional details for inclusion in employee training.

Dose is estimated by matching the intensity of color on a badge reader or color wheel (graduated color intensities which correspond to dose (ppm-minutes). The potential for individuals' color blindness to reds is a factor that can be addressed in the development of a badge program.

Users can develop written programs including a log of exposures or possibly lack of exposures. Documentation of dose can include details of the event leading to the exposure as well as details of any respiratory protection used. Useful information to record includes the name of the individual who wore the badge, the person entering the information, and the circumstances of the event. During training on the use of the badges, inform users that **ALL** exposures be reported immediately. In most cases, exposures warrant an incident investigation and accompanying documentation of that investigation.

Placement of badges can be an important element in a badge program. More useful and reliable results can be achieved if the badge is placed in the breathing zone of the individual. Badges that are affected by ultraviolet (UV) light and water may be adhered under the front brim of the hard-hat. Refer to badge manufacturer's instructions for specific information. Alternatively, clips can attach the badge to the collar to better secure the badge and still provide representative breathing zone concentration. Wearing badges under additional personal protective equipment (PPE) (slicker suits, bunker gear, etc.) and badges worn on the back of the hard-hat could hinder the badges' effectiveness.

Users may also consider including in the written program, Standard Operating Procedure or Job Safety Information, instructions on the proper use of badges and medical reporting procedures. Follow the badge manufacturer's recommendations for use. Since a dose of 48 ppm-min is equivalent to 480 minutes times the TLV of 0.1 ppm, values less than 48 ppm-min do not necessarily constitute an overexposure. This information may be helpful when considering the definition of "first aid" and "recordable injury." Some member companies have chosen to use 48 ppm-min as requiring reporting through the medical facility; others use a lesser value. It must be emphasized again, however, report ANY phosgene exposure for investigation keeping in mind the TLV and the hazard potential of phosgene.

Badges are also used as leak detection devices (see Section 6.1.2), especially in open-air environments where tiny leaks may escape detection using handheld monitors, area monitors or ammonia sprays. Badges may be placed and left for long periods of time (subject to the manufacturer's recommendations for maximum sampling time) to identify low concentrations of phosgene. The lower detectable limit of instrumentation that gives immediate concentration readout (usually 0.01 ppm) may be insufficient for very small leaks. Badges are also used for phosgene detection to confirm adequate clearing/decontamination of lines and equipment prior to opening. Care should be taken to differentiate badges used in this manner from badges used for exposure dose measurement on the person.

Other types of portable and fixed monitoring systems also are available which use either electrochemical cell detectors or a version of the color chemistry mentioned above. Instrumentation utilizing paper tape chemistries is usually very specific to phosgene. Electrochemical cell detectors may have cross-sensitivity to a number of contaminants typically found in industrial settings (e.g., sulfur compounds and hydrochloric acid (HCl) gas). Filters can help minimize the problem. It is beneficial to discuss this matter with the manufacturers of all these devices, especially where false indication of phosgene could impact your employees, neighboring industries or the community.

In some circumstances, it may be necessary to employ instrumentation in the event phosgene is released in areas where it could enter a building (e.g., intake through the heating, ventilating and air-conditioning (HVAC) system, conduit path openings, etc.). Detection of trapped phosgene vapors after a release is important because vapors could pose a threat to building occupants in the vicinity or persons downwind of a release.

Remote optical sensing systems such as Fourier Transform Infrared (FTIR) may be useful to monitor for phosgene down a long path, rather than detecting its presence at a single point.

#### **4.3. Medical Preparedness**

##### **4.3.1. Medical Examinations**

Facilities handling phosgene can benefit from development of medical management programs. Some companies have

developed programs under which their workers have both pre-placement and periodic (e.g., annual or biennial) medical examinations.

Pre-placement examinations may include analyses such as health history, general physical, chest X-ray, pulmonary function-FVC, and FEV-1 complete blood count and urinalysis. A history of cardiopulmonary disease, abnormalities in pulmonary function or inability to wear respirators should be considered by a physician prior to assignment to work with phosgene. Programs might also include periodic examinations including chest X-rays and lung function testing.

