THE CHLORINE INSTITUTE

Pamphlet 65

Personal Protective Equipment for Chlor-Alkali Chemicals

Edition 6

A LEGACY OF 1924 since SAFETY STEWARDSHIP

July 2015

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1. INTRODUCTION

1.1 PURPOSE

This Chlorine Institute (Institute or CI) pamphlet is intended to provide information pertaining to certain personal protective equipment used in the manufacture or handling of chlorine, sodium and potassium hydroxide (caustic), sodium hypochlorite, hydrochloric (muriatic) acid, sulfuric acid and anhydrous hydrogen chloride. With the exception of sulfuric acid, the chemicals discussed in this pamphlet are CI mission chemicals. Sulfuric acid is included because it is commonly used at chlorine-producing facilities. Personal protective equipment includes both barrier clothing, such as chemical protective suits, boots, gloves, or face shield, and respiratory protection, such as air supply respirators (ASRs) or air purifying respirators (APRs). It must be noted that compliance with the requirements of the Occupational Safety and Health Administration (OSHA) regarding exposure to the above air contaminants must first be achieved by administrative or engineering controls. It is only when feasible administrative or engineering controls are not successful in achieving full compliance that reliance upon personal protective equipment is appropriate.

1.2 SCOPE

The scope of this pamphlet includes most types of personal protective equipment (PPE) recommended for specific tasks and for emergency response in the manufacture and use of chlorine (liquid and gas), sodium and potassium hydroxide (10 - 50% by weight), sodium hypochlorite solutions (3 - 20% by weight), hydrochloric acid (7 - 37% by weight), sulfuric acid (38 - 98% by weight), and anhydrous hydrogen chloride (liquid and gas) all at temperatures below 120^{o}F (49°C).

Exposure to these chemicals at elevated temperatures (> 120^{o}F; >49°C) may require additional personal protective equipment for thermal protection and to ascertain that the PPE used is suitable at such temperatures is beyond the scope of this pamphlet. For those chemicals where a concentration is specified, the ranges shown have been selected because these concentrations represent those that are typically produced and are those with which CI members have the most experience. Concentrations greater than shown may require additional or different PPE. Concentrations less than those shown may require comparable PPE. Users of concentrations outside the ranges listed in this pamphlet should seek other sources (e.g., the supplier) for recommended PPE.

Hearing protection and head protection (except for chemical exposure) are examples of equipment not addressed. Hearing protection requirements vary from site to site and are based on an assessment of personnel exposure to high noise levels and are independent of the chemical(s) being manufactured or handled. Similarly, head protection requirements vary from site to site.

Because the nature of a potential hazardous condition and the duration of exposure by affected personnel will vary from site to site, each manufacturer/user should determine how the recommendations should be implemented at the individual facility.

Users of personal protective equipment should follow the use and maintenance recommendations of the safety equipment manufacturer. ASRs and APRs must be approved by the National Institute of Occupational Safety and Health (NIOSH). See

NIOSH Certified Equipment List (*12.10.1*) and 29 CFR 1910.134 (*12.6.4*). The user should ascertain that the personal protective equipment is suitable for protecting personnel from the chemical(s) being handled and at the concentrations encountered.

The reader is referred to Institute publication Pamphlet 137 (*12.1*) for a discussion of personal protective equipment requirements pertaining to asbestos. Institute Pamphlet 139 (*12.1*) addresses personal protective equipment requirements pertaining to cell house electrical systems used in chlor-alkali operations. Institute Pamphlet 63 (*12.1*) addresses first aid, medical management and occupational hygiene and monitoring practices of personnel exposed to chlorine.

1.3 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute exists to support the chlor-alkali industry and serve the public by fostering continuous improvements to safety and the protection of human health and the environment connected with the production, distribution and use of chlorine, sodium and potassium hydroxides, and sodium hypochlorite; and the distribution and use of hydrogen chloride. This support extends to giving continued attention to the security of chlorine handling operations.

Chlorine Institute members are committed to adopting CI's safety and stewardship initiatives, including pamphlets, checklists, and incident sharing, that will assist members in achieving measurable improvement. For more information on the Institute's stewardship program, visit CI's website at www.chlorineinstitute.org.

1.4 ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists – this is not a standards setting body
AHCl	Anhydrous Hydrogen Chloride
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
APR	Air Purifying Respirator
ASR	Air Supply Respirator
ASSE	American Society of Safety Engineers
ASTM	American Society for Testing and Materials
BEI	Biological Exposure Indices
CFR	U. S. Code of Federal Regulations
CGA	Compressed Gas Association
CI	The Chlorine Institute
EPA	U.S. Environmental Protection Agency

ERPG	Emergency Response Planning Guidelines (AIHA)
ESLI	End-of-Service-Life Indicator
G. I.	gastrointestinal
HEPA	High Efficiency Particulate Air
HMS	Hazardous Materials Specialist
HMT	Hazardous Materials Technician
IARC	International Agency for Research on Cancer
IDLH	Immediately Dangerous to Life or Health (NIOSH)
KOH	Potassium Hydroxide
mg/m^3	Milligrams Per Cubic Meter (milligrams of vapor or gas per cubic meter of contaminated air at 25^oC and 1 atm)
NaOH	Sodium Hydroxide
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NTP	The National Toxicology Program
OSHA	U. S. Occupational Safety and Health Administration
PEL	Permissible Exposure Limit (OSHA)
Percent (%)	In this pamphlet, it always refers to weight percent
PPE	Personal Protective Equipment
ppm	Parts Per Million (parts of vapor or gas per million parts of contaminated air by volume)
PSM	Process Safety Management
REL	Recommended Exposure Limit (NIOSH)
SCBA	Self-Contained Breathing Apparatus
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value (ACGIH)
TWA	Time Weighted Average
USCG	United States Coast Guard
WEEL	Workplace Environmental Exposure Level Guides (AIHA)

1.5 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The Chlorine Institute and its members, jointly and severally, make no guarantee, and assume no liability, in connection with any of this information. Moreover, it should not be assumed that every acceptable procedure is included or that special circumstances may not warrant modified or additional procedures. The user should be aware that changing technology may require a change in the recommendations herein. Appropriate steps should be taken to ensure that the information is current when used. These suggestions should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.6 APPROVAL

The Institute's Health and Safety Issue Team approved this pamphlet for publication on July 7, 2015.

1.7 REVISIONS

Suggestions for revisions should be directed to the Secretary of the Chlorine Institute.

1.8 SIGNIFICANT REVISION IN CURRENT EDITION

This edition was updated to include new guidance on the use of contact lenses. Additionally, guidance on exposure limits, respiratory protection, and maintenance of PPE was expanded. Pictures and examples of levels of PPE and types of respirators were also included.

1.9 REPRODUCTION

2. CHEMICALS AND THEIR PHYSIOLOGICAL EFFECTS

2.1 EXPOSURE LEVEL GUIDELINES

OSHA has established Permissible Exposure Limits (PELs) found in 29 CFR 1910.1000-1910.1052 (*12.6.6*) for regulating individual exposure to numerous chemicals. Similarly, ACGIH has established Threshold Limit Value (TLV) guidelines (*12.2.1*) and NIOSH has developed Recommended Exposure Limits (REL) (*12.10.3*). These may be expressed as time weighted averages (TWAs), short term exposure limits (STELs), ceilings, or a combination.

2.1.1 Permissible Exposure Limit (PEL)

PELs can be defined in two different ways as discussed in the OSHA regulation on air contaminants, 1910.1000:

- Ceiling values - at no time should this exposure limit be exceeded. Sometimes denoted with the letter C.

- 8-hour Time Weighted Averages (TWA) - are an average value of exposure over the course of an 8-hour work shift.

2.1.2 TWA

TWA is the individual's average airborne exposure in any 8-hour shift of a 40-hour work week which should not be exceeded.

The 8-hour TWA PEL is the level of exposure established as the highest level of exposure an individual may be exposed to without incurring the risk of adverse health effects.

2.1.3 STEL

STEL is the individual's 15-minute time weighted average exposure which should not be exceeded at any time during a work day. In some cases, a STEL of another time limit (e.g. STEL (30)) may be specified.

2.1.4 Ceiling

Ceiling is the individual's exposure which shall not be exceeded during any part of the work day. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute TWA which shall not be exceeded at any time over a working day.

2.1.5 Threshold Limit Value

Threshold Limit Value (guidelines developed by ACGIH®); The concentration that a worker can be exposed to for a prescribed period of time without suffering adverse effects (TLV-TWA; TLV-STEL; TLV-Ceiling).

2.1.6 IDLH (NIOSH)

IDLH is a condition "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment." (*12.6.4*). In establishing the IDLH value, the following conditions must be assured:

A. The ability to escape without loss of life or immediate or delayed irreversible health effects. (Thirty minutes is considered the maximum time for escape so as to provide some margin of safety in calculating an IDLH value.)

B. The prevention of severe eye or respiratory irritation or other reactions that would hinder escape.

2.1.7 ERPGs

The American Industrial Hygiene Association (*12.3.1*) has developed Emergency Response Planning Guideline values which are intended to provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects as described in the definitions for ERPG-1, ERPG-2 and ERPG-3 as a consequence of exposure to the specific substance.

ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing more than mild transient adverse health effects or without perceiving a clearly defined, objectionable odor.

ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

ERPG-3: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

2.2 PHYSIOLOGICAL EFFECTS OF CHLORINE

Chlorine is a potential irritant to the eyes, skin, mucous membranes, and the respiratory system. The United States Department of Transportation classifies it as class 2.3 poisonous gas and it has an NFPA classification of 4-0-0-Oxidizer. The primary concerns with exposure to chlorine are the respiratory system followed by the eyes. The impact of exposure to chlorine is both concentration and time dependent. (CI Pamphlet 63 (*12.1*) is one of several sources providing more information on the health effects of exposure to chlorine.) Also, refer to your suppliers SDS for additional health effects information. The following table summarizes health effects to humans:

Table 2.1 Chlorine Exposure Thresholds, Limits, and Guidelines (ppm)
(Refer to Section 2.1 for further explanation of exposure level designations)

0.2 – 0.4	Odor threshold (decrease in odor perception occurs over time)
Less than 0.5	No known acute or chronic effect
0.5	ACGIH TLV-TWA (8-hour time-weighted average)
1	OSHA PEL (ceiling) ACGIH TLV-STEL (15 minutes) AIHA ERPG-1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
1 – 3	Mild mucous membrane irritation, tolerated up to 1 hour
3	AIHA ERPG-2: The 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.
5 – 15	Moderate irritation of the respiratory tract. The gas is very irritating, and it is unlikely that any person would remain in such an exposure for more than a very brief time unless the person is trapped or unconscious.

10	NIOSH IDLH: The airborne concentration that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Values are based on a 30-minute exposure.
20	AIHA ERPG-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
30	Immediate chest pain, vomiting, dyspnea (shortness of breath), and cough
40 – 60	Toxic pneumonitis (inflammation of the lungs) and pulmonary edema (accumulation of fluid in the lungs)
430	Lethal over 30 minutes
1000	Fatal within minutes

Note: Values presented in Table 2.1 that are not designated as ACGIH, AIHA, NIOSH or OSHA values are from “Medical Toxicology: Diagnosis and Treatment of Human Poisoning,” Ellenhorn, M.J. and D.G. Barceloux, Eds., Elsevier, New York (1988). pp. 878-879.

2.2.1 Non Respiratory Effects of Exposure to Gaseous Chlorine

Gaseous chlorine absorbs in water to form both hypochlorous and hydrochloric acids. Chlorine gas can dissolve in body moisture (i.e., perspiration) to form these acids. At 3,500 ppm chlorine in air, the pH of moisture on the skin would be approximately 4. A pH of 4 is comparable to carbonated water. While a burning sensation and skin irritation can occur due to such exposure, a review of the literature has provided no specific human data to determine the concentration of chlorine required to produce such effects. As previously stated, irritation of the eye, when exposed to gaseous chlorine, begins to occur at the 1-3 ppm level. Thorough washing with water along with a skin conditioner afterward have proven effective for slight skin irritations from chlorine exposures.

