148-707 7/19/2010 1of593

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

JUL 19 2010

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

Rick Hesketh
Harcros Chemicals Inc.
P.O. Box 2930
Kansas City, KS 66110-2930

FILE COPY

Subject: Liquid Chlorine
EPA Registration No. 148-707
Submission Dated: April 7, 2010
Receipt Dated: April 20, 2010

Dear Mr. Hesketh:

The labeling for the product referred to above submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended to include the appropriate pamphlets/booklets, is acceptable with a comment/condition listed below.

Condition:

Revise the "Hazards to Humans and Domestic Animals" statement as follows:

DANGER. Fatal if inhaled or absorbed through skin. Corrosive. Causes irreversible eye damage and skin burns. Do not breathe vapors, or get in eyes, on skin or clothing. Wear goggles, protective clothing and rubber gloves. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Remove and wash contaminated clothing before reuse. Prolonged frequently repeated skin contact may causes allergic reactions in some individuals.

General Comments:

A stamped copy of the labeling accepted with a condition is enclosed. Submit one copy of your final printed labeling before distributing or selling the product bearing the revised labeling.

Should you have any questions or comments concerning this letter, please contact me at Henson.Wanda@epa.gov or call (703) 308-6345.

Sincerely,

Wanda Y. Henson
Acting Product Manager (32)
Regulatory Management Branch II
Antimicrobials Division (7510P)

FRONT PANEL

LIQUID CHLORINE

UN 1017 RQ

CHLORINE LIQUEFIED GAS UNDER PRESSURE

ACTIVE INGREDIENT: Chlorine 99.5%
OTHER INGREDIENTS 0.5%
TOTAL 100.0%

KEEP OUT OF REACH OF CHILDREN

DANGER POISON

FATAL IF INHALED.

LIQUID CHLORINE CAUSES SEVERE BURNS

EPA Reg. No. 148-707 EPA Est. No. 148-AL-004

Harcros Chemicals Inc. 5200 Speaker Road, Kansas City KS 66106 (913)321-3131

Net Contents: ☐100 Lbs. ☐150 Lbs. ☐650 Lbs. ☐1200 Lbs. ☐1300 Lbs. ☐2000 Lbs.

The DOT hazard warning labels: Inhalation Hazard (2), Corrosive (8), and Oxidizer (5.1) are on a separate tag.

LABEL SIZE
Approx.
4" x 9.25"

PRECAUTIONARY STATEMENTS

FIRST AID

IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for treatment advice.
IF ON SKIN OR CLOTHING: Take off contaminated clothing immediately. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
IF IN EYES: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first five minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
IF SWALLOWED: Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.
NOTE TO PHYSICIAN: Symptoms may become more severe up to 36 hours after exposure including pulmonary edema. Probable mucosal damage may contraindicate the use of gastric lavage.
HAVE THE PRODUCT CONTAINER OR LABEL WITH YOU WHEN CALLING A POISON CONTROL CENTER OR MEDICAL PHYSICIAN, OR GOING FOR TREATMENT.

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER: Fatal if inhaled or absorbed through the skin. Corrosive. Causes irreversible eye damage and skin burns. Do not breath vapors or get in eyes, on skin or clothing. Wear goggles, protective clothing and rubber gloves as discussed below. Wash hands thoroughly with soap and water after handling and before eating, drinking, or using tobacco. Remove contaminated clothing and wash clothing before reuse. Prolonged frequently repeated skin contact may cause allergic reactions in some individuals.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment requirements will vary depending on how chlorine is being used. Refer to Chlorine Institute Pamphlet # 65 for specific recommendations. Applicators and other handlers must wear long-sleeved shirts, long pants, shoes and socks.
IN CASE OF SPILL OR LEAKAGE: Handlers must wear chemical-resistant, waterproof, insulated gloves (such as nitrite or butyl), rubber boots and full-face respirators approved for chlorine (MSHA/NIOSH approval number prefix TC-14G) or self-contained breathing apparatus (SCBA) (MSHA/NIOSH approval number TC-13F). Since there is always the possibility of a spill or a leak, gloves and a respirator of a type specified above must be available and are required for anyone entering into an affected area in the event of a leak or spill.

PHYSICAL AND CHEMICAL HAZARDS

Chlorine is a non-flammable gas, liquefied, under pressure. Do not drop container. Do not heat container. Keep away from intense heat and open sunlight. Corrosive to most metals in the presence of moisture.

SEE BACK PANEL FOR ADDITIONAL PRECAUTIONS

DO NOT REMOVE THIS TAG

EMERGENCY: Chemtrec 1-800-424-9300

NSF
Certified to ANSI/NSF 60

Apr. 7, 2010

BACK PANEL

ENVIRONMENTAL HAZARDS

This pesticide is toxic or highly toxic to fish and aquatic invertebrates. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Before working with this product, handlers must be trained how to appropriately handle and use chlorine. Use only in well ventilated areas.
Refer to the appropriate Chlorine Institute Pamphlet for instructions on the required product use and safety procedures. **NEVER TAMPER WITH FUSIBLE PLUGS OR ATTEMPT TO ALTER OR REPAIR CYLINDERS, TON CONTAINERS, OR VALVES.** This product, including dispensing equipment, must be handled and used in accordance with the practices specified by all applicable product labeling and the appropriate Chlorine Institute Pamphlet. To contact the Chlorine Institute, call (703)741-5760 or visit its website at www.CL2.com.

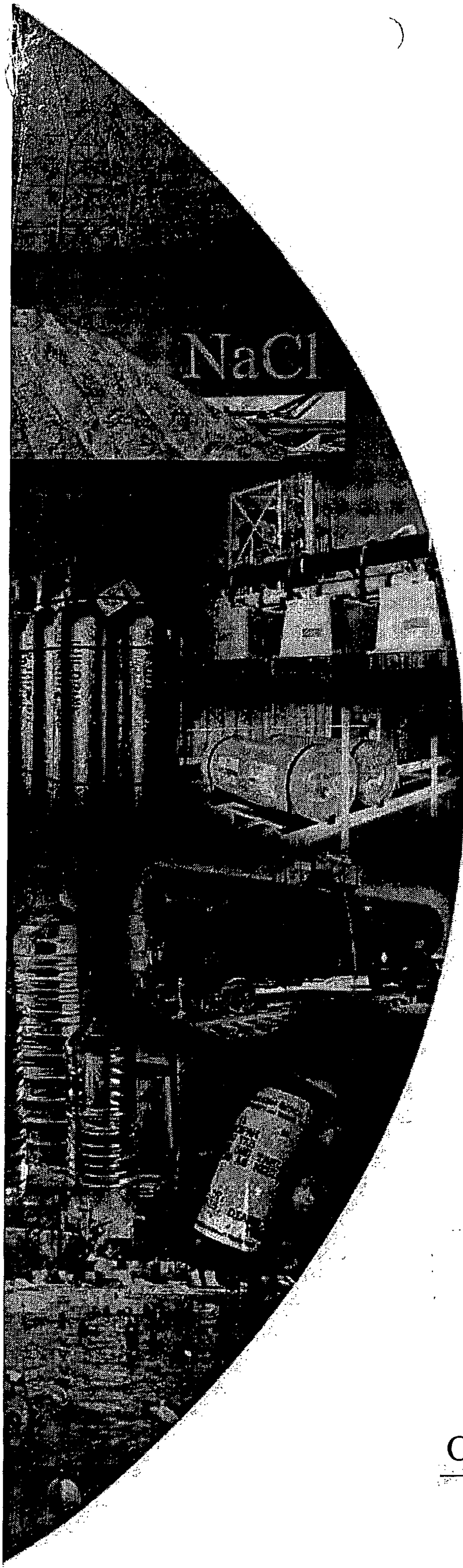
Chlorine Manual	CI Pamphlet #1
Piping Systems	CI Pamphlet #6
Chlorine Packaging Plants	CI Pamphlet #17
Cargo Tank Handling	CI Pamphlet #49
Emergency Response	CI Pamphlet #64
Personal Protective Equipment	CI Pamphlet #65
Railcar Handling	CI Pamphlet #66
Cylinders at Swimming Pools	CI Pamphlet #82
Potable Water Treatment	CI Pamphlet #155
Wastewater Treatment	CI Pamphlet #155