#### **4.3.2. Medical Treatment**

Medical treatment will be facilitated if physicians who might be called upon to treat a patient for phosgene exposure are thoroughly familiar with the signs and symptoms of exposure and available treatment options before services are needed. One source for information on the subject is the publication entitled "Information on Options for First Aid and Medical Treatment," available from the American Chemistry Council's Phosgene Panel's website at <http://www.americanchemistry.com/phosgenepanel>.

#### **4.4. First Aid**

To facilitate proper and timely first aid treatment, it is useful to arrange in advance and have available medical receiving facilities and names of physicians (backup as well as primary) trained in phosgene emergency treatment.

##### **4.4.1. Inhalation**

Because of the hazardous properties of phosgene, it is critical that exposed persons are removed immediately from the contaminated area. Immediate responders/rescue workers need to be aware of the potential exposure they may receive if phosgene may be present (in the air, as a pure liquid, or as a component of a mixture) in contaminated clothes or equipment and the need to wear the proper respiratory protection (See Section 4.5.8 for further information.) An option is to immediately remove contaminated clothing and store in an airtight container to help prevent further exposure. The provision of respiratory equipment may be required for an exposed person until the individual is removed from the

contaminated area and contaminated clothing is removed. See Section 4.5.12 for information on decontamination.

An unconscious worker who has been overcome by phosgene should be transported at once to an uncontaminated area and have the contaminated clothing removed and properly stored. As breathing may have stopped, note that artificial respiration may be immediately required. Transfer the worker without delay to a facility where proper medical care can be implemented. Personnel assisting with this emergency response may need to take precautions to prevent *their* exposure.

#### **4.4.2. Contact with the Eyes, Skin or Mucous Membranes**

It is important that eyes, skin, or mucous membranes that come into contact with phosgene are flushed with copious amounts of water. A number of companies have policies whereby eyes, skin or mucous membrane that have contact with phosgene are flushed with water for at least 15 minutes due to the potential corrosivity properties of phosgene. These types of exposures require immediate medical attention.

### **4.5. Personal Protective Equipment (PPE)**

#### **4.5.1. General**

Because the odor of phosgene may not give adequate warning as to the potential exposure hazard due to the low odor threshold and the odor not being unpleasant or irritating the establishment of engineering controls and work practices are needed to help protect against potential risks. Phosgene fatalities have occurred from overexposure, sometimes with few, if any, initial symptoms.

Handling phosgene in completely closed processing systems helps minimize exposure. In the event of a release of phosgene, the immediate evacuation of the area, and entering the area only with the use of appropriate respiratory protective equipment reduces potential concerns. (See Section 4.5.8 for additional information on respiratory equipment). It is beneficial to have several sets of protective equipment available at all times stored outside of, but near to, the area where phosgene is used.

Workers can benefit from instructions on how to avoid or minimize breathing phosgene in areas where they may be exposed to the gas. Other items may include: equipping and

instructing in the use of positive pressure self-contained breathing equipment when it is known that phosgene may escape; familiarizing workers with the location, operation and limitations on the duration of use of respiratory protective equipment; and reporting immediately any episode in which the gas was breathed or of contact of the skin or eyes with liquid phosgene.

Personal protective equipment serves to compliment but not substitute for safe working conditions, adequate process control, ventilation and proper conduct by employees working with phosgene (engineering controls). However, in some instances, it is the only practical means of protecting the worker in emergency situations and while performing tasks where engineering controls are not sufficient.

An appropriate choice in selection and use of personal protective equipment will normally be dictated by the total situation, rather than by the toxic properties of phosgene alone. These situations may also involve other hazardous materials or normally innocuous materials that can magnify potential concerns associated with phosgene. Therefore, the following information on equipment is to be considered as a potential reference point for general guidance. Users need to select appropriate personal protective equipment based on their specific needs and circumstances. Other chemicals or factors may require the use of additional protection. Except in extreme emergencies, no one should be given personal protective equipment without suitable training in its use.

**CAUTION:** It is important to consider all the chemicals potentially present with phosgene when selecting PPE.

#### 4.5.2 Availability and Use

Location, care and selection of appropriate PPE are dictated by the proposed use of the equipment. Companies have assigned personnel, facilities and programs for suitable care, decontamination and repair of all equipment.

#### 4.5.3. Training

Companies provide training so that employees using PPE in phosgene service are appropriately experienced in the use of the relevant PPE prior to its use in phosgene service. Consult the manufacturer recommendations where provided.