2.2.2 Non Respiratory Effects of Exposure to Liquid Chlorine

Liquid chlorine is a liquified compressed gas. At atmospheric pressure, liquid chlorine vaporizes at -34^{o}C (-29^{o}F). Typically, chlorine is stored in vessels as a liquid at atmospheric or elevated pressures. Liquid chlorine will cause eye and skin burns upon contact, similar to frostbite.

2.2.3 After Exposure to Chlorine

If liquid chlorine contacts the skin or penetrates through the clothing, immediately flush the affected area with water for at least 15 minutes. Care should be exercised when removing the protective clothing after use to avoid inhalation of chlorine from the contaminated clothing. Medical attention may be necessary for any personnel exposed (by inhalation or skin contact) to liquid or gaseous chlorine. CI Pamphlet 63 (*12.1*) provides more specific information concerning such treatment.

2.3 PHYSIOLOGICAL EFFECTS OF SODIUM AND POTASSIUM HYDROXIDE (10 - 50 WT %)

Sodium and potassium hydroxide (NaOH and KOH) solutions are classified as class 8 corrosives by the United States Department of Transportation and can cause mild to severe irritation of the eyes, mucous membranes (nose, sinus, throat, and lungs), and skin. It has an NFPA classification of 3-0-1. Exposure can occur by both direct contact with aqueous caustic solutions or entrained mists and aerosols. The degree of irritation or cell damage is related to both the concentration and temperature of the hydroxide solution and the duration of the exposure.

2.3.1 Sodium Hydroxide

Exposure to hydroxide solutions (caustic), mists, or aerosols at concentrations as low as 5% NaOH can cause severe skin irritation and/or burns. The severity can be reduced by prompt flushing of the affected areas with copious amounts of water and obtaining immediate medical attention. Ingestion of liquid sodium hydroxide solutions can cause severe burns to the mucous membranes of the mouth, throat, esophagus, and stomach. Sodium hydroxide is an odorless material (*12.10.3*). The following table summarizes health effects upon humans:

Table 2.2 Sodium Hydroxide (10 – 50 wt %) Exposure Thresholds, Limits and Guidelines (mg/m³) (Refer to Section 2.1 for further explanation of exposure level designations)

0.5	AIHA ERPG – 1 : The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
2	NIOSH REL – Ceiling OSHA–PEL- TWA
5	AIHA ERPG – 2: The 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.
10	NIOSH IDLH: The airborne concentration that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Values are based on a 30-minute exposure.
50	AIHA ERPG-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects. Eye irritation Can cause severe skin irritation and/or burns

2.3.3 Potassium Hydroxide

There are limited data to definitively establish exposure/effect information for potassium hydroxide. It is believed that the allowable limits established for sodium hydroxide generally can be applied to potassium hydroxide (Section 2.3.1).

2.4 PHYSIOLOGICAL EFFECTS OF SODIUM HYPOCHLORITE (3 - 20 WT %)

Sodium Hypochlorite (NaOCl) solutions are classified as a class 8 corrosive by the United States Department of Transportation, and is a mild to severe irritant to the eyes, skin, mucous membranes, and the respiratory system. It has an NFPA classification of 3-0-1. Exposure can occur by both direct contact with sodium hypochlorite solutions or entrained mists and aerosols. The primary concerns with exposure to sodium hypochlorite solution are with the eyes, followed by the mucous membranes, the respiratory system and the skin. The impact of exposure to sodium hypochlorite is dependent on the concentration of the solution, amount of excess sodium hydroxide contained in the solution and the time in contact with the affected parts of the body.

Contact with solutions of sodium hypochlorite can cause eye irritation. Increasing concentrations and amount of excess sodium hydroxide in the solution can cause severe irritation and/or burns and possible blindness. Sodium hypochlorite solutions, mists, or aerosols can also cause skin irritations. The severity can be reduced by prompt flushing of the affected areas with copious amounts of water and obtaining immediate medical attention.

Ingestion of sodium hypochlorite solution can cause severe burns to the mucous membranes of the mouth, throat, esophagus, and stomach. Breathing mist or spray can cause damage to the upper respiratory tract and lungs which could lead to chemical pneumonia, depending on the severity of the exposure.

Neither a PEL or TLV has been established by OHSA, but the American Industrial Hygiene Association (AIHA) recommends an exposure level for sodium hypochlorite solutions at 2 mg/m^3 as a 15-minute time weighted average, as stated in their Workplace Environmental Exposure Level (WEEL) Guide. **The predominant chlorine-like odor associated with sodium hypochlorite is hypochlorous acid (not chlorine) for which there are no established exposure limits**. The exposure limits for chlorine may be considered as applicable in many circumstances.

2.5 PHYSIOLOGICAL EFFECTS OF HYDROCHLORIC (MURIATIC) ACID (7 - 37 WT %)

Hydrochloric acid solutions are classified as a class 8 corrosive by the United States Department of Transportation. The NFPA classification is 3-0-1. At room temperature, hydrogen chloride is a colorless to slightly yellow gas with a pungent odor. Commercial concentrated hydrochloric acid contains 36% to 38% hydrogen chloride in water. Aqueous solutions generally are colorless but may be yellow due to traces of iron, chlorine, and organic impurities. Inhalation is an important route of exposure to hydrogen chloride. Its odor and highly irritating properties generally provide adequate warning for acute, high-level exposures. Hydrogen chloride is not absorbed through the skin. Direct contact with aqueous solutions of hydrogen chloride or with concentrated vapor can cause severe chemical burns. Ingestion of concentrated hydrochloric acid can cause severe corrosive injury to the lips, mouth, throat, esophagus, and stomach.

The following table summarizes health effects upon humans:

Table 2.3 Hydrochloric (Muriatic) Acid (7 – 37 wt %) Exposure Thresholds, Limits and Guidelines (ppm) [1 ppm = 1.49 mg/m^3] (Refer to Section 2.1 for further explanation of exposure level designations)

2	ACGIH – STEL: the individual's 15-minute time weighted average exposure which should not be exceeded at any time during a work day.
3	AIHA ERPG – 1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
5	OSHA TWA - PEL – Ceiling NIOSH REL - Ceiling
20	AIHA ERPG – 2: The 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.
50	NIOSH IDLH: The airborne concentration that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Values are based on a 30-minute exposure.
150	AIHA ERPG – 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

2.6 PHYSIOLOGICAL EFFECTS OF SULFURIC ACID (38 - 98 WT %)

Sulfuric acid is classified as a class 8 corrosive solution by the United States Department of Transportation and has an NFPA classification of 3-0-2-W. It is an odorless chemical (*12.10.3*) that can quickly cause second and third degree burns with severe necrosis (tissue death). Repeated and/or prolonged exposure to mists may cause irritation with itching, burning, redness, swelling, or rash. Exposure to mists may cause irritation of the nose and throat with sneezing, sore throat or runny nose, and non-specific effects such as headache, nausea, and weakness. Overexposure may cause irritation of the nose, throat, and lungs with cough, difficulty breathing or shortness of breath or pulmonary edema. Symptoms may be delayed.

The International Agency for Research on Cancer (IARC) has concluded that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic, causing cancer of the larynx (the voice box) and to a lesser extent, the

lung. However, no direct link has been established between exposure to sulfuric acid, itself, and cancer in humans.

Sulfuric acid in contact with the eye may cause corrosion, ulceration, and may result in blindness. Repeated and/or prolonged exposure to mists may cause eye irritation with tearing, pain, or blurred vision. Prompt flushing of the eyes with copious amounts of water and seeking immediate medical attention can reduce the severity. Ingestion of sulfuric acid can cause severe burns of the mouth, throat, esophagus, and stomach, with severe pain, bleeding, vomiting, and diarrhea. Symptoms may be delayed for several days.

The severity of any skin or eye exposure to sulfuric acid can be reduced by prompt flushing of the affected areas with copious amounts of water. Immediate medical attention should be obtained for any personnel exposed (by inhalation, skin or eye contact) to sulfuric acid. The following table summarizes health effects upon humans:

Table 2.4 Sulfuric Acid (38 – 98 wt %) Exposure Thresholds, Limits and Guidelines (mg/m³) (Refer to Section 2.1 for further explanation of exposure level designations)

1	OSHA PEL – TWA NIOSH REL – TWA ACGIH TLV - TWA
2	AIHA ERPG – 1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
3	ACGIH TLV - STEL
10	AIHA ERPG – 2: The 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.
15	NIOSH IDLH: The airborne concentration that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Values are based on a 30-minute exposure.
30	AIHA ERPG – 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

2.6.1 Sulfuric Acid Mist

Because the Chlorine Institute has limited knowledge of sulfuric acid as a mist, a simple laboratory test was conducted to measure the concentration of sulfuric acid over a liquid pool.

An open container filled with concentrated sulfuric acid having a surface area of 104 square inches was placed in a closed booth. An air sample was collected at approximately 6 inches above the sulfuric acid. The sample was collected in a lab hood with minimal air flow. The following are 8-hour TWA results:

Samples tested at 70°F (21°C)	Sulfuric Acid Concentration - mg/m^3
6" above container	0.09

Samples tested at 120°F (49°C)	Sulfuric Acid Concentration - mg/m^3
6" above container	0.23

These results would indicate that without higher temperatures or other conditions that are conducive to the creation of mists (agitation, pressure, etc.) - the level of sulfuric acid in a breathing zone should not be expected to be above 1 mg/m^3.

Note - These results may not apply to confined spaces or other areas where air circulation might be different than in the laboratory experiment.

2.7 PHYSIOLOGICAL EFFECTS OF ANHYDROUS HYDROGEN CHLORIDE (AHCL)

Anhydrous hydrogen chloride is classified as a class 2.3 poisonous gas by the United States Department of Transportation and has an NFPA classification of 3-0-1. Due to its high water solubility, gaseous anhydrous hydrogen chloride (AHCl) dissolves quickly in water to form hydronium ions (H_3O+) (*12.11.2*). Consequently, AHCl is an irritant to the eyes, skin, mucous membranes, and the respiratory system. The primary concerns with exposure to AHCl are the respiratory system followed by the eyes. The following table summarizes health effects upon humans:

Table 2.5 Anhydrous Hydrogen Chloride Exposure Thresholds, Limits and Guidelines (ppm) [1 pmm = 1.49 mg/m^3] (Refer to Section 2.1 for further explanation of exposure level designations)

3	AIHA ERPG – 1: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
5	OSHA PEL – Ceiling NIOSH REL – Ceiling ACGIH TLV - Ceiling
20	AIHA ERPG – 2: The 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.

50	NIOSH IDLH: The airborne concentration that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere. Values are based on a 30-minute exposure.
150	AIHA ERPG-3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

2.7.1 Non Respiratory Effects of Exposure to Gaseous AHCl

Due to its high water solubility, gaseous AHCl will dissolve in any liquid contacting the body, including sweat, saliva and tears. Exposures, other than minor, may result in severe burns to the skin and eyes. Minor exposure may result in a burning sensation and skin or eye irritation. While a burning sensation and skin or eye irritation can occur due to such exposure, a review of the literature has provided no specific human data to determine the concentration of AHCl required to produce such effects.

2.7.2 Exposure to Liquid AHCl

Liquid anhydrous hydrogen chloride is a refrigerated compressed gas. At atmospheric pressure, liquid anhydrous hydrogen chloride vaporizes at -85^{o}C (-121^{o}F). Typically, AHCl is stored in vessels as a liquid at atmospheric or elevated pressures. Liquid AHCl will cause eye and skin burns upon contact, similar to frostbite.

2.7.3 After Exposure to AHCl

If liquid AHCl contacts the skin or penetrates through the clothing, immediately flush the affected area with water for at least 15 minutes. Care should be exercised when removing the protective clothing after use to avoid inhalation of AHCl from the contaminated clothing. Immediate medical attention should be obtained for any personnel exposed (by inhalation or skin contact) to liquid or gaseous AHCl.

2.7.4 Regulations

OSHA regulations concerning PPE, Process Safety Management of Highly Hazardous Chemicals, Hazardous Waste Operations and Emergency Response, Hazardous Communication, and Air Contaminants can be found in 29 CFR 1910, subsections 119-138. Since skin, eye, or lung contact with the chlor-alkali chemicals discussed in this pamphlet can have negative effects, it is imperative that personnel involved in any aspect of handling, packaging and/or transportation are knowledgeable of the regulatory requirements. Publications should be readily available for reference (*12.6*).