APPLICATIONS:
Only for formulation into an algaeicide, slimicide, disinfectant or sanitizer and for the following uses(s):
As a disinfectant in potable and wastewater treatment,
As a disinfectant and algaecide in non-residential swimming pools,
As a disinfectant and algaecide in pulp and paper process water systems, and
For cooling tower water treatment,
As a sanitizer for wash water treatment of food handling premises and equipment,
For wash water for raw agricultural commodities and certain other food commodities,
For repackaging into smaller containers, or
For manufacture of sodium hypochlorite.
The registrant is solely responsible for the safety of the servicing equipment used with this pesticide, and for the repackaging of this gas from the larger containers into portable cylinders and ton containers. Each repackager must obtain its own EPA Registration Number for this pesticide for this use, and its own EPA Establishment Number from the EPA. Repackagers may only dispense this product to portable containers that are approved for chlorine and are appropriately labeled.
NSF maximum use level: 30 mg/l.

STORAGE AND DISPOSAL

STORAGE: Store cylinders and ton containers in a dry area away from sources of heat and protected from intense sunlight. Do not store in excessive heat. Segregate chlorine containers from other compressed gases and never store near hydrocarbons, finely divided metals such as filings or granules, turpentine, ether, anhydrous ammonia, or other flammable materials. All storage containers and cylinders must have a weather resistant label and must not be accessible to the general public. Do not drop container. If container is damaged or leaking, refer to procedures in the Chlorine Manual and the appropriate Chlorine Emergency Kit Manual and/or notify supplier immediately.
LEAK PROCEDURES: Make daily inspections for leaks. Stop a leak at once, since it will become worse with time.
In case of a leak, evacuate everyone from the immediate area. For entry into the effected area to correct problem, wear personal protective equipment (including prescribed respirators) specified in the Hazards to Humans section of this labeling. When possible, move leaking or damaged cylinders outdoors or to an isolated location. Observe strict safety precautions. Work upwind, if possible. Allow any liquid chlorine to evaporate. Only correctly trained and Personal Protective Equipment (PPE)-equipped handlers are to perform such cleanup. Do not permit entry into the leak area by any other person until the chlorine has completely dispersed. It is illegal to ship a leaking chlorine container.
DISPOSAL OF CONTAINER: Refill this container with Chlorine Gas only. Do not reuse this container for any other purpose. Container is returnable and must be returned as promptly as possible to supplier according to prescribed instructions and practices in CI Pamphlet # 76 for cylinders and ton containers. All valves must be closed tight and closures or caps secured. It is illegal to ship a leaking chlorine container. Follow U.S. DOT regulations for returning empty containers, including proper installation of valve protective housing for all storage and shipments.

April 7, 2010



THE CHLORINE INSTITUTE, INC.

Pamphlet 1

Chlorine Basics

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

Edition 7

A LEGACY OF SAFETY STEWARDSHIP since 1924

October 2008

Table of Contents

1. INTRODUCTION

1.1 CHLORINE BASICS

The first Chlorine Manual was published by The Chlorine Institute in 1947. It was a comprehensive compilation of information to assist chlorine producers, packagers, and end users in the safe handling, storage, shipment, and use of chlorine. In the years since the original Chlorine Manual was published, the Institute has developed numerous documents that provide more detailed information on safe chlorine management.

With this edition of Pamphlet 1, the Chlorine Manual has been re-named Chlorine Basics. This change reflects the fact that a single document can no longer adequately communicate the detailed information required to safely handle, store, transport, and use chlorine. This pamphlet remains a valued resource, providing overview and reference information to the many other resources available from The Chlorine Institute. For more detailed information, an on-line catalog is available on the Institute's website – www.chlorineinstitute.org.

1.2 CHORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. (CI) 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 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 the CI website at www.chlorineinstitute.org.

1.3 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require changes in the recommendations contained herein. Appropriate steps should be taken to ensure that the information is current, when used. These recommendations should not be confused with federal, state, provincial, municipal regulations, insurance requirements, or with national safety codes.

1.4 APPROVAL

The Institute's Customer Stewardship Issue Team approved Edition 7 of this pamphlet on October 7, 2008.

1.5 REVISIONS

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

1.6 CHECKLISTS

Several pamphlets contain checklists to assist members and non-members in self-audits or other reviews.

Because Chlorine Basics only summarizes some of the information contained in other pamphlets, the reader should refer to specific referenced pamphlets and their checklists. These checklists are designed to emphasize major topics and highlight the key recommendations for someone who has already read and understood the pamphlets.

The Chlorine Institute encourages the use of the pamphlets and checklists.

1.7 ABBREVIATIONS AND ACRONYMS

AAR	Association of American Railroads
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	ASTM International (Formerly American Society for Testing and Materials)
AWWA	American Water Works Association
CAS	Chemical Abstracts Service
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CI	The Chlorine Institute, Inc.
CIH	Chronic Inhalation Hazard
CIIT	Chemical Industry Institute of Toxicology
DHS	Department of Homeland Security
DOL	Department of Labor
DOT	Department of Transportation
EPA	Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act

IMDG	International Maritime Dangerous Goods Code
kPa	kilopascal
MSDS	Material Safety Data Sheet
NAS	National Academy of Sciences
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NSF	National Science Foundation
OSHA	Occupational Safety and Health Administration
PMRA	Pest Management Regulatory Agency, a division of Health Canada
POV	Pneumatically Operated Valve
ppm	Parts per million
psia	Pounds per square inch, absolute pressure
psig	Pounds per square inch, gauge pressure
PSM	Process Safety Management
RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Plan
RTECS	Registry of Toxic Effects of Chemical Substances
SSP	Site Security Plan
SVA	Security Vulnerability Assessment
TC	Transport Canada
TDG	Transportation of Dangerous Goods Act and Regulations
TEMA	Tubular Exchanger Manufacturers Association, Inc.
TLV	Threshold Limit Value
WEF	Water Environment Foundation
WHMIS	Workplace Hazardous Materials Information System
WHO	World Health Organization

1.8 REFERENCES

Chlorine Institute publications referenced in this document are referred to by pamphlet number, drawing number, or by condensed name if no number exists.

At the beginning of Section 11 – "Selected References," complete information about the Institute publications is provided. Other sources are referenced in this publication in the following manner: (Reference 11.4.1). Section 11 provides information on each of these references. In most cases, an address also is provided.

A number of pamphlets are available electronically from the CI website or can be ordered as hard copies. A free publications catalog can be obtained from the CI website or by contacting the Institute Publications Department, 1300 Wilson Boulevard, Arlington, VA 22209:

Ph: 703-741-5760
Fax: 703-741-6068
Web: www.chlorineinstitute.org

2. GENERAL INFORMATION

For detailed information, refer to the following CI literature:

Pamphlet #	Title
10	North American Chlor-Alkali Industry Plants and Production Data Reports
21	Nitrogen Trichloride - A Collection of Reports and Papers
100	Dry Chlorine: Definitions and Analytical Issues
152	Safe Handling of Chlorine Containing Nitrogen Trichloride

2.1 WHAT IS CHLORINE?

Chlorine is one of 90 natural elements, the basic building blocks of our world. Since it is highly reactive, it is usually found chemically bonded to other elements, such as sodium, forming sodium chloride which is common table salt.