#### 4.5.4. Protective Clothing

Where the presence of liquid phosgene is anticipated or in an emergency response situation where either a high concentration of phosgene gas and/or liquid may be present, protection against the cryogenic liquid may be needed. Phosgene gas is not chemically irritating to the skin but can easily permeate clothing and equipment, which can later expose personnel if appropriate decontamination procedures are not followed.

Chemically resistant suits (“slicker suits”) are often used for protection against liquid splash. In addition, as one possible reference source, users may consider information provided from the Quick Selection Guide to Chemical Protective Clothing.<sup>10</sup> The Quick Selection Guide provides specific recommendations for exposures >4 hours and for exposures >8 hours.

The use of long sleeve shirts and full-length pants may provide some modest protection against accidental skin exposure.

The Quick Selection Guide to Chemical Protective Clothing also provides that the following PPE designations would be appropriate where contact with Phosgene is anticipated:

- Level A (highest level of respiratory, skin (fully encapsulating suit) and eye protection) or
- Level B (highest level of respiratory protection, less skin protection than Level A (one or two piece chemical resistant clothing) may be chosen depending upon need and availability.

#### 4.5.5. Foot Protection

Leather or rubber safety shoes with built-in steel toe caps provide extra protection against injury for workers handling cylinders of phosgene. Rubber shoes may be worn over leather safety shoes where liquid phosgene may be encountered. It will be necessary to thoroughly clean, or in some cases to discard, footwear that has become contaminated with phosgene.

#### 4.5.6. Hand Protection

Hand protection should be considered to protect against cryogenic burns if the possibility of contact with liquid phosgene exists.

#### 4.5.7. Eye Protection

Phosgene exposure is corrosive to the eyes. Safety glasses with side shields help protect personnel during routine operations. When there is splash potential or concentrations that may cause eye irritation, the use of a full-face supplied air respiratory protection provides greater safeguards.

#### 4.5.8. Respiratory Protection

Users may require that only persons who are medically approved to wear respiratory protection be allowed to work in areas where they may be exposed to phosgene. Serious, even fatal exposure to phosgene may occur in tanks during equipment cleaning and repairs, when decontaminating areas following spills, or in case of failure of piping or equipment. To help prevent injury, respiratory protection and training in its use can be provided to employees who may be subject to such exposures. Examples of available types are described below.

The Occupational Safety and Health Administration (OSHA) has provided requirements for respiratory protective equipment. (See Title 29 CFR 1910.134 as amended). Such equipment is carefully maintained, inspected, cleaned and disinfected at regular intervals and before use by another person. Consult a reliable safety equipment dealer for details on the proper use of approved equipment.

In its Pocket Guide to Chemical Hazards, the National Institute for Occupational Safety and Health (NIOSH) recommends supplied air up to a concentration of 1 ppm phosgene. NIOSH also provides that in concentrations up to 2 ppm, (maximum use concentration), it is recommended that persons use supplied air respirator or self-contained breathing apparatus. For emergencies or planned entry into unknown concentrations or Immediately Dangerous to Life or Health (IDLH) conditions, NIOSH recommends a pressure demand or positive pressure full-face supplied air respirator in combination with an auxiliary self-contained breathing apparatus or SCBA. The IDLH concentration is 2 ppm.

Note: The use of a positive pressure breathing apparatus can help reduce the risk of exposure should the face seal of the respirator be compromised.

Note: Use of dosimeter badge paper inside of a full face breathing mask may be utilized to indicate if phosgene has entered the mask.

### **Respiratory Protection Options for Entry and Emergency Escape**

The following list includes examples of available respiratory protection devices which users may consider as they select a level of protection for entry.

- Supplied air breathing apparatus with in-line egress unit.
- Self-contained breathing apparatus.
- Self-contained breathing apparatus with communication system.
- Supplied air breathing apparatus with in-line egress unit with communication system.
- Supplied air breathing apparatus (overpressure) 2/3 L bottle.

The following list includes examples of available respiratory protection devices for emergency escape which users may consider as they select a level of protection.

- Supplied air egress bottle.
- Cartridge respirator with organic vapor/acid gas cartridge.
- Mouth-bit respirator with acid gas cartridge.

Because the odor warning properties of phosgene preclude approval by NIOSH and Mine Safety and Health Administration (MSHA), users can refer to independent testing that has been conducted regarding canister/cartridge material protection against phosgene.