3. PERSONAL PROTECTIVE EQUIPMENT SELECTION

The information contained in Sections 4 through 9 of this pamphlet provides personal protective equipment recommendations only for the specific chemical discussed. The facility should also evaluate the need for and specify additional PPE requirements that are site specific and protect against other hazards that may be encountered on the job.

These requirements may include PPE such as hard hats, safety glasses, gloves, protective clothing and safety-toe shoes.

3.1 GENERAL

This pamphlet covers the recommended PPE for performing the following tasks in a facility producing, using, or otherwise handling the chemicals listed in Section 2.

- Initial Line Break;
- Material Sampling;
- Loading/Unloading; and
- Emergency Response.

These recommendations assume that the facility has written operating and maintenance procedures including an emergency response plan (CI Pamphlet 64 (*12.1*)) and has trained its individuals in these procedures. OSHA regulations 29 CFR 1910.132, (*12.6.4*) require that the employer conduct a hazard assessment and equipment selection to determine if hazards are present, or likely to be present, that would necessitate the use of PPE. If such hazards are present, or likely to be present, the individual needs to select the appropriate PPE, communicate the selection decision with each affected individual, and verify the communication has been performed through written certification. Facilities covered by the OSHA PSM rule need to develop procedures in accordance with 29 CFR 1910.119 (*12.6.2*) and CI Pamphlet 155 (*12.1*).

These recommendations also assume the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed job safety analysis is performed and documented, and it concludes that a different level of personal protective equipment will protect the individual(s) performing the work, such different level of PPE is fully compatible with the purposes and intent of these recommendations.

The OSHA regulation 29 CFR 1910.134 addressing respiratory protection (*12.6.4*) states, in part, the following:

> "(a) Permissible practice. (1) In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used…"

Thus it is preferable to institute engineering controls in place of PPE when feasible.

Chemical burn injuries have occurred to individuals after completing the assigned task while removing the PPE. Section 10.2 discusses the decontamination of PPE after completing the assigned task. It is extremely important (especially with acid and alkaline liquids) that the PPE is washed thoroughly with water prior to removal to prevent dripping of the liquid on a body part that was protected by the PPE while performing the task.

Initial line break, as used in this pamphlet, is defined as the **first time opening** of a line or a section of a line, a vessel, other equipment such as a compressor or pump that previously contained the specified chemical. For the purpose of this pamphlet, initial line break does not include (1) material sampling activities through engineered sample points or (2) connecting or disconnecting of containers for loading/unloading purposes because PPE recommendations for material sampling and loading/unloading are defined separately within this document.

Chemical burn injuries have occurred to individuals working on process equipment after the initial line break has occurred. In such cases, the individuals have been exposed to the chemicals contained in the process because the equipment was not or could not be decontaminated prior to commencing the maintenance activity. Accordingly, it is recommended that such individuals wear the same PPE as recommended for the initial line break until the equipment has been decontaminated and/or verified as clear, safe for the work being performed, and follows your company's procedure for changing PPE prior to task completion.

Material sampling, as used in this pamphlet, is the collection of the specified chemical for the purpose of performing a chemical analysis, for retention, or other purpose. Recommendations for material sampling assume no site engineered sampling stations have been constructed. Such sampling stations may preclude the need for some of the PPE recommendations. In such situations, a job analysis should be performed to determine, among other things, the required PPE.

Loading/unloading, as used in this pamphlet, is defined as the connecting or disconnecting of hoses/piping and the opening/closing of loading/unloading valves on shipping equipment containing the specified chemical. As used in this pamphlet, a shipping container includes barges, railroad tank cars, tank motor vehicles, ton containers, cylinders with a minimum net weight of 100 pounds, and drums with a minimum volume of 30 gallons. Smaller sized containers are beyond the scope of this pamphlet. Loading/unloading does not include the periodic inspection/monitoring of the container and associated equipment during the loading/unloading activity.

Emergency response, as used in this pamphlet, refers to the OSHA definition found in 29 CFR 1910.120 (*12.6.3*). The OSHA definition is as follows:

> "Emergency response or responding to emergencies means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual-aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result, in an uncontrollable release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releases of hazardous substances where there is no potential safety or health hazards (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses."

Responses to incidental releases should be addressed by operating/maintenance procedures for individual facilities. Such procedures need to be consistent with OSHA PPE guidance as discussed in 29 CFR 1910.132 - 138 (subpart I) (*12.6.4*).

The overall emergency response coordinator (Incident Commander) should be given appropriate authority to modify any requirements after assessing the situation. Where applicable, the OSHA regulation 29 CFR 1910.120(q)(3) (*12.6.3*) gives this individual (designated as the individual in charge of the incident command system) such authority (within limits) to do so. The Institute recommends that the facility's Emergency Response Plan specify the extent of such authority.

3.2 CONTACT LENSES

The use of contact lenses in facilities that use the chlor-alkali chemicals mentioned in this pamphlet should be considered during each facility's hazard assessment. It was long believed that the use of contact lenses in any chemical environment should be banned due to risk of chemical interaction with the lens or adherence of the lens to the eye. In the 2003 edition of the NIOSH Pocket Guide to Chemicals Hazard, NIOSH removed the prohibition against contact lenses in the industrial environment. An excerpt of NIOSH's position in *Current Intelligence Bulletin 59 – Contact Lens Use in a Chemical Environment*, can be found in Appendix C.

3.3 RESPIRATORY PROTECTION

Respirators should be used to provide personal protection in emergencies and in operations where engineering and/or work practice controls are not available. The main objective of a respirator protection program is to prevent the inhalation of substances that may result in adverse health effects to exposed personnel.

In the United States OSHA requires a written program (*12.6.4*). The program should define the specifics of equipment used for different applications, responsibility for maintenance, replacement and inspection, and the training and fit-testing activities. Additionally, the manufacturer's instructions on cleaning, storage, maintenance, and expiration should be closely followed.

All individuals who use non-escape respirators must be involved in the company's medical surveillance program. More details on how to administer an effective medical surveillance program can be found in CI Pamphlet 63 (*12.1*).

Examples of common types of non-escape respirators can be found in Appendix B.

3.3.1 Escape Respirators

Escape respirators are intended to allow the wearer to quickly exit an area that has become unsafe for human occupancy. Escape respirators shall not be used for maintenance work or emergency response. Escape respirators shall not be used in place of SCBA, full-face, or half-face respirators.

Figure 3-1. Example of an escape respirator – nose clip and mouth piece.

3.3.2 Proper Use and Care

Proper use of respiratory protection is essential. Improper use could lead to a chemical exposure. Proper use of escape respirators is extremely time-critical. Since escape respirators are used only in emergency situations, anyone using one should be able to properly don the escape respirator within 15 seconds. Escape respirators should be stored and maintained in accordance with the manufacturer's instructions.

3.3.3 Fit Testing

Fit testing is not required for escape respirators, as most escape respirators work by sealing the nose and a cartridge mouthpiece and do not depend on a seal to the face.

3.3.4 Training

Training on the use of escape respirators is essential. Since escape respirators are used only in emergency situations, anyone using one should be able to don the escape respirator within 15 seconds. This cannot be done if the escape respirator is in excessive packaging or more than an arm's reach away at all times. It should be noted that one aspect of escape respirator training should be to train workers not to breathe deeply prior to donning the escape respirator. If a breath is taken, chlorine will be inhaled. After it is made clear an escape respirator is needed, the first breath should not be taken until after the respirator is in place.

3.3.5 Non-Escape Respirators

Non-escape respirators are used in non-emergency situations, both for routine and maintenance tasks. Follow your company's policy on when non-escape respirators should be used.

3.3.6 Proper Use

Proper use of respiratory protection is essential. Improper use could lead to chemical exposure.

3.3.7 Inspection

A formal inspection program is an essential part of the maintenance plan for respirators. In the United States the OSHA regulations require that respirators used for emergency response and self-contained breathing apparatus be inspected monthly and after each use, and a permanent record of the inspections be kept. Trained inspectors should check the equipment according to manufacturer's recommendations. Proper storage is very important. Inspection points to note include the following: appropriate air pressure in cylinders (where applicable), proper cleanliness (presence of protective wrapping), facepiece crimping, expiration date printed on cartridge or canister, and condition of valves and straps.

3.3.8 Fit Testing

Respirators should not be worn when conditions exist that prevent a good face seal (e.g., facial hair, scars, facial irregularities, eye glasses). Additionally, to assure proper protection, the wearer should perform a user seal check each time the respirator is used. This may be done by following OSHA's 29 CFR 1910.134 (*12.6.4*), and the manufacturer's facepiece fitting instructions.

3.3.9 Training

Annual training including documentation of such training in all aspects of a respiratory protection program is recommended. Workers must understand the potential hazards and the proper use of the appropriate respirators needed to achieve the necessary protection.

3.4 BASIS FOR RECOMMENDATIONS

The recommendations contained in this pamphlet are based in part on the assumption that workers performing certain tasks and those responding to a specific chemical release may encounter a concentration at or above that designated by the National Institute for Occupational Safety and Health as immediately dangerous to life or health (IDLH). In addition to the assumptions stated in Section 3.1, these recommendations also assume that no other hazardous chemicals requiring more stringent requirements will be encountered by the emergency responders. This pamphlet is not intended to cover firefighting operations. OSHA has additional specific requirements found in 29 CFR 1910.156(e) (*12.6.5*) for such operations.

The recommendations contained in this pamphlet are designed to protect specific parts of the body (e.g., head, neck, face, eyes, hands, arms, feet, legs, trunk, and respiratory system.). Tables listing recommended PPE to protect these body parts are provided at the end of Sections 4 through 9.

While there are numerous PPE alternatives for protecting the eyes against exposure, the Institute believes that face shields with or without safety glasses do not, by themselves, provide sufficient protection against exposure to liquids. ANSI Standard Z 87.1-1989 states that "Face shields are secondary protection and shall be used only with primary protection" (*12.4.1*). Accordingly, whenever a face shield is recommended to protect the face, the Institute also recommends chemical protective goggles to protect the eyes.

Several of the tasks discussed in this pamphlet include PPE recommendations for protection of the head. For some tasks discussed, PPE recommendations include chemical protection of the head and neck. As discussed in this pamphlet, protection of the head includes the top of the head, but not the front or the back. Face and eye protection are needed to protect the front of the head. A hood or comparable PPE is needed to protect the back of the head and neck. A hood can also serve to protect the top of the head. A hood with an integral face mask serves to also protect the face and eyes. A hard hat typically used to protect the top of the head from impact can provide chemical protection for the top of the head if of suitable design. A suitably designed hat in combination with a face shield and chemical splash goggles can serve to protect the head, face and eyes.

Figure 3-2. Example of hoods intended to protect the top of the head and neck.

3.5 LEVELS OF PROTECTION

In the United States, OSHA has developed guidelines found in 29 CFR 1910.120 (*12.6.3*) for an employer to use to select the appropriate PPE for emergency response. The guidelines point out that site information may suggest the use of combinations of PPE selected from the four different protection levels discussed in the OSHA guidelines as being more suitable to the hazards of the work. For example, the Chlorine Institute defines and recommends an Enhanced Level B protection in certain situations.

Based on the experience of its members, the Chlorine Institute has developed Enhanced Level B recommendations as initial selection criteria for personal protective equipment for specific work tasks and for responders to certain chemical releases involving liquid chlorine, hydrochloric acid, sulfuric acid, and anhydrous hydrogen chloride. While these recommendations are intended to provide guidance to facilities in general, a facility may choose to alter these recommendations after review of site specific hazards.

Furthermore, it is pointed out in the OSHA guidelines that the listing “does not fully address the performance of specific PPE material in relation to the specific hazards at the job site, and that PPE selection, evaluation and reselection is an ongoing process until sufficient information about the hazards and PPE performance is obtained.”

Whenever the air supply respirator option, as discussed below, is selected, such equipment should be used with appropriate full facepiece and an auxiliary self-contained air supply (escape air provision). Appendix B further discusses this option.

The types of hazards for which levels A, Enhanced B, B, C, and D protection are appropriate are discussed below.