Chlorine plays a vital role in many key uses and applications:

- Chlorine is used to control bacteria and viruses in drinking water that can cause devastating illnesses such as cholera and typhoid. Approximately 98% of modern drinking water systems in the US use chlorine chemistry to ensure the drinking water remains safe from bacterial contamination.
- 90% of all pharmaceuticals rely on chlorine chemistry, including medicines that treat heart disease, cancer, AIDS, and many other life-threatening diseases.
- Chlorine chemistry is involved in the production of over 96% of crop protection chemicals.

- Chlorine chemistry contributes more than $46 billion to the U.S. economy each year, through sales of chlorine and other building block chemicals that are used to make thousands of essential products.

2.2 CHLORINE MANUFACTURE

Most chlorine is manufactured electrolytically by the diaphragm, membrane, or mercury cell process. In each process, a salt solution (sodium or potassium chloride) is electrolyzed by the action of direct electric current which converts chloride ions to elemental chlorine. Chlorine is also produced in a number of other ways, for example, by electrolysis of molten sodium or magnesium chloride to make elemental sodium or magnesium metal; by electrolysis of hydrochloric acid; and by non-electrolytic processes (Reference 11.18.2).

$$Salt + Water + Electricity \rightarrow Chlorine + Caustic + Hydrogen$$
$$NaCl + H_2O + e^- \rightarrow \tfrac{1}{2}Cl_2 + NaOH + \tfrac{1}{2}H_2$$

Figure 1. Basic Chlor-Alkali Chemical Reaction Equation

Chlorine production for 2006 in short tons/year is estimated to be as follows:

Table 1 Chlorine Production

Area	Million Short Tons
Globally	65
United States	13.8
Canada	1.1
Mexico	0.5

2.2.1 Diaphragm Cell Technology

Currently in North America, most chlorine production is from diaphragm cell technology. The products of this type of cell are chlorine gas, hydrogen gas, and cell liquor composed of sodium hydroxide and sodium chloride solution.

A nearly saturated sodium chloride solution (brine) enters the diaphragm cell anolyte compartment and flows through the diaphragm to the cathode section. Chloride ions are oxidized at the anode to produce chlorine gas. Hydrogen gas and hydroxide ions are produced at the cathode. Sodium ions migrate across the diaphragm from the anode compartment to the cathode side to produce cell liquor containing 10% to 12% sodium hydroxide. Some chloride ions also migrate across the diaphragm resulting in the cell liquor containing about 16% sodium chloride. The cell liquor is typically concentrated to 50% sodium hydroxide by an evaporation process. The salt recovered in the evaporation process is returned to the brine system for reuse.

2.2.2 Membrane Cell Technology

Membrane cell technology uses sheets of perfluorinated polymer ion exchange membranes to separate the anodes and cathodes within the electrolyzer. Ultra-pure brine is fed to the anode compartments, where chloride ions are oxidized to form chlorine gas. The membranes are cation selective resulting in predominantly sodium ions and water migrating across the membranes to the cathode compartments. Water is reduced to form hydrogen gas and hydroxide ions at the cathodes. In the cathode compartment, hydroxide ions and sodium ions combine to form sodium hydroxide.

Membrane electrolyzers typically produce 30% to 35% sodium hydroxide, containing less than 100 ppm of sodium chloride. The sodium hydroxide can be concentrated further, typically to 50%, using evaporators.

2.2.3 Mercury Cell Technology

Mercury Cell technology uses a stream of mercury flowing along the bottom of the electrolyzer as the cathode. The anodes are suspended parallel to the base of the cell, a few millimeters above the flowing mercury. Brine is fed into one end of the cell box and flows by gravity between the anodes and the cathode. Chlorine gas is evolved and released at the anode.

The sodium ions are deposited along the surface of the flowing mercury cathode. The alkali metal dissolves in the mercury, forming a liquid amalgam. The amalgam flows by gravity from the electrolyzer to the carbon-filled decomposer, where deionized water is added. The water chemically strips the alkali metal from the mercury, producing hydrogen and 50% sodium hydroxide. The mercury is then pumped back to the cell inlet, where the electrolysis process is repeated.

2.3 CHLORINE TRANSPORTATION

2.3.1 General

Chlorine is normally shipped as a liquefied compressed gas. The transportation of chlorine by all modes is controlled by various regulations. It is the responsibility of each person shipping or transporting chlorine to know and to comply with all applicable regulations.

2.4 OTHER REGULATORY ASPECTS

Chlorine manufacturers, packagers, and most consumers are subject to workplace regulations pertaining to chlorine.

2.4.1 United States

There are many regulations at the federal, state, and local levels that apply to chlorine manufacture, transport, and use. Agencies such as OSHA, EPA, DOT, and DHS regulate various aspects of the chlorine industry and should be consulted. Refer to Section 9 of this pamphlet for more information.

Table 2 Chlorine Classification

Country	Hazard Class	Division	Key Regulation	Other
United States	Primary: 2 Secondary: 5, 8	Primary: 2.3 Poison Gas Secondary: 5.1 Oxidizer Secondary: 8 Corrosive	Land: 49 CFR Barge: 33 CFR and 46 CFR	Poison Zone B inhalation hazard material rating. Various state and/or local regulations.
Canada	Primary: 2 Secondary: 5	Primary: 2.3 Poison Gas Secondary: 5.1 Oxidizer	Transportation of Dangerous Goods Act and Regulations (TDG)	Various provincial and/or local regulations
Mexico	Primary: 2 Secondary: 5	Primary: 2.3 Poison Gas Secondary: 5.1 Oxidizer	Regulation for Surface Transportation of Hazardous Materials and Waste	Various state and/or local regulations.
International			International Maritime Dangerous Goods Code (IMDG)	Designation for chlorine: UN1027

2.4.2 Canada

There are many regulations at the federal, provincial, and local levels that apply to chlorine manufacture, transport, and use. Agencies such as Health Canada, Environment Canada, and Transport Canada regulate various aspects of the chlorine industry and should be consulted.

2.5 TERMINOLOGY

2.5.1 Elemental Chlorine

Chlorine's symbol is Cl, its atomic number is 17, and its atomic weight is 35.453. Elemental chlorine almost always exists as a molecule with two chlorine atoms bound together as Cl_2. Its molecular weight is 70.906. The CAS registry number is 7782-50-5.

2.5.2 Liquid Chlorine

Chlorine (Cl_2) which has been cooled and compressed to a liquid form. Under atmospheric temperature and pressure, liquid chlorine evaporates quickly, with one pound of liquid forming about 5.4 cubic feet of chlorine gas.

Liquid chlorine is NOT the same as a hypochlorite or chlorine bleach solutions and this terminology should not be used to describe such solutions.

2.5.3 Chlorine Gas

At atmospheric conditions, chlorine is a gas.

2.5.4 Dry Chlorine/Wet Chlorine

DRY chlorine is defined as chlorine with its water content dissolved in solution. If a condition is reached anywhere in the system that will allow the water to exceed its solubility and form a second aqueous liquid phase, the chlorine is defined as WET chlorine. WET chlorine will form corrosive compounds affecting the safety and integrity of the system (See CI Pamphlet 100 and Figure 10.5 and Figure 10.6).

Dry Chlorine is NOT a dry chlorinating compound such as calcium hypochlorite or chloroisocyanurates and this terminology should not be used to describe such a substance.