#### **4.5.8.1 Supplied Air Considerations**

Handling phosgene often necessitates use of supplied breathing air systems. Where it is prudent to use a separate supply of breathing air rather than relying on ambient air, the following items may be of assistance with regard to the quality of supplied air.

Breathing air quality is discussed in 29 CFR 1910.134(i). Refer to regulatory text for the potential updates and further detail. The specification originated with the Compressed Gas Association (CGA) Commodity Specification G-7.1 (1997).

Breathing air is produced by: (1) compressing ambient air, or (2) synthesizing (blending) gases. Regardless of the method used, verifying the air quality before use helps prevent potential problems.

During validation, evaluate whether the oxygen content is maintained between 19.5-23.5%. (See 29 CFR 1910.134 regarding oxygen content). Any deviation from an actual concentration of 20.9 % can signal cause for follow-up activity.

Review whether breathing air outlets have been capped.

Alarms warn of low pressure/volume. While specific parameters ultimately depend upon the number of users on the system, alarm set-points of 25% of capacity have been used in some cases. Refer to the National Institute for Occupational Safety & Health (NIOSH) for information relevant to pressure at the point of hose connection. Careful consideration of alarm siting choices increases the system's effectiveness. Centralized (control room) alarms may not adequately protect end users unless communication devices/hole watch can warn of depletion in remote locations. (For further information on permissible hose length, consult National Institute for Occupational Safety & Health standards).

Evaluate inclusion of material specifications in piping for breathing air systems (*e.g.*, stainless steel has been used previously), and the use of welded piping (*i.e.*, not screwed connections) where possible. New piping commissioning and new service tie-ins can benefit from including a procedure for pipe cleaning and drying. Dew point readings may be part of this procedure. Dedicated fittings can isolate breathing air from other piping systems. Backflow preventers offer an additional safeguard for accidental tie-in of another gas source.

#### **Where an on-site compressor is used:**

Consider siting of the inlet to the compressor. Emission sources such as relief valves, stacks, etc. may impact quality of air. OSHA Respiratory Protection 1910.134 (i) requires that breathing air must have a "lack of noticeable odor". The use of detectors or filters, specific to each operation, may be helpful. For facilities that produce phosgene from chlorine and carbon monoxide, sensors can be utilized that detect all three of these

gases. Depending upon usage, a back-up air supply may be desirable to improve the reliability of the supplied air rather than relying exclusively on the use of a 5-minute escape bottle. Consider whether emergency response procedures include activities performed on breathing air, as well as how such activities will be handled during such an event. During an emergency gas release, determine whether the inlet to the breathing air compressor is protected, or switch to a back up system such as bottled air.

#### **Where bottled or cylinder air is used:**

Purchased breathing air will typically be provided with a Certificate of Analysis (COA). Maintaining the COA provides verification that testing was performed by the supplier. Although this formal analysis is required, performing a redundant “check” on the oxygen content using a reliable method provides an additional level of protection. An O<sub>2</sub>/LEL (lower exposure limit) analyzer offers an alternative to laboratory analysis of a bagged sample. Consult the instrument manufacturer recommendations for calibration procedures. A physical tag can be placed on individual bottles or groups of bottles (if using a manifold system) to help assure end users that checks have been made. When using a cascade system, consider opening *all* bottles, rather than relying on opening one at a time.

Cylinder inspection programs can include hydrotest dates as part of the analysis. The process of hydrotesting can introduce water into steel cylinders, creating rust, which may reduce the oxygen content over time. Note that the hydrotest date only indicates the time period within which a cylinder can be *refilled*. It does not provide any indication of whether the cylinder should be *used* after years of storage. Use of bottles within a reasonable period of time after receipt reduces potential problems. Some companies use five years as a benchmark.

#### **4.5.9. Head Protection**

The use of hard hats helps protect against head injuries that may result from falling objects or from running into low piping or other equipment.

#### **4.5.10. Storage of PPE for Phosgene Service**

Making emergency escape respirators readily available or carried by person in areas where escape from phosgene may be required reduces potential risks. It is desirable that

emergency response equipment (respirators, chemical protective clothing, etc.) be located in strategic locations to help facilitate prompt response, yet also be sufficiently removed from the phosgene process area so as not to be involved in an emergency should one arise.