Level A protection should be used when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system based on either the measured (or potential for) high concentration of atmospheric vapors, gases,

liquids or particulates; or the site operations and work functions involve a high potential for splash, immersion or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the skin;

- Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible; or

- Operations are being conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A have not yet been determined.

Figure 3-3. Example of Level A PPE.

Level A protection is defined as a specialized chemical protective clothing which, when used in conjunction with air supplied respiratory protection devices, offers a sealed, integral level of full body protection from a hostile environment.

Enhanced Level B should be used when:

The hazardous substance has been identified and requires a high level of respiratory protection as in Levels A and B. Skin protection greater than that required by Level B but less than Level A is appropriate. Enhanced Level B protection is appropriate for exposure to several of the chemicals discussed and explained in the following sections.

The Institute defines its Enhanced Level B protection as follows:

Positive pressure, full-face self-contained breathing apparatus (SCBA) or air supply respirator (ASR) with an auxiliary self-contained air supply (escape air provision).

Protective clothing including the following items:

- Chemical protective suit;

- Footwear or footwear cover;

- Hood (for protection of head and neck); and

- Undergarments to provide thermal protection for exposure to liquid chlorine and anhydrous hydrogen chloride.

Fig. 3-4. Example of Enhanced Level B PPE.

Enhanced Level B protection provides fully encapsulated protective equipment, but is not gas tight. This involves atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.

Level B protection should be used when:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection;
- The atmosphere contains less than 19.5 % oxygen; or
- The presence of incompletely identified vapors or gases is indicated, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.

Level B is defined as either single or multi-piece chemical splash suits, SCBA, and appropriate gloves and footwear protection.

Level C protection should be used when:

Figure 3-6. Example of Level C PPE.

- The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin;
- The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants; and
- All criteria for the use of air-purifying respirators are met.

Level C protection is defined as full-face, air purifying respirator, chemical-resistant respirator, chemical-resistant outer gloves, and chemical-resistant boots.

Level D protection should be used when:

Figure 3-7. Example of Level D PPE.

- The atmosphere contains no known hazards; and
- Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Level D protection does not require specific respiratory or skin protection

3.6 CRITERIA FOR PPE SELECTION

The PPE recommended for the specific tasks should meet the criteria as listed in Table 3.1. Additional criteria for emergency response PPE selection criteria are discussed in the section for each chemical.

The National Fire Protection Association (NFPA) has developed standards addressing vapor-protective suits (*12.9.1*) and liquid splash-protective suits (*12.9.2*) for hazardous chemical emergencies and has issued standards for certification of certain PPE for emergency response personnel.

NFPA 1991 (*12.9.1*) provides criteria for vapor-protective and liquid splash protection ensembles for twenty-one chemicals. These chemicals include chlorine (gas), hydrogen chloride (gas), sodium hydroxide, and sulfuric acid.

The NFPA standard does not include protection against liquid chlorine, potassium hydroxide, sodium hypochlorite, nor liquid anhydrous hydrogen chloride.

NFPA 1992 (*12.9.2*) provides criteria for liquid splash protective ensembles and clothing. PPE emergency response equipment certified as to meeting the applicable NFPA standard is in conformance with the recommendations of this pamphlet.

Table 3.1 - PPE Component Selection Criteria

PPE Component	Recommended Test
Chemical Protective Suit	I and V or I and II
Chemical Protective Gloves	I and V or I and II
Chemical Protective Boots	II or V
Hood	II or V
Face Shield	II or V
Chemical Splash Goggles	II or V
Ensemble System (everything)	III or IV

I ASTM D2136-02 modified to -30°F (-34°C) (low temperature flex test)

II ASTM F739-12e1 (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

IV ASTM F1052-14 (pressure test)

V ASTM F903-10 (chemical resistance – penetration; no penetration in 60 minutes)

Reference 12.5 provides a further explanation of these tests.

* For all tests, NFPA 1993, Appendix C (*12.9.3*) provides further information on the test application and criteria.

- Criterion I should be performed prior to conducting other recommended criteria.
- The Institute believes Criterion V provides sufficient protection for workers performing the specified tasks involving potential exposure to the chemicals discussed in this pamphlet. Criterion II, a more stringent test, is shown because some vendors may prefer to perform this test.

4. PERSONAL PROTECTIVE EQUIPMENT SELECTION - CHLORINE

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

During activities that have the potential to release chlorine, consideration should be given to ensure adequate personnel protection is implemented and maintained throughout the activities. For individuals directly involved, requirements for donning PPE in relation to job progression should be specified along with conditions to downgrade if desired including confirmation of below PEL/no concentration of chlorine. Adjacent, downwind, or potentially impacted areas should be evaluated for risk of exposure to individuals not directly involved. Considerations should be given to limiting/restricting access to the areas and communication of higher risk activity throughout the area (area announcement, barricades, operational attendance, etc.)

This section covers the recommended PPE for performing the specified tasks involving chlorine liquid or gas below 120^{o}F (49°C).

4.1 INITIAL LINE BREAK

If the specific initial line break currently being performed has been performed periodically in the past and it has been demonstrated that the evacuation techniques and the maintenance procedures utilized will result in chlorine concentrations no more than the capability of the respirator.

Recommendations:

Chlorine Gas	-	Full face air purifying respirator approved for protection against chlorine.
Chlorine Liquid	-	Full face air purifying respirator approved for protection against chlorine. Gloves for thermal (cold) protection.

If the above criteria have not been met,

Recommendations:

Chlorine Gas	-	SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).
Chlorine Liquid	-	Enhanced Level B

4.2 MATERIAL SAMPLING

If the specific sampling task has been periodically undertaken in the past and industrial hygiene sampling results demonstrated that the techniques being utilized may result in chlorine concentrations no more than that for which the respirator is approved,

Recommendations:

Chlorine Gas	-	Full face air purifying respirator approved for protection against chlorine.
Chlorine Liquid	-	Full face air purifying respirator approved for protection against chlorine. Gloves for thermal (cold) protection.

If the above criteria have not been met,

Recommendations:

Chlorine Gas	-	SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).
Chlorine Liquid	-	SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision) gloves for thermal (cold) protection.

4.3 LOADING/UNLOADING

Most shipping containers contain both liquid and gaseous chlorine. If such is the situation, the recommendation for chlorine liquid should be followed.

In addition to the assumptions discussed in Section 3.1, the next recommendation assumes the facility has a system to allow for the purging and evacuation of the pipeline/hoses used for loading and unloading.

If the loading/unloading task being done has been periodically undertaken in the past and industrial hygiene sampling results demonstrated that the techniques being utilized may result in chlorine concentrations no more than for which the respirator is approved,

Recommendations:

Chlorine Gas	-	Full face respirator approved for protection against chlorine.
Chlorine Liquid	-	Full face respirator approved for protection against chlorine. Gloves for thermal (cold) protection.

If the above criteria have not been met,

Recommendations:

Chlorine Gas	-	SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).
Chlorine Liquid	-	SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision). Gloves for thermal (cold) protection.

4.4 EMERGENCY RESPONSE

In addition to the assumptions stated in 3.1, these recommendations also assume that no other hazardous materials requiring additional PPE would be encountered by the responders.

4.4.1 Gaseous Chlorine Emergency Response

Through their collective experience the members of the Chlorine Institute have determined that Level B (not enhanced) protection (chemical resistant clothing) provides appropriate protection to emergency responders for gaseous chlorine releases. Unless it is designed to be self-sealing, the chemical-resistant clothing should be taped using chlorine compatible tape at the openings for the hands and feet. The PPE selected should meet specific criteria that the Institute believes are appropriate for emergency responders to gaseous chlorine.

The collective experience of the members of the Chlorine Institute is that a higher level of protection provides no additional measure of protection to emergency responders of gaseous chlorine releases when not entering a confined space; and, because of its bulkiness, increases the time required to stop the release.

Prior to an individual reentering a gaseous chlorine release area after the refilling of any self-contained breathing equipment tank, the individual should be interviewed by a knowledgeable person to verify that skin irritation has not occurred.

4.4.2 Liquid Chlorine Emergency Response

Through their collective experience the members of the Institute have determined that Enhanced Level B, as defined by the Institute in Section 3.5, provides appropriate protection to emergency responders for liquid chlorine releases.

Recommendations:

Chlorine Gas	-	Level B
Chlorine Liquid	-	Enhanced Level B

4.5 SUMMARY OF RECOMMENDATIONS

Tables 4.1 and 4.2 summarize the recommendations contained in this section.

The Institute recognizes that a purchaser of Enhanced Level B PPE may opt to specify Level A PPE in order to reduce the different types of PPE held in inventory or to simplify the PPE selection process.

Table 4.1 - Summary Of PPE Recommendations For Tasks Involving Potential Exposure To Gaseous Or Liquid Chlorine

	Task Previously Sampled and Within Respiratory Limitations	Task Not Previously Sampled or Sampled and Above Respirator Limitations	
		Gas	Liquid
Initial line break	FFR G	SCBA	Enhanced Level B
Material Sampling	FFR G	SCBA	SCBA G
Loading/Unloading	FFR G	SCBA	SCBA G
Emergency Response	When liquid is not involved – Level B When liquid is involved – Enhanced Level B		

FFR - Full face air purifying respirator approved for protection against chlorine

G - Gloves for thermal (cold) protection) - Recommendation is for liquid only

SCBA - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision)

Table 4.2 - Recommended Criteria to Evaluate Selected PPE Components for Tasks Involving Liquid or Gaseous Chlorine

PPE Component	Multi-piece Enhanced Level B Chlorine Liquid**	Hood for Multi- piece Enhanced Level B Chlorine Liquid**	One Piece Enhanced Level B Chlorine Liquid	Level A Chlorine Liquid	Level B Chlorine Gas
Base Material for Suit and Booties	I and V or I and II	I and V or I and II	I and V or I and II	I and V or I and II	V or II
Visor	Not Applicable	I and V or I and II	Not Applicable	I and V or I and II	Not Applicable
Gloves System	I and V or I and II	Not Applicable	I and V or I and II	I and V or I and II	V or II
Boots	*	Not Applicable	*	Not Applicable	*
Seams/Tape	V or II	Not Applicable	V or II	V or II	V or II
Ensemble System	III	Not Applicable	III	IV	Not Applicable

I ASTM D2136-02 modified to -30^{o}F (-34°C) (low temperature flex test)

II ASTM F739-12e1 (chemical resistance - permeation, no breakthrough in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

IV ASTM F1052-14 (pressure test)

V ASTM F903-10 (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 12.5 provide a further explanation of these tests.

***** Level B boots should be resistant to chlorine and consistent with the facility's foot protection policy.

** Hood must be used with multi-piece Enhanced Level B.

5. PERSONAL PROTECTIVE EQUIPMENT SELECTION - SODIUM AND POTASSIUM HYDROXIDE (10 - 50 WT %)

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

This section covers the recommended PPE for performing the specified tasks involving sodium or potassium hydroxide at concentration between 10 - 50% at temperatures below 120^{o}F (49°C). Materials for PPE should be chemically resistant against 10-50% sodium or potassium hydroxide at 120^{o}F (49°C) or the applicable.

Where sodium/potassium hydroxide products are being sampled/handled, and the product temperature is above 120^{o}F (49°C), PPE for thermal protection may be necessary in addition to any chemical resistant PPE used. Contact a safety supply provider or a PPE manufacturer for proper PPE selection.

5.1 INITIAL LINE BREAK

Recommendation:

Chemical protection for the head, neck, face, eyes, hands, body, and feet.

5.2 MATERIAL SAMPLING

Recommendation:

Chemical protection for the face, eyes, and the hands.

5.3 LOADING

In addition to the assumptions discussed in Section 3.1, the PPE recommendations listed next assume the actual loading operation can be started and stopped while the worker is remote from the loading connection (i.e. the point that sodium or potassium hydroxide leaves the loading line and enters the loading container).

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, face, eyes, and hands.

In the absence of such remotely operated equipment, the facility should follow the recommendations listed immediately below.

- Chemical protection for the head, face, eyes, hands, body, and feet.

While inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

5.4 UNLOADING

Unloading a container of sodium or potassium hydroxide is deemed to be potentially more hazardous than the loading of such a container that is initiated by remote operations. Unloading such a container typically involves either pressurizing the container or installing connections at a valve located on the bottom of the container or inserting a pump into the container.

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, face, eyes, hands, body, and feet.

While inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

5.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 3.1, these recommendations also assume that no other hazardous materials requiring additional PPE will be encountered by the emergency responders.

Based on the experience of its members, the Chlorine Institute has developed the following recommendations as initial selection criteria for personal protective equipment for responders to a sodium or potassium hydroxide release. The recommendations are based in part on the assumption that responders to a severe release involving spraying sodium or potassium hydroxide may encounter a concentration at or above that designated by the National Institute for Occupational Safety and Health as immediately dangerous to life or health (the IDLH is 10 mg/m^3 as sodium hydroxide).

Recommendations:

- Chemical protection for the head, neck, face, eyes, hands, body, and feet.

Respiratory protection recommendations are as follows:

In severe cases with spraying sodium or potassium hydroxide in a major leak,

- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

In less severe cases such as a leaking valve or pipeline with no appreciable spraying and/or splashing product,

- No respiratory protection is needed.

This recommendation is based on the assumption that unless otherwise determined by the Incident Commander that the responders to such a sodium or potassium hydroxide release will not be exposed to concentrations in excess of 2 mg/m³ in any 15-minute period.

5.6 SUMMARY OF RECOMMENDATIONS

Tables 5.1 and 5.2 summarize the recommendations contained in this section. Table 5.1 also includes specific examples of PPE that provide protection for specific body parts.

Table 5.1 - Summary of PPE Recommendations for Tasks Involving Potential Exposure to 10 - 50 % Sodium or Potassium Hydroxide Below 120°F (49°C)

	Chemical Protective Hat or Hood	Face Shield and Chemical Splash Goggles	Chemical Splash Goggles (without face shield)	Chemical Protective Suit	Chemical Protective Gloves	Chemical Protective Boots or Overshoes	Respiratory Protection
Initial line break *	R	R		R	R	R	N/A
Material sampling	N/A	R		N/A	R	N/A	N/A
Loading - remotely activated	R	R		N/A	R	N/A	N/A
Loading - not remotely activated	R	R		R	R	R	N/A
Unloading	R	R		R	R	R	N/A
Loading/ Unloading - only when inspecting dome with no product flowing	N/A	N/A	R	N/A	N/A	N/A	N/A
Emergency Response* Severe cases – spraying	R	R		R	R	R	SCBA
All others	R	R		R	R	R	N/A

R - Recommended PPE for this task

N/A - This PPE is not believed necessary for this task

SCBA - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision)

* Chemical protection of the neck (e.g., hood) is also recommended for initial line break and emergency response.

Note: When chemical protective equipment is worn to protect the feet and body, and the garment has pant legs but does not have integral foot protection, the legs of the protective garment must be placed on the outside of the protective footwear.

Table 5.2 - Recommended Criteria to Evaluate PPE Components for Tasks Involving 10 - 50% Sodium Or Potassium Hydroxide	
PPE Component	**Recommended Test**
Base Material, Seam, Visor, Gloves, Boots, Overshoes*	V or II performed at 120°F or applicable temperature
Ensemble System	III

II ASTM F739-12e1 (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

V ASTM F903-10 (chemical resistance – penetration; no penetration in 60 minutes)

Table 3.1 and Reference 12.5 provide a further explanation of these tests.

* The appropriate shoe consistent with the facility's foot protection policy should be worn.

6. PERSONAL PROTECTIVE EQUIPMENT SELECTION - SODIUM HYPOCHLORITE (3 - 20 WT %)

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

This section covers the recommended PPE for performing the specified tasks involving sodium hypochlorite at concentrations between 3 - 20% at temperatures below 100°F (38°C). Typically, sodium hypochlorite must be maintained below 100°F (38°C) to minimize decomposition. Materials for PPE should be chemically resistant against 3-20% sodium hypochlorite at 100°F (38°C) or the applicable temperature.

6.1 INITIAL LINE BREAK

Recommendation:

Chemical protection for the head, face, eyes, hands, body, and feet.

6.2 MATERIAL SAMPLING

Recommendation:

Chemical protection for the face, eyes, and the hands.

6.3 LOADING

In addition to the assumptions discussed in Section 4.1, the PPE recommendations listed next assume the actual loading operation can be started and stopped while the worker is remote from the loading connection (i.e. the point that sodium hypochlorite leaves the loading line and enters the loading container).

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, face, eyes, and hands.

In the absence of such remotely operated equipment, the facility should follow the recommendations listed immediately below.

- Chemical protection for the head, face, eyes, hands, body, and feet.

While inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

6.4 UNLOADING

Unloading a container of sodium hypochlorite is deemed to be potentially more hazardous than the loading of such a container that is initiated by remote operations. Unloading such a container typically involves either pressurizing the container or installing connections at a valve located on the bottom of the container or inserting a pump into the container.

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, face, eyes, hands, body, and feet.

While inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

6.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 3.1, these recommendations also assume that no other hazardous materials requiring additional PPE would be encountered by the responders.

Responders should be aware that sodium hypochlorite will react with acidic and other incompatible materials (e.g. ammonia, organics) resulting in the release of chlorine or other hazardous chemicals or a fire.

Recommendations:

- Chemical protection for the head, neck, face, eyes, hands, body, and feet.

Respiratory protection recommendations are as follows:

In severe cases with spraying sodium hypochlorite in a major leak,

- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

In less severe cases such as a leaking valve or pipeline with no appreciable spraying and/or splashing product,

- No respiratory protection is needed.

This recommendation is based on the assumption that unless otherwise determined by the Incident Commander that the responders to a sodium hypochlorite release will not be exposed to concentrations of fumes or material in excess of 2 mg/m^3 in any 15-minute period.

6.6 SUMMARY OF RECOMMENDATIONS

Tables 6.1 and 6.2 summarize the recommendations contained in this section. Table 6.1 also includes specific examples of PPE that provide protection for specific body parts.

Table 6.1 - Summary of PPE Recommendations for Tasks Involving Potential Exposure To 3 - 20% Sodium Hypochlorite Below 100°F (38°C)

	Chemical Protective Hat or Hood	Face Shield & Chemical Splash Goggles	Chemical Splash Goggles (without face shield)	Chemical Protective Suit	Chemical Protective Gloves	Chemical Protective Boots or Overshoes	Respiratory Protection**
Initial line break	R	R		R	R	R	N/A
Material sampling	N/A	R		N/A	R	N/A	N/A
Loading - remotely activated	R	R		N/A	R	N/A	N/A
Loading - not remotely activated	R	R		R	R	R	N/A
Unloading	R	R		R	R	R	N/A
Table 6.1 (Continued)	**Chemical Protective Hat or Hood**	**Face Shield & Chemical Splash Goggles**	**Chemical Splash Goggles (without face shield)**	**Chemical Protective Suit**	**Chemical Protective Gloves**	**Chemical Protective Boots or Overshoes**	**Respiratory Protection****
Loading/ Unloading - only when inspecting dome with no product flowing	N/A	N/A	R	N/A	N/A	N/A	N/A

Emergency Response* (Severe cases – spraying)	R	R		R	R	R	SCBA
All Others	R	R		R	R	R	N/A

R - Recommended PPE for this task

N/A - This PPE is not believed necessary for this task

SCBA - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision)

* Chemical protection of the neck (e.g., hood) is also recommended for emergency response.

**Respiratory equipment may be needed in situations where there is a risk of sodium hypochlorite mixing with acidic or other incompatible materials resulting in the release of chlorine gas.

Note: When chemical protective equipment is worn to protect the feet and body, and the garment has pant legs but does not have integral foot protection, the legs of the protective garment must be placed on the outside of the protective footwear.

Table 6.2 - Recommended Criteria To Evaluate PPE Components For Tasks Involving 3 - 20% Sodium Hypochlorite

PPE Component	Recommended Test
Base Material, Seam, Visor, Gloves, Boots, Overshoes*	V or II performed at applicable temperature
Ensemble System	III

II ASTM F739-12e1 (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

V ASTM F903-10 (chemical resistance – penetration; no penetration in 60 minutes)

Table 3.1 and Reference 12.5 provide a further explanation of these tests.

* The appropriate shoe consistent with the facility's foot protection policy should be worn.

7. PERSONAL PROTECTIVE EQUIPMENT SELECTION - HYDROCHLORIC ACID (7 - 37 WT %)

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

This section covers the recommended PPE for performing the specified tasks involving hydrochloric acid at concentration between 7 - 37% and below 120^{o}F (49°C). Materials

for PPE should be chemical resistant against 7 - 37% hydrochloric acid at 120°F (49°C) or the applicable temperature.

7.1 INITIAL LINE BREAK

If the specific initial line break currently being performed has been performed periodically in the past and it has been demonstrated that the evacuation techniques and the maintenance procedures utilized will result in hydrogen chloride concentrations no more than the capacity of the respirator,

Recommendations:

- Full face air purifying respirator approved for protection against hydrogen chloride.
- Chemical protection for the head, face, eyes, hands, body, and feet.

If the above criteria have not been met,

- SCBA or full face air supply respirator with escape bottle.
- Chemical protection for the head, face, eyes, hands, body, and feet.

7.2 MATERIAL SAMPLING

As stated in Section 3.1, these recommendations are made for the sampling in the absence of site engineered sampling station.

If the specific sampling has been periodically undertaken in the past, and industrial hygiene sampling results indicate that the techniques being utilized will result in hydrogen chloride concentrations no more than the ceiling level of 5 ppm,

Recommendations:

- Chemical protection for the face, eyes, and hands.

If the specific sampling task has been periodically undertaken in the past and industrial hygiene sampling results demonstrated that the techniques being utilized may result in hydrogen chloride concentrations more than the ceiling level of 5 ppm, but no more than the capability of the respirator,

- Full face air purifying respirator approved for protection against hydrogen chloride.
- Chemical protection for the face, eyes, and hands. (A full face respirator provides protection for the face and eyes.)

If the above criteria have not been met,

- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).
- Chemical protection for the face, eyes, and hands. (A SCBA or full face respirator provides protection for the face and eyes.)

7.3 LOADING/UNLOADING

In addition to the assumptions discussed in Section 3.1, the next two recommendations assume the facility has a system to allow for the purging and evacuation of the pipeline/hoses used for loading and unloading.

If the loading/unloading task has been periodically undertaken in the past, and industrial hygiene sampling results indicate that the techniques being utilized will result in hydrogen chloride concentrations no more than the ceiling level of 5 ppm,

Recommendations:

- Chemical protection for the head, face, eyes, hands, body, and feet.

If the loading/unloading task has been periodically undertaken in the past, and industrial hygiene sampling results indicate that the techniques being utilized will result in hydrogen chloride concentrations more than the ceiling level of 5 ppm, but no more than the capability of the respirator,

- Full face air purifying respirator approved for protection against hydrogen chloride
- Chemical protection for the head, face, eyes, hands, body, and feet. (A full face respirator provides protection for the face and eyes.)

If the above criteria have not been met,

- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).
- Chemical protection for the head, face, eyes, hands, body, and feet (A SCBA or full face respirator provides protection for the face and eyes.)

7.4 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 3.1, these recommendations assume that no other hazardous materials requiring additional PPE will be encountered by the responders.

Emergency responders to a hydrochloric acid release can be potentially exposed to the acid, which is capable of causing chemical burns. In addition, responders to releases of hydrochloric acid can be exposed to hydrogen chloride vapors above levels of 5 ppm. Unless deemed unnecessary by the overall Incident Commander, the Institute recommends that, initially, emergency responders adhere to the guidelines for an Enhanced Level B protection.

7.5 SUMMARY OF RECOMMENDATIONS

Tables 7.1a, 7.1b, and 7.2 summarize the recommendations contained in this section. Tables 7.1a and 7.1b also include specific examples of PPE that provide protection for specific body parts.

The Institute recognizes that a purchaser of Enhanced Level B PPE may opt to specify Level A PPE in order to reduce the different types of PPE held in inventory or to simplify the PPE selection process.