2.5.5 Moist Chlorine

Synonymous with wet chlorine.

2.5.6 Saturated Chlorine Gas

Chlorine gas, in such condition, that the removal of any heat or an increase in pressure will cause some portion of it to condense to a liquid. This term does not describe or refer to the relative moisture content of the chlorine.

2.5.7 Saturated Chlorine Liquid

Chlorine liquid, in such condition, that the addition of any heat or a decrease in pressure will cause some portion of the chlorine to vaporize to a gas. This term does not describe or refer to the relative moisture content of the chlorine.

2.5.8 Chlorine Solution (Chlorine Water)

A solution of chlorine in water (See Figure 10.3).

A chlorine solution is NOT the same as hypochlorite or chlorine bleach solutions and this terminology should not be used to describe such solutions.

2.5.9 Liquid Bleach

An aqueous solution of hypochlorite, usually sodium hypochlorite (NaOCl).

2.5.10 Container

In this publication, a container is a pressure vessel authorized by an applicable regulatory body for the transport of chlorine. It does not include pipelines or stationary storage tanks.

2.5.11 Filling Density

By DOT and TC regulation, the weight of chlorine that is loaded into a container may not exceed 125% of the weight of water at 60°F (15.6°C) that the container will hold.

2.5.12 Sodium Hydroxide

Normally sodium hydroxide (NaOH) is the co-product produced as a solution when chlorine is generated through the electrolytic decomposition of sodium chloride solution. Sodium hydroxide is frequently referred to as caustic soda or lye.

2.5.13 Potassium Hydroxide

A co-product produced as a solution when chlorine is generated through the electrolytic decomposition of potassium chloride salt solution. Potassium hydroxide (KOH) is frequently referred to as caustic potash.

2.6 SPECIFIC MANUFACTURING AND USE HAZARDS

2.6.1 Hydrogen

Hydrogen (H_2) is a co-product of all chlorine manufactured by the electrolysis of aqueous brine solutions. Within a known concentration range, mixtures of chlorine and hydrogen are flammable and potentially explosive. The reaction of chlorine and hydrogen can be initiated by direct sunlight, other sources of ultraviolet light, static electricity, or sharp impact (See CI Pamphlet 121).

2.6.2 Nitrogen Trichloride

Small quantities of nitrogen trichloride (NCl_3), an unstable and highly explosive compound, can be produced in the manufacture of chlorine. When liquid chlorine containing nitrogen trichloride is evaporated, the nitrogen trichloride may concentrate to hazardous concentrations in the residue (See CI Pamphlets 21 and 152).

2.6.3 Oils and Grease

Chlorine can react, at times explosively, with a number of organic materials such as oil and grease from sources such as air compressors, valves, pumps, oil-diaphragm instrumentation, pipe thread lubricants, as well as wood and rags from maintenance work.

2.7 OTHER HAZARDS

2.7.1 Fire

Chlorine is neither explosive nor flammable. Chlorine will support combustion under certain conditions. Many materials that burn in oxygen (air) atmospheres will also burn in chlorine atmospheres.

2.7.2 Chemical Action/Reactions

Chlorine has a very strong chemical affinity for many substances. It will react with many inorganic and organic compounds, usually with the evolution of heat. Chlorine reacts with some metals under a variety of conditions (See Section 10.3.3).

2.7.3 Corrosive Action on Steel

At ambient temperatures, dry chlorine, either liquid or gas, does not corrode steel. Wet chlorine is highly corrosive because it forms hydrochloric and hypochlorous acids. Precautions should be taken to keep chlorine and chlorine equipment dry. Piping, valves, and containers should be closed or capped when not in use to keep out atmospheric moisture such as precipitation or humidity. If water is used on a chlorine leak, the resulting corrosive conditions will make the leak worse.

2.7.4 Volumetric Expansion

The volume of liquid chlorine increases with temperature. Precautions should be taken to avoid hydrostatic rupture of piping, vessels, containers, or other equipment filled with liquid chlorine (See Figure 10.4).

3. CYLINDERS AND TON CONTAINERS

For detailed information, refer to the following CI literature:

Pamphlet #	Title
6	Piping Systems for Dry Chlorine
17	Packaging Plant Safety and Operational Guidelines
65	Personal Protective Equipment for Chlor-Alkali Chemicals
76	Guidelines for the Safe Motor Vehicular Transportation of Chlorine Cylinders and Ton Containers
91	Checklist for Chlorine Packaging Plants, Chlorine Distributors and Tank Car Users of Chlorine
155	Water and Wastewater Operators Chlorine Handbook

Drawing #	Title
Drawing 122	Ton Container Lifting Beam
Drawing 183	Manifolding Ton Containers for Liquid Chlorine Withdrawal
Drawing 189	Closed Yoke Chlorine Container Valve
Drawing 197	Chlorine Ton Containers

3.1 CONTAINER DESCRIPTIONS

3.1.1 General

Cylinders and ton containers have many similarities in the way in which they are handled. The terms "cylinder," "ton cylinder," or "drum" should not be used to describe the ton container. Emergency and other equipment for handling ton containers is different from that used for cylinders and confusion can be avoided if the proper terms are used.

In this document, "container" will be used to refer to any vessel that holds chlorine for the purpose of transporting the product. This may include cylinders, ton-containers, cargo tanks, tank cars, and barges. If the information provided is specific to the type of container, it will be specified.

Site chlorine inventories exceeding the threshold quantity are subject to such regulations as RMP and PSM. Check with federal, state, and provincial agencies for threshold requirements.

3.1.2 Cylinders

Chlorine cylinders are of seamless construction with a capacity of 1 to 150 lb (0.45 to 68 kg); those of 100 and 150 lb (45.4 and 68 kg) capacity predominate. The only opening in the cylinder is the valve connection at the top of the cylinder. The steel valve protective housing should be utilized to cover the valve during shipment and storage. Care must be taken with the protective cap since the cylinder neck-ring to which it is attached is not physically welded to the cylinder.

3.1.3 Ton Containers

Ton containers are welded tanks having a capacity of one short ton, 2000 lb (907 kg), and a loaded weight of as much as 3650 lb (1655 kg). The sides are crimped inward at each end to form chimes which provide a substantial grip for lifting beams. The ton container valves are protected by a removable steel valve protective housing.

3.2 CONTAINER VALVES

3.2.1 Cylinder Valves

The typical cylinder is equipped with one valve. The valve outlet threads are not standard pipe threads, but are special straight threads. These outlet threads are intended for securing the valve outlet cap and not for connecting unloading connections or other devices. Typical cylinder connections are made with a yoke and adapter (See CI Pamphlet 17). The valve is also equipped with a fusible metal pressure relief device or, as more commonly named, a fusible plug.

3.2.2 Ton Container Valves

Each ton container is equipped with two identical valves near the center of one end. They are different from the typical cylinder valve in that they have no fusible metal plug and usually have a larger internal passage. Each valve connects to an internal eduction tube (See CI Pamphlet 17).

3.3 PRESSURE RELIEF DEVICES

3.3.1 General

A metal relief device or fusible plug is designed to yield or melt between 158°F and 165°F (70°C and 74°C) to relieve pressure and prevent container rupture if exposed to fire or other high temperature. The relief device is designed to activate only in the event of a temperature increase and will not prevent over-pressurization due to overfilling.

3.3.2 Cylinders

Cylinder valves are equipped with one fusible metal relief device or fusible plug.

3.3.3 Ton Containers

Ton containers are equipped with fusible metal pressure relief devices. Most have six fusible metal plugs, three in each end.

3.4 CONTAINER SHIPPING

3.4.1 Cylinders

Cylinders may be shipped by highway, rail, or water. Suitable restraints are necessary to prevent cylinders from shifting during transportation (See CI Pamphlet 76).