#### 4.5.11. Maintenance of PPE for Phosgene Service

Refer to the manufacturer's instructions / recommendations for PPE use, inspection and maintenance. Checklists for inspections are often available from the manufacturer. Federal law may mandate inspection frequencies (e.g., OSHA 29 CFR 1910.134(h)(3)).

#### 4.5.12. Decontamination

If phosgene contamination on clothing is present, emergency response personnel should take precautions including the wearing of appropriate respiratory protection while removing any contaminated clothing. Such clothing can be placed immediately in an airtight container until it can be decontaminated. Exposed persons may require the provision of respiratory protection until outside the contaminated area and their contaminated clothing is removed.

It may be necessary that phosgene contaminated clothing and equipment are sealed in an airtight container and disposed of as hazardous waste if the contamination is the result of an emergency response action or a spill and cannot be decontaminated.

**CAUTION!** The decontamination options listed below are only intended for PPE and other equipment. Care is needed to avoid contacting human skin with these solutions.

Decontamination of PPE and other equipment has been accomplished through such means as:

- Immersion in ammonia water solution.
- Immersion in a 20% soda ash in water solution.
- Washing in soap and water.

Verifying decontamination by available means (e.g., use of phosgene detection instrumentation or phosgene badges) **BEFORE** respiratory protection is removed can help reduce risks of exposure.

#### 4.5.13. Line Breaking and/or Vessel Entry

Both line breaking and confined space entry may introduce additional risk to employees. The following practices have been used previously although more stringent practices may be required:

- Restrict entry of unauthorized personnel.
- Level A or Level B PPE during initial line-breaking.
- Check equipment to verify “clean” atmosphere before downgrading protection. See Monitoring Instrumentation section.

**CAUTION!** “Pockets” of phosgene may be trapped in process fluids, solids or low dips in pipe or equipment. It is important to consider this issue before downgrading PPE.

**Note:** Maintenance workers should consider whether the possibility of liquid phosgene exposure exists, and take appropriate precautions.

#### 4.5.14. PPE Use During an Accidental Release

During a gas leak or liquid spill, the highest level of respiratory protection may be required for entry into the area (see Section 4.5.8 for further information). Consider use of either Level A or Level B skin protection (see Section 4.5.4 for further information).

**Note:** Phosgene may contaminate equipment and PPE, and can be a hazard if breathed from these secondary sources.

#### 4.5.15 Handling of Phosgene Badges that have Detected an Accidental Exposure

Phosgene badges that have detected an unprotected human exposure should be removed and bagged after the person is clear of potential, continuing exposure. Should the exposed worker need to don respiratory protection and re-enter the contaminated area, the first badge should be secured in an uncontaminated place and a second badge used. The dose measurements provided by these badges will be essential data for medical assessment and treatment decisions and should be preserved. The data on the worker’s dose will also be valuable to subsequent incident investigations.

## References

<sup>1</sup>Patty's Industrial Hygiene and Toxicology, Vol. II, Part F, 4th Ed. Wiley-Interscience, NY 1994.

<sup>2</sup>Morgan, W. K. and Anthony Seaton "Occupational Lung Diseases," W. B. Saunders, Philadelphia.

<sup>3</sup>Phosgene Induced Edema: Diagnosis and Therapeutic Countermeasures, Vol. 1, Issue 2, Toxicology and Industrial Health Series, 1985.

<sup>4</sup>Phosgene Exposure: Mechanisms of Injury and Treatment Strategies. Journal of Occupational & Environmental Medicine. 43(2):110-119, February 2001.

<sup>5</sup>Odor Thresholds for Chemicals with Established Occupational Health Standards, ACGIH, 1989.

<sup>6</sup>American Conference of Governmental Industrial Hygienists, TLV Annual Publication.

<sup>7</sup>NIOSH Pocket Guide to Chemical Hazards, 2005 (<http://www.cdc.gov/niosh/npg/npgd0504.html>).

<sup>8</sup>NIOSH Manual of Analytical Methods, 2<sup>nd</sup> Ed., Vol. 2, 1977.

<sup>9</sup>OSHA Sampling and Analytical Methods, Method No. 61 (<http://www.osha.gov/dts/sltc/methods/organic/org061/org061.html>).

<sup>10</sup>Quick Selection Guide to Chemical Protective Clothing, 2nd. Ed., March 1985, Arthur D. Little, Inc.