Table 7.1a - Summary of PPE Recommendations for Tasks Involving Potential Exposure to 7 - 37% Hydrochloric Acid Below 120°F (49°C)

See Table 7.1b for Respiratory Protection Recommendations

	Chemical Protective Hat or Hood	Face Shield & Chemical Splash Goggles	Chemical Protective Suit	Chemical Protective Gloves	Chemical Protective Boots or Overshoes
Initial line break	R	R	R	R	R
Material sampling	N/A	R	N/A	R	N/A
Loading/Unloading	R	R	R	R	R
Emergency Response*	R	R	R	R	R

R - Recommended PPE for this task

N/A - This PPE is not believed necessary for this task

* Chemical protection of the neck (e.g., hood) is also recommended for emergency response.

Note: When chemical protective equipment is worn to protect the feet and body, and the garment has pant legs but does not have integral foot protection, the legs of the protective garment must be placed on the outside of the protective footwear.

Table 7.1b – Summary of Respiratory Protection Recommendations for Tasks Involving Potential Exposure to 7 – 37% Hydrochloric Acid Below 120°F (49°C)

	Task Previously Sampled		Task Not Previously Sampled or Sampled and Above Respirator Limits
	Results # 5.0 ppm	Results > 5 ppm But Within Respirator Limits	
Initial line break	FFR	FFR	SCBA
Material Sampling	N/A	FFR	SCBA
Loading/Unloading	N/A	FFR	SCBA
Emergency Response	Enhanced Level B		

FFR	- Full face respirator approved for protection against hydrogen chloride
SCBA	- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision)
N/A	- This PPE is not believed necessary for this task

Note: When chemical protective equipment is worn to protect the feet and body, and the garment has pant legs but does not have integral foot protection, the legs of the protective garment must be placed on the outside of the protective footwear.

Table 7.2 - Recommended Criteria to Evaluate PPE Components for Tasks Involving 7 - 37% Hydrochloric Acid

PPE Component	Recommended Test
Base Material, Seam, Visor, Gloves, Boots, Overshoes	V or II performed at 120°F (49°C) or applicable temperature
Ensemble System	III

II	ASTM F739-12e1 (chemical resistance - permeation, no breakthrough in 60 minutes)
III	ASTM F1359/F1359M-13 (shower test)
V	ASTM F903-10 (chemical resistance - penetration; no penetration in 60 minutes)

Table 3.1 and Reference 12.5 provide further explanation of these tests.

Note: The appropriate shoe consistent with the facility's foot protection policy should be worn.

8. PERSONAL PROTECTIVE EQUIPMENT SELECTION - SULFURIC ACID (38 - 98 WT %)

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

This section covers the recommended PPE for performing the specified tasks involving sulfuric acid at concentrations between 38 - 98% and below 120°F (49°C). Materials for PPE should be chemically resistant against 38 - 98% sulfuric acid.

Exposure to mists may cause irritation of the nose and throat with sneezing, sore throat or runny nose, and non-specific effects such as headache, nausea, and weakness. Overexposure may cause irritation of the nose, throat, and lungs with cough, difficulty

breathing or shortness of breath or pulmonary edema. Symptoms may be delayed. The ACGIH, the IARC and the NTP list exposure to sulfuric acid mists as a suspected human carcinogen.

If in any of the activities below are believed to generate “sulfuric acid mist”, or if it is uncertain, respiratory protection must be utilized.

In most chlor-alkali manufacturing facilities, sulfuric acid is used to dry chlorine gas. Sulfuric acid that has been in contact with chlorine may evolve chlorine. Appropriate respiratory precautions should be taken.

8.1 INITIAL LINE BREAK

Recommendation:

Chemical protection for the head, neck, eyes, face, hands, body, and feet.

8.2 MATERIAL SAMPLING

As stated in Section 3.1, these recommendations are made for sampling in the absence of site engineered sampling stations.

Recommendation:

Chemical protection for the face, eyes, hands, and upper body.

8.3 LOADING

In addition to the assumption discussed in Section 3.1, the PPE recommendations listed below assume the actual loading operation can be started and stopped while the worker is remote from the loading connection (i.e. the point that sulfuric acid leaves the loading line and enters the loading container).

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, face, eyes, and hands.

In the absence of such remotely operated equipment, the facility should follow the recommendations listed immediately below.

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, neck, face, eyes, hands, body, and feet.

Only while inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

8.4 UNLOADING

Unloading of a container containing sulfuric acid is deemed to be potentially more hazardous than the loading of such a container that is initiated by remote operations. Unloading a sulfuric acid container typically involves pressurizing the container.

Recommendations:

Except while inspecting an open dome when no product is flowing,

- Chemical protection for the head, neck, eyes, face, hands, body, and feet.

Only while inspecting an open dome when no product is flowing,

- Chemical protection for the eyes.

8.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 3.1, these recommendations assume that no other hazardous materials requiring additional PPE will be encountered by the responders.

Recommendations:

- Chemical protection for the head, neck, face, eyes, hands, body, and feet.

Respiratory protection recommendations are as follows:

In cases with spraying sulfuric acid in a leak,

- SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

Responders to cases with spraying sulfuric acid should be at a minimum equipped with Enhanced Level B protection.

In less severe cases such as a leaking valve or pipeline with no appreciable spraying and/or splashing product:

- No respiratory protection is needed.

8.6 SUMMARY OF RECOMMENDATIONS

Tables 8.1 and 8.2 summarize the recommendations contained in this section. Table 8.1 also includes specific examples of PPE that provide protection for specific body parts.

The Institute recognizes that a purchaser of Enhanced Level B PPE may opt to specify Level A PPE in order to reduce the different types of PPE held in inventory or to simplify the PPE selection process.

Table 8.1 - Summary of PPE Recommendations for Tasks Involving Potential Exposure To 38 - 98% Sulfuric Acid

	Chemical Protective Hood	Face Shield & Chemical Splash Goggles	Chemical Splash Goggles (without face shield)	Chemical Protective Suit	Chemical Protective Gloves	Chemical Protective Boots or Overshoes	Respiratory Protection
Initial line break	R	R		R	R	R	N/A
Material sampling	N/A	R		R*	R	N/A	N/A
Loading - remotely activated	R**	R		N/A	R	N/A	N/A
Loading - not remotely activated	R	R		R	R	R	N/A
Unloading	R	R		R	R	R	N/A
Loading/Unloading - only when inspecting dome with no product flowing	N/A	N/A	R	N/A	N/A	N/A	N/A
Emergency Response Spraying	At Minimum, Enhanced Level B						
Emergency Response All other	R	R		R	R	R	N/A

R - Recommended PPE for this task

R* - Recommended protection for the upper body only (e.g., apron)

R** - Chemical Protective hat or hood (neck protection is not believed necessary)

N/A - This PPE is not believed necessary for this task

Note: When chemical protective equipment is worn to protect the feet and body, and the garment has pant legs but does not have integral foot protection, the legs of the protective garment must be placed on the outside of the protective footwear.

Table 8.2 - Recommended Criteria To Evaluate PPE Components For Tasks Involving 38 - 98% Sulfuric Acid	
PPE Component	**Recommended Test**
Base Material, Seam, Visor, Gloves, Boots, Overshoes	V or II performed at 120°F (49°C) or applicable temperature
Ensemble System	III

II ASTM F739-12e1 (chemical resistance - permeation, no break through in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

V ASTM F903-10 (chemical resistance - penetration; no penetration in 60 minutes)

Table 3.1 and Reference 12.5 provide further explanation of these tests.

Note: The appropriate shoe consistent with the facility's foot protection policy should be worn.

9. PERSONAL PROTECTIVE EQUIPMENT SELECTION - ANHYDROUS HYDROGEN CHLORIDE (AHCL)

As stated in Section 3.1, the recommendations in this pamphlet assume that the facility has not performed a detailed hazard analysis of the specific task being performed. If such a detailed hazard analysis of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the individual(s) performing the work, such different levels of PPE are compatible with the purposes and intent of these recommendations.

This section covers the recommended PPE for performing the specified tasks involving anhydrous hydrogen chloride at temperatures below 120°F (49°C). Materials for PPE should be chemical resistant against gaseous anhydrous hydrogen chloride at 120°F (49°C) or the applicable temperature. Special precautions should be taken for liquid AHCl since temperatures can reach 121°F (49.4°C) (see Section 9.4).

9.1 INITIAL LINE BREAK

If the specific initial line break currently being performed has been performed periodically in the past and it has been demonstrated that the evacuation techniques and the maintenance procedures utilized will result in anhydrous hydrogen chloride concentrations no more than the capability of the respirator,

Recommendations:

AHCl Gas - Full face air purifying respirator approved for protection against hydrogen chloride.

AHCl Liquid - Full face purifying respirator approved for protection against hydrogen chloride. Gloves for thermal (cold) protection.

If the above criteria have not been met,

AHCl Gas - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

AHCl Liquid - Enhanced Level B.

9.2 MATERIAL SAMPLING

If the specific sampling has been periodically undertaken in the past and industrial hygiene sampling results demonstrated that the techniques being utilized may result in hydrogen chloride concentrations no more than the capability of the respirator,

Recommendations:

AHCl Gas - Full face air purifying respirator approved for protection against hydrogen chloride.

AHCl Liquid - Full face air purifying respirator approved for protection against hydrogen chloride. Gloves for thermal (cold) protection.

If the above criteria have not been met,

AHCl Gas - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

AHCl Liquid - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision). Gloves for thermal (cold) protection.

9.3 LOADING/UNLOADING

Most shipping containers contain both liquid and gaseous anhydrous hydrogen chloride. If such is the situation, the recommendation for liquid anhydrous hydrogen chloride should be followed.

In addition to the assumptions discussed in Section 3.1, the next two recommendations assume the facility has a system to allow for the purging and evacuation of the pipeline/hoses used for loading and unloading.

If the loading/unloading task being done has been periodically undertaken in the past and industrial hygiene sampling results demonstrated that the techniques being utilized may result in hydrogen chloride concentrations no more than the capability of the respirator,

Recommendations:

AHCl Gas - Full face respirator approved for protection against hydrogen chloride.

AHCl Liquid - Full face respirator approved for protection against hydrogen chloride. Gloves for thermal (cold) protection.

If the above criteria have not been met,

AHCl Gas - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision).

AHCl Liquid - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision). Gloves for thermal (cold) protection.

9.4 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 3.1, these recommendations assume that no other hazardous materials requiring additional PPE will be encountered by the emergency responders.

Prior to an individual reentering a gaseous anhydrous hydrogen chloride release area after the refilling of any self-contained breathing equipment tank, the individual should be interviewed by a knowledgeable person to verify that skin irritation has not occurred.

Through their collective experience the members of the Institute have determined that Enhanced Level B, as defined by the Institute in Section 3.5, provides appropriate protection to emergency responders for gaseous and liquid anhydrous hydrogen chloride releases. Caution must be taken anytime emergency responders are in the vicinity of liquid anhydrous hydrogen chloride due to its low temperature (boiling point of -85^{o}C (-121°F) at atmospheric pressure).

If the Enhanced Level B suit is not certified for low temperature use, embrittlement of the suit material may occur, which can result in a breach of the protective suit.

Prior to an individual reentering a gaseous anhydrous hydrogen chloride release area after the refilling of any self-contained breathing equipment tank, the individual should be interviewed by a knowledgeable person to verify that skin irritation has not occurred.

Recommendations:

AHCl Gas - Enhanced Level B.

AHCl Liquid - Enhanced Level B.

9.5 SUMMARY OF RECOMMENDATIONS

Tables 9.1 and 9.2 summarize the recommendations contained in this section. Table 9.1 also includes specific examples of PPE that provide protection for specific body parts.