3.4.2 Ton Containers

Most ton containers are shipped by highway. Trucks must have suitable hold-down devices to prevent the ton containers from shifting during transportation. Trucks are sometimes equipped with a crane and lifting beam to facilitate loading and unloading (See CI Pamphlet 76).

PIOP593

3.5 CONTAINER MARKING/LABELING AND VEHICLE PLACARDING

Containers in transportation must be marked and labeled and the vehicle placarded as required by regulations.

3.6 CONTAINER HANDLING

3.6.1 General

Chlorine containers must be handled with care. During shipment and storage, container valve protective housings should be in place. Containers should not be dropped and no object should be allowed to strike them with force. Containers should be secured to prevent them from rolling (See CI Pamphlet 76).

3.6.2 Cylinders

Cylinders can be moved using a properly balanced hand truck. The hand truck should have a clamp or chain two-thirds of the way up the cylinder wall to hold the cylinder in place. If cylinders must be elevated by hoist, a specially designed cradle or carrier should be used. Slings and magnetic devices are unacceptable. Cylinders must not be lifted by the valve protective housing because the neck-ring to which the housing is attached is not designed to carry the weight of the cylinder.

3.6.3 Ton Containers

Ton containers are typically moved using a monorail or crane with a lifting beam (See Drawing 122). They can be rolled on rails or roller conveyors designed for this purpose. If a forklift truck is used, the ton container must be adequately restrained to prevent it from falling off, particularly when the truck changes direction. The forklift truck must be rated to handle the gross weight of the ton container.

3.7 CONTAINER STORAGE

Containers may be stored indoors or outdoors. The storage area should comply with federal and state regulations. See CI Pamphlets 17 and 155 for more detail on storage considerations.

3.8 CONTAINER USE

3.8.1 General

Before connecting or disconnecting a container, the operator should make sure that all safety and emergency equipment is available and operable. Containers and valves must not be modified, altered, or repaired by anyone other than the owner.

3.8.2 Gas Discharge

Chlorine gas discharge rates vary significantly because of local ambient temperature, humidity and air circulation, as well as the variations in the piping system and feeding equipment connected to the container. See CI Pamphlet 155 for details.

If the gas discharge rate from a single container will not meet the flow requirements, two or more may be connected to a manifold. Alternately, liquid from one or more containers may be sent to a vaporizer for increasing the chlorine gas delivery rate (See Section 3.8.3).

When discharging through a gas manifold, all containers should be at the same temperature to prevent transfer of gas from a warm container to a cool container.

3.8.3 Liquid Discharge

Discharging liquid chlorine has special design requirements (See CI Pamphlet 6).

Liquid chlorine is delivered from the lower valve of a ton container. Very high liquid withdrawal rates can be obtained. The rate depends on the temperature of the chlorine in the ton container and on the back pressure. The dependable continuous discharge rate of liquid chlorine under normal temperature conditions and against a pressure of 35 psig (241 kPa gauge) is at least 400 lb/hr (181 kg/hr) for ton containers. When connected to a manifold, ton containers discharging liquid chlorine should include precautions to equalize the pressure. Drawing 183 depicts a system for equalizing pressures for gas valves connected to a manifold. It is not sufficient to depend on ton containers reaching the same pressure merely by storing them in the same working area. Piping evacuation procedures should be established so liquid chlorine is not trapped in the system.

3.8.4 Weighing

Because chlorine is shipped as a compressed liquefied gas, the pressure in a container depends on the temperature of the chlorine (Figure 10.1). The pressure is not related to the amount of chlorine in the container. Container contents can be determined accurately only by weighing.

3.8.5 Connections

A chlorine compatible flexible connection must be used between the container and a pressurized piping system. If a system is to remain in operation while containers are being connected or disconnected, auxiliary (isolating) container valves must be used. Flexible connections should be inspected and replaced on a regular basis. A flat gasket on the face of the valve is part of the connection. A new gasket should be used each time a connection is made (See CI Pamphlets 6 and 155 and Drawing 189).

3.8.6 Opening Valves

The container valve is opened by turning the valve stem in a counter-clockwise direction. One full turn of the stem typically permits an appropriate feed rate. More stem turns should not be made unless recommended by the supplier. A wrench, no longer than 8 inches, should be used. Never use a wrench extension (cheater bar) as the valve may be damaged preventing gas-tight shut-off. Once the valve is opened, the wrench should be left in place so that the valve can be closed quickly. Do not loosen the packing nut unless authorized by the supplier.

Once connections have been made, pressurize the system with a small amount of chlorine, and check for leaks (See Section 5.4.2). If a leak is found, it must be remedied before proceeding (See CI Pamphlet 155).

3.8.7 Closing Valves

Apply 25-30 foot-pounds to the valve stem. Check for leaks. If any leaks still exist, the torque may be increased up to 40 foot-pounds. If the leak has not stopped at 40 foot-pounds, increase the torque on the valve stem to 50 foot-pounds. If this fails to work, contact your supplier.

3.8.8 Disconnecting Containers

As soon as a container is empty, the valve should be closed (See Section 3.8.7). Prior to disconnecting, reconfirm that the valve is closed and provide a means of removing the chlorine trapped in the flexible connecting line. This can be accomplished by either purging the line with dry air or nitrogen with a dew point of -40°F (-40°C) or lower or by applying a vacuum. Personal Protective Equipment should be used as appropriate for the task (See CI Pamphlet 65). The container should be cautiously disconnected in case residual chlorine remains in the lines. The outlet cap should be applied promptly and the valve protective housing should be replaced. The open end of the disconnected flexible line should be capped promptly to keep atmospheric moisture from entering the system.

4. BULK SHIPPING CONTAINERS

For detailed information, refer to the following CI literature:

Pamphlet #	Title
6	Piping Systems for Dry Chlorine
49	Recommended Practices for Handling Chlorine Bulk Highway Transports
57	Emergency Shut-Off Systems for Bulk Transfer of Chlorine
60	Chlorine Pipelines

Pamphlet #	Title
66	Recommended Practices for Handling Chlorine Tank Cars
166	Angle Valve Guidelines for Chlorine Bulk Transportation

Drawing #	Title
Drawing 104	Standard Chlorine Angle Valve Assembly

4.1 GENERAL

Bulk chlorine is shipped by pipeline, tank cars, tank motor vehicles, portable tanks, and barge tanks.

4.2 TANK CARS

4.2.1 General

The following is generalized information on chlorine tank cars (See CI Pamphlet 66).

4.2.2 Specifications

The most commonly used tank cars have a chlorine capacity of 90 tons. By regulation, tank cars may not be loaded with chlorine in excess of the nominal weight.

Table 3 Key Government Specifications

United States	49 CFR 179.102-2	49 CFR 176-314 (c) note 12
Transport Canada	79.102-2	73.314 (c) note 12

The regulations require tank cars to be equipped with a pressure relief device whose setting is stenciled on the side of the car. Tank cars equipped with manual angle valves must have interior eduction pipes with approved excess flow valves to be used for liquid discharge. Tank cars must be thermally protected with four inches of insulating material.

4.2.3 Manway Arrangement

4.2.3.1 General

Five fittings are mounted on the manway cover within the protective housing. Four of these are angle valves and the fifth, located in the center, is a pressure relief valve designed to relieve if excessive pressure builds up in the tank car.

4.2.3.2 Angle Valves

The manually operated angle valves for the standard manway arrangement should comply with CI Pamphlet 166. The two angle valves on the longitudinal centerline of the tank car are for liquid discharge. The angle valves on the transverse centerline are connected to the vapor space.