Table 9.1 - Summary of PPE Recommendations for Tasks Involving Potential Exposure to Anhydrous Hydrogen Chloride

	Task Previously Sampled and Within Respiratory Limitations	Task Not Previously Sampled or Sampled and Above Respirator Limitations	
		Gas	Liquid
Initial line break	FFR, G*	SCBA	Enhanced Level B
Material Sampling	FFR, G*	SCBA	SCBA, G*
Loading/Unloading	FFR, G*	SCBA	SCBA, G*
Emergency Response	Enhanced Level B		

FFR - Full face air purifying respirator approved for protection against hydrogen chloride

G* - Gloves for thermal (cold) protection - Recommendation is for liquid only

SCBA - SCBA or full face air supply respirator with an auxiliary self-contained air supply (escape air provision)

Table 9.2 - Recommended Criteria to Evaluate Selected PPE Components For Tasks Involving Liquid Or Gaseous Anhydrous Hydrogen Chloride (AHCl)

PPE Component	Multi-piece Enhanced Level B AHCl Liquid**	Hood for Multi-piece Enhanced Level B AHCl Liquid**	One Piece Enhanced Level B AHCl Liquid	Level A AHCl Liquid	Level B AHCl Gas
Base Material for Suit and Booties	I and V or I and II	I and V or I and II	I and V or I and II	I and V or I and II	V or II
Visor	Not Applicable	I and V or I and II	Not Applicable	I and V or I and II	Not Applicable
Gloves System	I and V or I and II	Not Applicable	I and V or I and II	I and V or I and II	V or II
Boots	*	Not Applicable	*	Not Applicable	*
Seams/Tape	V or II	Not Applicable	V or II	V or II	V or II
Ensemble System	III	Not Applicable	III	IV	Not Applicable

I ASTM D2136-02 modified to -30^{o}F (low temperature flex test)

II ASTM F739-12e1 (chemical resistance - permeation, no breakthrough in 60 minutes)

III ASTM F1359/F1359M-13 (shower test)

IV ASTM F1052-14 (pressure test)

V ASTM F903-10 (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 12.5 provide a further explanation of these tests.

***** Level B boots should be resistant to chlorine and consistent with the facility's foot protection policy.

** Hood must be used with multi-piece Enhanced Level B.

10. MAINTENANCE OF PERSONAL PROTECTIVE EQUIPMENT

10.1 MAINTENANCE OF PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment is effective only if it is properly maintained. An effective maintenance program consists of proper decontamination, inspection, repair and storage. **Furthermore PPE protocol should be followed for reuse and or replacement of any PPE used.**

10.2 DECONTAMINATION

Decontamination is defined as the task undertaken to remove, neutralize, or detoxify hazardous materials which contaminate personal protective equipment.

Personal protective equipment should be decontaminated for several reasons, including to:

- Allow the safe removal of the PPE;
- Permit the safe reuse of previously contaminated PPE (permeation and/or deterioration of PPE should be positively identified if PPE is chosen to be re-used);
- Provide for safe assistance to the wearer (changing air cylinders, etc.) (concentrated chlorine vapors can corrode metallic surfaces on SCBA framework and cylinder nozzles); and
- Allow emergency removal of PPE in the event the wearer requires medical attention.

The interactions among the contaminant and the PPE ensemble determine the efficiency of decontamination and the methods which may be selected. The most commonly used material for decontamination is water. Water is by far the most readily available of all possible solvents, it generates no toxic fumes or contamination of its own, and it has minimal effect on the physical properties of most protective clothing materials. Appropriate precautions should be taken to ensure that any wash water discharges have no adverse environmental consequences.

There are many commercially available decontamination products. Check with the equipment manufacturer to assure that a proper decontamination product is chosen.

10.3 INSPECTION

An effective PPE inspection will feature the following elements:

- Inspection, operational testing, and recordkeeping of equipment received from the factory or distributor;
- Inspection of equipment as it is issued to workers;
- Inspection after use or training; and

- Periodic inspection of stored equipment.

Detailed inspection procedures, where appropriate, are usually available from the manufacturer. Inspection procedures should be documented and a record retention policy should be established in accordance with company policy and applicable regulations. Appendix A provides a sample PPE inspection checklist guide.

10.4 REPAIR

Repair of the PPE should be performed according to the manufacturer's recommendations prior to storage.

10.5 STORAGE

PPE should be stored according to the manufacturer's recommendations to prevent damage or malfunction due to exposure to elements such as dust, moisture, sunlight, damaging chemicals, and extreme temperatures. Procedures should be specified for both pre-issuance warehousing and, more importantly, post-issuance storage.

The following are general recommendations for storage of PPE:

- Potentially contaminated clothing should be isolated from street clothing until it has been decontaminated.
- Different types and materials of clothing and gloves should be identified and stored separately to prevent issuing the wrong materials of construction.
- Protective clothing should be folded or hung in accordance with manufacturer's recommendations.

10.6 DISPOSAL

Personal protective equipment that cannot be repaired to a condition suitable for use should be made unusable to prevent unauthorized reuse and disposed of in accordance with the manufacturer's recommendations.

11. TRAINING IN THE USE OF PERSONAL PROTECTIVE EQUIPMENT

11.1 OPERATIONS AND MAINTENANCE

The OSHA Hazard Communication Standard (*12.6.7*) requires that all workers be provided information and training on hazardous chemicals in their work areas. Training should include measures workers can take to protect themselves such as specific procedures the employer has implemented to protect workers from exposure to hazardous chemicals (e.g., appropriate work practices, emergency procedures, and PPE to be used). The users of PPE should be instructed and trained in the proper selection, use, limitations, care and maintenance of the PPE they are expected to use. Respirator training should be done in accordance with the OSHA Respiratory Protection Standard (*12.6.4*) and persons who may require them should be trained in their use.

11.2 EMERGENCY RESPONSE

The Chlorine Institute recommends that all producers and users of chlorine have a written emergency response plan (ERP) (*12.3.1*). More information on how to construct an emergency response plan can be found in Pamphlet 64 (*12.1*). PPE to be used in the event of an Emergency Response should be stored in an area unlikely to become contaminated in such a release scenario so that emergency response personnel are able to access and don the PPE in a non-contaminated environment.

Emergency response training (including PPE) should be based on the duties and functions performed by each responder of an emergency response organization, and should follow the OSHA requirements found in 29 CFR 1910.120 (*12.6.3*).

12. REFERENCES

12.1 INSTITUTE PUBLICATIONS

The following publications are specifically referenced in CI Pamphlet 65. The latest editions of CI publications may be obtained at http://www.chlorineinstitute.org.

Pamphlet #	Title
63	*First Aid, Medical Management / Surveillance and Occupational Hygiene Monitoring Practices for Chlorine*, ed. 8; Pamphlet 63; The Chlorine Institute: Arlington, VA, **2011**.
64	*Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities*, ed. 7; Pamphlet 64; The Chlorine Institute: Arlington, VA, **2014**.
137	*Guidelines: Asbestos Handling for the Chlor-Alkali Industry*, ed. 6; Pamphlet 137; The Chlorine Institute: Arlington, VA, **2011**.
139	*Electrical Safety in Chlor-Alkali Cell Facilities*, ed. 5; Pamphlet 139; The Chlorine Institute: Arlington, VA, **2012**.
155	*Water and Wastewater Operators Chlorine Handbook*, ed. 3; Pamphlet 155; The Chlorine Institute: Arlington, VA, **2014**

12.2 ACGIH PUBLICATIONS

12.2.1 Annual Reports of the Committees on TLVs and BEIs for Year 2014, Publication #0108A, ACGIH: Cincinnati, OH, 2014.

12.3 AIHA PUBLICATIONS

12.3.1 American Industrial Hygiene Association Industrial Hygienists' Roles and Responsibilities in Emergency Preparedness and Response, 2013 Edition, AIHA: Fairfax, VA.

12.4 ANSI PUBLICATIONS

12.4.1 ANSI/ASSE Z87.1-2003, Occupational and Educational Personal Eye and Face Protection Devices, ANSI: Washington, DC, 2003.

12.5 ASTM PUBLICATIONS

12.5.1 ASTM D2136-02 Standard Test Method for Coated Fabrics - Low Temperature Bend Test, ASTM: West Conshohocken, PA, 2012.

12.5.2 ASTM F739-12el, Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases Under Conditions of Continuous Contact, ASTM: West Conshohocken, PA, 2012.

12.5.3 ASTM F1359 / F1359M-13, Standard Practice for Liquid Penetration Resistance of Protective Clothing or Protective Ensembles Under a Shower Spring While on a Mannequin, ASTM: West Conshohocken, PA, 2013.

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12.5.5 ASTM F903-10, Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Liquids, ASTM: West Conshohocken, PA, 2010.

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12.6.1 29 CFR 1910.95 – Occupation Noise Exposure, OSHA: Washington, DC.

12.6.2 29 CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals, OSHA: Washington, DC.

12.6.3 29 CFR 1910.120 – Hazardous Waste Operations and Emergency Response, OSHA: Washington, DC.

12.6.4 29 CFR 1910.132-.138 – Personal Protective Equipment, OSHA: Washington, DC.

12.6.5 29 CFR 1910.156 – Fire Brigades, OSHA: Washington, DC.

12.6.6 29 CFR 1910.1000 - .1052 – Air Contaminants, OSHA: Washington, DC.

12.6.7 29 CFR 1910.1200 – Hazard Communication, OSHA: Washington, DC.

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12.7 CGA PUBLICATIONS

12.7.1 Pamphlet G-7, Compressed Air for Human Respiration, Edition 7, CGA: Chantilly, VA, 2014.

12.7.2 Pamphlet G-7.1, Commodity Specification for Air, Edition 6, CGA: Chantilly, VA, 2013.

12.8 LAWRENCE LIVERMORE LABORATORY PUBLICATIONS

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12.9.1 NFPA 1991 Standard on Vapor-Protective Ensembles for Hazardous Chemical Emergencies, NFPA: Quincy, MA, 2005 Edition.

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12.10 NIOSH PUBLICATIONS

12.10.1 Publication No 2002-144, NIOSH Certified Equipment List, NIOSH: Cincinnati, OH, March 2002.

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12.10.3 Publication 2005-149, NIOSH Pocket Guide to Chemical Hazards, NIOSH: Cincinnati, OH, September 2007.

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12.11.1 Patty's Toxicology, Volume 3, Metals and Metal Compounds/Compounds of Inorganic Nitrogen, Carbon, Oxygen and Halogens, 6th Edition, John Wiley and Sons, Inc., 2012.

12.11.2 The Common Sense Approach to Hazardous Materials, 2nd Edition, Frank L. Fire, October 1996.

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APPENDIX A - SAMPLE PPE INSPECTION CHECKLIST GUIDE

A PPE inspection checklist should cover the following items:

GENERAL INFORMATION

- Date of inspection
- Name of inspector
- Actual findings
- Comments

CHEMICAL PROTECTIVE GARMENT (e.g., suit, jacket, pants, apron)

Before each use:

- Level A suits should be tested per manufacturer testing recommendations
- Determine that the clothing material is correct for the specified task at hand
- Visually inspect for:
    - defective seams and closures
    - non-uniform coatings
    - tears and holes
    - discoloration
    - swelling
    - stiffness
- Flex the item:
    - observe for cracks
    - observe for other signs of deterioration

During Use:

The user should be aware of and monitor the following:

- Evidence of chemical attack such as discoloration, swelling, stiffening, and softening
- Defective closure on seams
- Tears or holes

CHEMICAL PROTECTIVE BOOTS AND GLOVES

If the PPE have been used previously, inspect for signs of chemical or physical attack:

- Proper fit, adequate seal
- Cracks
- Punctures
- Signs of pliability (stiffness)
- Signs of deterioration
- Discoloration

RESPIRATORY PROTECTIVE EQUIPMENT

Section 3.3 has information on respiratory protective equipment inspection and maintenance.

EYE AND FACE PROTECTIVE EQUIPMENT

Inspect for:

- Cracks
- Fogging
- Crazing (cloudy, alligator fine lines)
- Lenses properly secured

APPENDIX B - COMMON TYPES OF RESPIRATORS

AIR SUPPLY RESPIRATORS

Air supply respirators are supplied with respirable compressed air. Sometimes these are referred to as airline respirators. The source of air is typically either large stationary compressed breathing air cylinders or compressed air from a plant air system that meets the requirements for respirable air. The Compressed Gas Association states that Quality Verification Level D is the minimum requirement for such air (*12.7.1*).

Figure B-1. Example of air supply respirator.

Air is supplied to the respirator wearer through an air hose not to exceed 300 feet in length (or less, depending upon the specific NIOSH approval (*12.6.4*)) in a continuous flow with a demand or pressure demand regulator.

Figure B-2. Example of Grade D respirable compressed air.