Chlorine tank cars may also be equipped with pneumatically operated valves (POVs).

4.2.3.3 Excess Flow Valves

Except for tank cars equipped with pneumatically operated valves, under each liquid valve there is an excess-flow valve. The excess-flow valve consists of a rising ball which closes when the rate of flow exceeds a predetermined value. It does not respond to pressure in the car. It is designed to close automatically against the flow of liquid chlorine if the angle valve is broken off in transit. It may close if a catastrophic leak involving a broken connection occurs but it is not designed to act as an emergency shut-off device during transfer. Tank cars equipped with POVs are equipped with a ball check valve under both the liquid and vapor outlets.

4.2.3.4 Eduction Pipes

Liquid chlorine is withdrawn through eduction pipes. Bottom outlets are not permitted in chlorine cars. The eduction pipes are attached to the excess-flow valves, or directly to the bottom of the tank car dome if equipped with POVs, and extend to the bottom of the car.

4.2.3.5 Pressure Relief Valve

In the center of the manway cover is a two-stage spring loaded pressure relief valve. The device is set to start-to-discharge at the pressure stenciled on the car.

4.2.4 Transfer Operations

The following is general information (See CI Pamphlet 66).

4.2.4.1 Precautions

Every site handling chlorine in bulk containers should have RMP and PSM programs.

Special attention should be directed to the appropriateness of emergency procedures and to equipment to be used in an emergency.

Chlorine transfer operations must be performed only by personnel who are trained as required by applicable hazardous material regulations.

DOT (49 CFR), OSHA (29 CFR) and TC (Sec. 10.2) have specific training requirements applicable to handling of hazardous materials.

All personnel responsible for transfer operations should be knowledgeable about the facility's emergency response plan for handling spills and leaks of products (See CI Pamphlet 66).

Before beginning transfer operations, a number of things should be considered. Details can be found in Pamphlet 66. A partial list of topics includes:

- Connections
- Pressure Padding
- Monitoring
- Disconnecting

4.3 CARGO TANK MOTOR VEHICLES

4.3.1 General

The following is generalized information on chlorine cargo tank motor vehicles (See CI Pamphlet 49). In North America, they usually have a capacity ranging from 15 to 22 tons (13,600 kg to 20,000 kg) with certain exceptions. DOT specifications apply only to the tank.

4.3.2 Manway Arrangement

4.3.2.1 General

The manway arrangement is the same as that on chlorine tank cars (see Section 4.2.3) except that special excess-flow valves are required under the gas valves.

4.3.2.2 Angle Valves

The angle valves are the same as those on tank cars (See Section 4.2.3.2).

4.3.2.3 Excess-Flow Valves

Under each liquid angle valve there is an excess-flow valve. There is an excess-flow valve of different design under each gas angle valve. These valves have a removable basket so that the ball can be removed and the interior of the tank inspected.

4.3.2.4 Pressure Relief Valve

The pressure relief valve is the same type as that used on tank cars (See Section 4.2.3.5). On all cargo tanks, the start-to-discharge pressure is 225 psig (1,551 kPa gauge pressure).

4.3.3 Transfer Operations

Procedures for transferring chlorine to/from cargo tanks are essentially the same as for tank cars. There is, however, more variation in facilities and conditions at customers' plants, and these may require modifications of methods and equipment.

4.3.3.1 Precautions

The engine should be shut off, hand brakes must be set, and wheel chocks must be in place during transfer. The tank motor vehicle must be attended at all times. The tank motor vehicle must not be moved when loading or unloading connections are attached to the vehicle (see discussion of tank car transfer, Section 4.2.4.1, for additional, applicable precautions.)

4.3.3.2 Emergency Equipment

Approved respiratory equipment is required on the transport vehicle. An Emergency Kit "C" must be on the transport vehicle. Proper training on the use of emergency equipment is required (OSHA 29 CFR 1910.134).

It also is required that the transport vehicle have 2-way communication such as a cell phone or radio.

4.3.3.3 Connections/Disconnecting

See discussion for tank cars (Section 4.2.4).

The driver should recheck all equipment by a visual inspection before starting the vehicle.

4.3.3.4 Pressure Padding

See discussion for tank cars (Section 4.2.4).

4.4 <u>PORTABLE TANKS</u>

Tanks suitable for multi-modal transportation (road, rail, and water) of chlorine should be built under the provisions of DOT 51 and special provisions for chlorine (See CI Pamphlet 49).

4.5 <u>TANK BARGES</u>

Consult your supplier for information on chlorine barges.

5. EMERGENCY MEASURES

For detailed information, refer to the following CI literature:

Pamphlet #	Title
64	Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite and Hydrogen Chloride Facilities
65	Personal Protective Equipment for Chlor-Alkali Chemicals
66	Recommended Practices for Handling Chlorine Tank Cars
74	Guidance on Complying with EPA Requirements Under the Clean Air Act by Estimating the Area Affected by Chlorine Release
89	Chlorine Scrubbing Systems
IB/A	Instruction Booklet: Chlorine Institute Emergency Kit "A" for 100- and 150-lb. Chlorine Cylinders
IB/B	Instruction Booklet: Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers
IB/C	Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks

5.1 GENERAL

A chlorine emergency may occur during manufacture, use, or transportation. Trained employees, along with a comprehensive, written emergency response plan are necessary to mitigate the consequences of the emergency. Regular drills and reviews of emergency response plans with all involved organizations are encouraged (See CI Pamphlet 64). Federal, state and provincial regulations, as well as various local fire and building codes, regulate chemical emergency preparedness and response. All persons responsible for the handling of chlorine must be familiar with those requirements. Regulatory requirements deal generally with preparation and response to chemical and other emergencies (See CI Pamphlet 64). Help is also available from CHLOREP (see Sections 5.5.1 to 5.5.3) which can be accessed through the Institute and CHEMTREC (U.S.). In Canada, CANUTEC may provide advice, as well as contact information for the appropriate CHLOREP Team.

5.2 RESPONSE TO A CHLORINE RELEASE

As soon as there is any indication of a chlorine release, immediate steps must be taken to correct the condition. Chlorine leaks always get worse if they are not promptly corrected. When a chlorine leak occurs, authorized, trained personnel equipped with respiratory and appropriate other PPE should investigate and take proper action. Personnel should not enter into atmospheres containing concentrations of chlorine in excess of the IDLH Concentration of 10 ppm without appropriate personal protective equipment and back-up personnel.

CI Pamphlet 65 provides PPE recommendations for responders to a chlorine release. Keep unnecessary personnel away and isolate the hazard area. Persons potentially affected by a chlorine release should be evacuated or sheltered in place as circumstances warrant.

Area chlorine monitors and wind direction indicators can supply timely information (e.g., escape routes) to help determine whether personnel are to be evacuated or sheltered in place.

When evacuation is necessary, potentially exposed persons should move to a point upwind of the leak. To escape in the shortest time, persons already in a contaminated area should move crosswind. Because chlorine is heavier than air, higher elevations are preferable.

When inside a building and sheltering in place is selected, shelter by closing all windows, doors and other openings, and turning off air conditioners and air intake systems. Personnel should move to the side of the building furthest from the release.

Care must be taken not to position personnel without an escape route. A safe position may be made hazardous by a change in wind direction. New leaks may occur or the existing leak may get larger.

If notification of local authorities is required, the following information should be provided:

- Company name, address, telephone number and the name of the person(s) to contact for further information
- Description of the emergency
- Travel directions to the site
- Type and size of container involved
- Corrective measure being applied
- Other pertinent information, i.e., weather conditions, injuries, etc.

There are specific government requirements for reporting a hazardous chemical release. Releases must be reported in a timely manner (See CI Pamphlet 64).

5.3 RESPONSE TO A FIRE

If fire is present or imminent, chlorine containers and equipment should be moved away from the fire, if it is possible to do so safely. If a non-leaking container or equipment cannot be moved, it should be kept cool by applying water on it.

Water should not be used directly on a chlorine leak. Chlorine and water react forming acids and the leak will quickly get worse. However, where several containers are involved and some are leaking, it may be prudent to use a water spray to help cool the non-leaking containers. Whenever containers have been exposed to flames, cooling water should be applied until well after the fire is out and the containers are cooled. Containers exposed to fire should be isolated and the supplier should be contacted as soon as possible.

5.4 RELEASES

5.4.1 General

Chlorine facilities should be designed and operated so that the risk of a chlorine release into the environment is minimized. However, accidental releases and leaks of chlorine may occur. The overall effects of such releases must be considered.

5.4.2 Detection of Minor Releases and Leaks

A plastic squeeze bottle containing 26° Baumé aqua ammonia can be used to detect a minor release or leak. If ammonia vapor is directed at a leak, a white cloud will form indicating the source of the leak. If a wash bottle is used, the dip tube should be cut off so that squeezing the bottle directs vapor, not liquid, out of the nozzle. Avoid contact of aqua ammonia with brass or copper. Portable electronic chlorine monitors can also be used to detect leaks. If a leak occurs from equipment or piping, the chlorine supply should be shut off, the pressure relieved and necessary repairs made.

Leaks around shipping container valve stems usually can be stopped by tightening the packing gland. If such tightening does not stop the leak, the container valve should be closed. Leaks at the packing nut will always stop when the valve is closed (See CI Pamphlet 66). If simple corrective measures are not sufficient, the appropriate Chlorine Institute Emergency Kit should be applied or the cylinder should be placed in a recovery vessel designed to contain the leak, and the chlorine supplier notified (See Section 5.8).

5.4.3 Area Affected

The area affected by a chlorine release and the duration of the exposure depend upon the total quantity released, the rate of release, the height of the release point and weather conditions, as well as the physical form of the chlorine being released. These factors are difficult to evaluate in an emergency situation. Chlorine downwind can vary from barely detectable to high concentrations. CI Pamphlet 74 provides information on the area affected by specific chlorine release scenarios.

5.4.4 Physical Form of the Chlorine Released

Typically, chlorine is stored and transported as a liquid under pressure. Liquid chlorine expands in volume by nearly 460 times when it vaporizes; therefore, a liquid chlorine leak can have significantly greater downwind effect than a gaseous chlorine leak.

During a release, chlorine can escape as a gas, a liquid, or both. When pressurized liquid or gas is released from a container, the temperature and pressure inside the container will decrease thus reducing the release rate.

5.4.5 Effect of Chlorine on the Environment

5.4.5.1 Vegetation

Plants in the path of a chlorine release may be damaged. Leaves may be bleached and browning and leaf loss may occur. Healthy plants will usually recover with time.

5.4.5.2 Animals

Seek medical attention for evaluation or treatment for pets and other animals that experience irritation or any signs of respiratory distress.

5.4.5.3 Aquatic Life

Chlorine is only slightly soluble in water and there would be little absorption from a cloud of chlorine gas. If chlorine is released into a lake or stream, it may harm aquatic plants and animals until it dissipates.

5.5 <u>TRANSPORTATION EMERGENCIES</u>

DOT and TC require that any person who offers chlorine for transportation must provide a staffed 24-hour emergency response telephone number that can be called in the event of an emergency involving chlorine. The MSDS, provided by the chlorine supplier, contains this contact information. This information may also be found on the bill of lading and the shipping container.

5.5.1 CHLOREP

The Chlorine Emergency Plan (CHLOREP) was established in January 1973 by the Institute as an industry-wide program to improve the speed and effectiveness of response to chlorine emergencies in the United States and Canada.

The primary purpose of the Plan is to minimize the risk of injury arising from the actual or potential release of chlorine during emergencies occurring in the course of transportation, at distribution points, or at chlorine user locations. Under this Plan, the United States and Canada have been divided into regional sectors where trained emergency teams from producing, packaging, distribution, and consuming plants are on constant alert on a 24-hour basis to handle possible or actual chlorine releases.

5.5.2 CHEMTREC, CANUTEC, & SETIQ

During a chlorine emergency, any carrier, customer, or civil authority can obtain basic emergency information and contact information for the closest chlorine emergency group through CHEMTREC (U.S.), CANUTEC (Canada), SETIQ (Mexico), or their chlorine supplier. The emergency response call center, i.e. CHEMTREC and CANUTEC, provides immediate advice for those at the scene of emergencies. CHEMTREC will promptly contact the appropriate responder group as required. CANUTEC will provide contact information and participate on a call to the appropriate responder, which must be initiated by the incident scene contact. In many cases, the responder will be the shipper. However, in some cases, the designated response group is called and then the shipper is notified.

Table 4 Emergency Contact Information

Dispatch Agency	Country	Phone Number
CHEMTREC	Continental United States	1-800-424-9300
CHEMTREC	Alaska and Hawaii	1-703-527-3887
CHEMTREC	Marine radio telephone	1-703-527-3887
CHEMTREC	Collect calls anywhere in the US	1-703-527-3887
CANUTEC	Canada	1-613-996-6666 (collect calls accepted)
SETIQ	Mexico	01-800-00214-00
SETIQ	Mexico – from outside the country	011-55-5-5591588

5.5.3 In Transit Emergency Response

If a chlorine leak develops in transit, appropriate emergency measures should be taken as quickly as possible.

If a vehicle transporting chlorine cylinders or ton containers is disabled and there is any possibility of fire, the containers should be removed from the vehicle to a safe distance if possible.

If a tank car or cargo tank trailer is disabled and chlorine is leaking, appropriate emergency procedures should be instituted in consultation with local authorities. Clearing of track or highway should not be started until safe working conditions are established. See Section 5.3 for action to take if a fire occurs.

The specific actions taken by emergency responders will vary. Some items to consider acting upon are:

- Is it possible to safely turn the container so that gas instead of liquid escapes? The quantity of chlorine that escapes from a gas leak is much less than the amount that escapes from a liquid leak through the same size hole.
- Is it possible to safely reduce the pressure in the container by removing the chlorine as gas (not as liquid) to a process or a disposal system? (See Sections 5.6 and 5.7).

- Can the container be safely moved to an isolated spot where the consequences can be minimized?

- Is it possible to safely apply the appropriate Chlorine Institute Emergency Kit or place the cylinder in a recovery vessel designed to contain the leak? (See Section 5.8).

A leaking chlorine container must not be immersed or thrown into a body of water; the leak will be aggravated and the container may float when still partially full of liquid chlorine allowing gas evolution at the surface.

Specific government regulations must be followed for the shipment of a leaking chlorine container or a container which has been exposed to fire, whether full or partially full. In such cases, special arrangements are required and the chlorine supplier should be consulted first.

5.6 CHLORINE LEAK AT A CONSUMING LOCATION

In addition to leak mitigation efforts, the following may be considered:

- It may be best to consume the chlorine through the regular process. If the consuming process cannot handle chlorine under emergency conditions, a standby alkali absorption system or a scrubber should be considered.

- It must be recognized that systems consuming liquid chlorine at low rates may not significantly reduce pressure in the supply container. In order to reduce pressure in the supply container, chlorine must be removed as a gas at a rate high enough to cause cooling of the remaining liquid. (See Section 3.8.2).