Continuous flow types may be equipped with either a quarter, half or full tight-fitting facepiece or a helmet, hood or suit. A vortex tube may also be used for heating or cooling if approved by NIOSH for use with the specific device. A large volume of respirable quality air is required to supply these systems.

Demand or pressure demand can only be used with tight fitting half or full facepiece. The respirators must not be used in atmospheres immediately dangerous to life or health or in oxygen deficient atmospheres unless equipped with an auxiliary escape air supply.

AIR PURIFYING RESPIRATORS

Air purifying respirators are designed to remove specific gas and vapors and/or particulates from the atmosphere. Air purifying respirators do not compensate for a lack of oxygen. A minimum of 19.5% oxygen must be present (Reference 12.6.4 (29 CFR 1910.134(d) (Table II)).

Air purifying respirators must not be worn when the contaminant concentration is above the IDLH concentration or the potential contaminant exposure concentration is greater than the product of the respiratory assigned protection factor times the permissible exposure limit for the contaminant, or the manufacturer's use limitation for the cartridge or canister. Air purifying respirators are under slight negative pressure when the wearer inhales. Therefore, any leakage will be to the inside of the face piece and can result in potential wearer exposure.

Individual exposure should be determined through appropriate industrial hygiene air sampling to assure that the protection limit of the respirator is not exceeded.

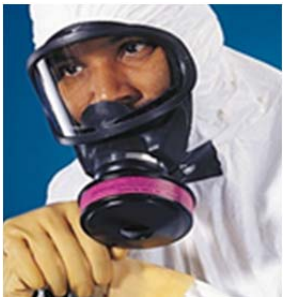

Figure B-3. Example of Air Purifying Respirator.

GAS AND VAPOR CARTRIDGES

The cartridge, canister, or filter is designed for specific types of contaminants. An acid gas cartridge will remove chlorine or hydrogen chloride, but will not remove ammonia, amines, or organic vapors. There are combinations available such as an organic vapor/acid gas cartridge which will remove many organic vapors and acid gases but not ammonia or dusts and mists. There are also combinations of vapor cartridge and dust and mist filters such as an organic vapor/dust and mist cartridge which are commonly used for spray painting. For information on which cartridges are certified for specific uses refer to the NIOSH Certified Equipment List (*12.10.1*).

The service life of a canister, cartridge, or filter is dependent on many factors such as the concentration of contaminants in the air, the user's breathing rate and the efficiency with which the filtering system removes the contaminants from the air. Humidity and temperature may also affect service life, for example high humidity may increase service life of an acid gas sorbent, but decrease service life for an organic vapor sorbent.

Figure B-4. Example of Cartridge in Air Purifying Respirator.

An increasing concentration of contaminants in the air or an increase in the breathing rate will decrease the available service life of a respirator cartridge or filter. Day-to-day changes in job operation, the level of physical work, or the level and mixture of contaminants in the air affect the service life. The recommendations provided by the manufacturer of the respirator should be followed.

The category "organic vapors" covers a wide range of materials with very different physical and chemical properties. Therefore, the absorptive capacity of cartridges also varies. As a general rule, the absorptive capacity increases as the volatility of the compound decreases (*12.8.1*).

If a canister or cartridge does not have an end-of-service-life indicator (ESLI) then a change schedule is needed based on objective information as described above (29 CFR 1910.134(d)(3)(iii) (*12.6.4*).

PARTICULATE FILTERS

Particulates are mechanically removed from the air by a fibrous filter media. The filter selected needs to be NIOSH certified under either 30 CFR part 11 (for HEPA filters), or 84 CFR part 84 (for other filters).

NIOSH has designated a matrix of filter certifications based on the filter's ability to resist oil mist, and its percent filtration of the contaminant.

POWERED AIR PURIFYING RESPIRATORS

Powered air purifying respirators filter the air by removing particulate or toxic gases and vapors from the atmosphere and delivering respirable air to the wearer by means of portable powered blower or a non-portable powered blower. Tight-fitting quarter, half, or full facepiece masks or loose fitting helmets or hoods are used with this type of respirator. Powered air respirators must not be used in oxygen deficient atmospheres.

APPENDIX C - CONTACT LENSES

Excerpt from Current Intelligence Bulletin 59 – Contact Lens Use in a Chemical Environment, published by NIOSH. The full report can be downloaded directly from http://www.cdc.gov/niosh/docs/2005-139/pdfs/2005-139.pdf

Contact Lens Use in a Chemical Environment Background

Since 1978, the National Institute for Occupational Safety and Health (NIOSH) has recommended that workers not wear contact lenses during work with chemicals that present an eye irritation or injury hazard [NIOSH 2004]. This policy was recommended by the 1978 Standards Completion Program and is based on the "best professional opinion of the committee membership based on literature data" [NIOSH 1978]. The policy was also consistent at that time with general industry practice, Occupational Safety and Health Administration (OSHA) regulations, and recommendations of professional groups such as the American Chemical Society.

Current Practice

Recently, a number of groups have issued new guidelines that remove most previous restrictions for wearing contact lenses in the industrial environment. These groups include the American Optometric Association, the American College of Occupational and Environmental Medicine, the American Academy of Ophthalmology, the American Chemical Society, and Prevent Blindness America. NIOSH has reviewed these new guidelines as well as the limited literature on the use of contact lenses in a chemical environment and the potential absorption and adsorption of chemicals by contact lenses. In addition, NIOSH has reviewed company policies on contact lens use and injuries involving contact lenses among a small number of chemical manufacturing firms. Some of these companies continue to restrict contact lens wear in their work settings, but others have relaxed their restrictions.

Experimental Studies

In general, injury data are lacking to clearly indicate that contact lens wear should be restricted during work with hazardous chemicals; however, appropriate eye protection is always necessary. Only limited research has been conducted on the hazards of wearing contact lenses when working with specific chemicals. Several laboratory studies have focused on absorption and adsorption of acids, bases, and other solvents by contact lenses [LaMotte et al. 1995; Hejkal et al. 1992; Nilsson and Andersson 1982]. In these experimental studies, various lens materials were exposed to chemicals for extended periods using either vials or animals. The results suggest that contact lens uptake and release of chemicals to eye tissue is not likely to be a significant issue for workers wearing contact lenses. However, one similar laboratory in vitro study indicates that isopropyl and ethyl alcohol may pose risks to exposed workers wearing contact lenses [Cerulli et al. 1985].

In all of these studies, researchers examined the resistance of contact lenses to chemical exposures under test conditions. They did not examine actual chemical exposures in workers and did not examine the use of appropriate eye protection simultaneously with contact lens use.

Wearing contact lenses under some circumstances provides workers with a greater choice of eye and face protection (such as goggles or full-facepiece respirators without prescription inserts) as well as better visual acuity. However, the risk is unknown for contact lens wearers

compared with nonwearers working with chemicals listed in the NIOSH Pocket Guide to Chemical Hazards [NIOSH 2004]. Currently, OSHA recommends against contact lens use when working with acrylonitrile, methylene chloride, 1, 2 dibromo-3-chloropropane, ethylene oxide, and methylene dianiline. These recommendations are presumably based on best professional judgment, as no specific basis is provided in the preambles to these standards.

Recommendations

NIOSH recommends that workers be permitted to wear contact lenses when handling hazardous chemicals provided that the safety guidelines listed here are followed and that contact lenses are not banned by regulation or contraindicated by medical or industrial hygiene recommendations. However, contact lenses are not eye protective devices, and wearing them does not reduce the requirement for eye and face protection. The following guidelines for contact lens use in a chemical environment will help occupational safety and health professionals and employers safely implement the contact lens use policy:

1. **Conduct an eye injury hazard evaluation in the workplace that includes an assessment of the following:**

    - Chemical exposures (as required by OSHA's personal protective equipment standard [29 CFR 1910.132])
    - Contact lens wear
    - Appropriate eye and face protection for contact lens wearers

    The eye injury hazard evaluation should be conducted by a competent, qualified person such as a certified industrial hygienist, a certified safety professional, or a toxicologist.

    Information from the hazard evaluation should be provided to the examining occupational health nurse or occupational medicine physician.

    The chemical exposure assessment for all workers should include, at a minimum, an evaluation of the properties of the chemicals in use—including concentration, permissible exposure limits, known eye irritant/ injury properties, form of chemical (powder, liquid, or vapor), and possible routes of exposure. The assessment for contact lens wearers should include a review of the available information about lens absorption and adsorption for the class of chemicals in use and an account of the injury experience for the employer or industry, if known.

2. **Provide suitable eye and face protection for all workers exposed to eye injury hazards, regardless of contact lens wear**.

    Wearing contact lenses does not appear to require enhanced eye and face protection. For chemical vapor, liquid, or caustic dust hazards, the minimum protection consists of well-fitting nonvented or indirectly vented goggles or full-facepiece respirators. Close-fitting safety glasses with side protection provide limited chemical protection but do not prevent chemicals from bypassing the protection. Workers should wear face shields over other eye protection when needed for additional face protection; but they should not wear face shields instead of goggles or safety glasses—regardless of contact lens wear.

3. **Establish a written policy documenting general safety requirements for wearing contact lenses, including the eye and face protection required and any contact lens wear restrictions by work location or task.**

In addition to providing the general training required by the OSHA personal protective equipment standard [29 CFR 1910.132], provide training in employer policies on contact lens use, chemical exposures that may affect contact lens wearers, and first aid for contact lens wearers with a chemical exposure.

4. **Comply with current OSHA regulations on contact lens wear and eye and face protection.**

5. **Notify workers and visitors about any defined areas where contact lenses are restricted.**

6. **Identify to supervisors all contact lens wearers working in chemical environments to ensure that the proper hazard assessment is completed and the proper eye protection and first aid equipment are available.**

7. **Train medical and first aid personnel in the removal of contact lenses and have the appropriate equipment available.**

8. **In the event of a chemical exposure, begin eye irrigation immediately and remove contact lenses as soon as practical.**

Do not delay irrigation while waiting for contact lens removal.

9. **Instruct workers who wear contact lenses to remove the lenses at the first signs of eye redness or irritation.**

Contact lenses should be removed only in a clean environment after the workers have thoroughly washed their hands. Evaluate continued lens wear with the worker and the prescribing ophthalmologist or optometrist. Encourage workers to routinely inspect their contact lenses for damage and/or replace them regularly.

10. **Evaluate restrictions on contact lens wear on a case-by-case basis.**

Take into account the visual requirements of individual workers wearing contact lenses as recommended by a qualified ophthalmologist or optometrist.

These recommendations are for work with chemical hazards. They do not address hazards from heat, radiation, or high-dust or high-particulate environments.

APPENDIX D - CHECKLIST

This checklist emphasizes major topics and is designed for someone who has already read and understood this pamphlet. Taking recommendations from this list without understanding related topics can lead to inappropriate conclusions and actions.

Place a check mark (√) in the appropriate box below:

YES	NO	N/A	ITEM	PAMPHLET SECTION
❒	❒	❒	1. Does the facility comply with the PPE recommendation for specific tasks involving gaseous or liquid chlorine?	4
❒	❒	❒	2. Does the facility comply with the PPE recommendation for specific tasks involving 10-50% sodium hydroxide?	5
❒	❒	❒	3. Does the facility comply with the PPE recommendation for specific tasks involving 10-50% potassium hydroxide?	5
❒	❒	❒	4. Does the facility comply with the PPE recommendation for specific tasks involving 3-20% sodium hypochlorite?	6
❒	❒	❒	5. Does the facility comply with the PPE recommendation for specific tasks involving 7-37% hydrochloric acid?	7
❒	❒	❒	6. Does the facility comply with the PPE recommendation for specific tasks involving 55-98% sulfuric acid?	8
❒	❒	❒	7. Does the facility comply with the PPE recommendation for specific tasks involving gaseous or liquid anhydrous hydrogen chloride?	9
❒	❒	❒	8. Does the facility have a preventive maintenance program for PPE that complies with Institute recommendations?	10
❒	❒	❒	9. Does the facility include in its Hazard Communication training, information on measures that individuals can take to protect themselves from exposure to hazardous chemicals?	11

REMINDER:

Users of this checklist should document exceptions to the recommendations contained in this pamphlet.

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