5.7 ABSORPTION SYSTEMS

Chlorine is readily absorbed in and reacted with an alkaline solution. The alkaline solution consists of water and sodium hydroxide, sodium carbonate, or potassium hydroxide. Contact your chlorine supplier and consult CI Pamphlet 89.

5.8 EMERGENCY KITS AND RECOVERY VESSELS

Chlorine Institute Emergency Kits and cylinder recovery vessels are designed to contain most leaks which may be encountered from chlorine containers. The following kits and recovery vessels are available:

- Kit A - for 100 lb and 150 lb cylinders

- Kit B - for ton containers.

- Kit C - for tank cars and tank trucks.

- Recovery vessels for cylinders.

The kits contain step-by-step instructions for the use of the devices. The necessary tools are included, but personal protective equipment is not included. CI Pamphlets IB/A, IB/B, and IB/C provide information on these kits and their use.

Chlorine recovery vessels are commercially available equipment designed to hold an entire cylinder. A leaking cylinder can be placed in a recovery vessel which is then closed, thus containing the leak. The chlorine can then be recaptured from the recovery vessel.

For chlorine barges, contact your supplier for information or equipment for leak mitigation.

Chlorine consumers should incorporate plans for the use of these kits in their emergency programs, provide instruction to the emergency responders, and properly maintain the equipment. Further information on the utility, availability, and purchase of kits, kit components, and audio visual training aids is available from the Institute or the chlorine supplier.

Chlorine use or storage locations should have either the appropriate emergency kit(s) or containment vessel(s) readily available with emergency responders trained in their use or have a formal arrangement with an outside emergency response group that can respond to emergencies using such equipment.

5.9 REPORTING

Most governmental agencies have reporting requirements for chlorine releases. Producers, transporters, and users of chlorine should be aware of the "reportable quantity" and of all relevant requirements.

6. EMPLOYEE TRAINING AND SAFETY

For detailed information, refer to the following CI literature:

Pamphlet #	Title
63	First Aid, Medical Management/Surveillance and Occupational Hygiene Monitoring Practices for Chlorine
65	Personal Protective Equipment for Chlor-Alkali Chemicals

6.1 Employee Training

Safety in handling chlorine depends, to a great extent, upon the effectiveness of employee training, proper safety instructions and the use of suitable equipment. It is the responsibility of the employer to train employees and to document such training as appropriate and as required by regulation. It is the responsibility of employees to carry out correct operating procedures safely and to properly use the safety equipment provided.

Employee training should include but is not limited to:

- Instruction and periodic refresher courses in operation of chlorine equipment and handling of chlorine containers.
- Instruction in the properties and physiological effects of chlorine, including the information on the MSDS.
- A MSDS is provided by the chlorine supplier.
- Instruction to report to the proper authority all equipment failures and chlorine leaks.

Instruction and periodic drills regarding:

- Locations, purpose, and use of chlorine emergency equipment, fire fighting equipment, fire alarms and shut-down equipment such as valves and switches.
- Use and installation of emergency kits, such as the Chlorine Institute Emergency Kits A, B, or C and the recovery vessel if they are part of emergency equipment and planning at the location.
- Locations,. purpose, and use of personal protective equipment.
- Locations, purpose, and use of safety showers, eye washes, or the closest source of water for use in emergencies.
- Locations, purpose, and use of any specialized first aid equipment.

6.2 Personal Protective Equipment

6.2.1 Availability and Use

There is a potential for exposure to chlorine whenever chlorine is handled, stored, or used. If chlorine is used in widely separated locations, personal protective equipment should be available near each use point. Personal protective equipment (PPE) for emergency use should be available away from areas of likely contamination. CI Pamphlet 65 provides recommendations on appropriate PPE for specific tasks including loading/unloading, initial line entry, material sampling, and emergency response.

6.2.2 Respiratory Equipment

Respiratory equipment should be selected based on evaluation of hazards and degree of potential exposure. The need to protect the eyes from chlorine should be part of the evaluation of appropriate respiratory equipment (See CI Pamphlet 65).

All personnel entering areas where chlorine is stored or handled should carry or have immediately available appropriate respiratory protection.

A self-contained breathing apparatus (SCBA), with full face piece, is required for performing tasks when chlorine may be present unless air sampling verifies the chlorine concentration is such that a lower level of respiratory protection is sufficient.

Fit testing and regular maintenance programs for respirator equipment are necessary. Documented, regularly scheduled training is required to assure competency with self-contained breathing apparatus (29 CFR 1910).

6.3 CONFINED SPACE ENTRY

Confined space entry procedures must comply with all applicable local codes and regulations. The OSHA standard 29 CFR 1910.146 must be adhered to by most facilities in the United States.

6.4 PERSONAL EXPOSURE MONITORING

Because the odor of chlorine in itself is an inadequate indicator of concentration, it is essential that some quantitative measure of exposure be determined. Exposure guidelines are listed on the MSDS, including OSHA PEL and American Conference of Governmental Industrial Hygienists (ACGIH) TLV (Reference 11.4.1)

7. MEDICAL ASPECTS AND FIRST AID

For detailed information, refer to the MSDS provided by the chlorine supplier.

Pamphlet #	**Title**
63	First Aid, Medical Management/Surveillance and Occupational Hygiene Monitoring Practices for Chlorine

7.1 HAZARDS TO HEALTH

Chlorine gas is primarily a respiratory irritant. At low concentrations, chlorine gas has an odor similar to household bleach. As the concentrations increase from the level of detection by smell, so do the symptoms in the exposed individual. Depending on the level of exposure to chlorine, the effects may become more severe for several days after the incident. Observations of exposed individuals should be considered part of the medical response program.

The following list is a compilation of potential chlorine exposure thresholds and potential responses in humans, with considerable variation among subjects:

Table 5	Chlorine Exposure Thresholds in ppm and Reported Responses
0.2 – 0.4	Odor threshold (decrease in odor perception occurs over time)
1 – 3	Mild mucous membrane irritation, tolerated up to 1 hour
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
30	Immediate chest pain, vomiting, dyspnea, cough
40 – 60	Toxic pneumonitis and pulmonary edema
430	Lethal over 30 minutes
1000	Fatal within a few minutes.

7.2 FIRST AID

First aid is the immediate temporary treatment given to an exposed individual before the services or recommendations of a physician are obtained. Prompt action is essential. Reassurance to the individual will help to alleviate anxiety. Medical assistance must be obtained as soon as possible. Never give anything by mouth to an unconscious or convulsing person.

If chlorine has saturated an exposed person's clothes or skin, decontamination should be done by removing affected clothing and showering as recommended on the MSDS.

CI Pamphlet 63 contains detailed guidance on first aid for chlorine exposure, including:

- Inhalation
- Respiratory Assistance
- Oxygen Administration
- Skin Contact
- Eye Contact
- Medical Management of Chlorine Exposures
- Delayed Effects

8. ENGINEERING DESIGN AND MAINTENANCE

For detailed information, refer to the following CI literature:

Pamphlet #	Title
5	Bulk Storage of Liquid Chlorine
6	Piping Systems for Dry Chlorine
9	Chlorine Vaporizing Systems
17	Packaging Plant Safety and Operational Guidelines
65	Personal Protective Equipment for Chlor-Alkali Chemicals
73	Atmospheric Monitoring Equipment for Chlorine
89	Chlorine Scrubbing Systems
100	Dry Chlorine: Definitions and Analytical Issues
155	Water and Wastewater Operators Chlorine Handbook
164	Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials

8.1 STRUCTURES

Items to be considered include:

- Local building and fire codes;
- Avoid co-storage with other materials where possible, especially flammables;
- Chlorine monitoring equipment; and
- Means and locations of egress.

8.2 VENTILATION

The ventilation requirements must be determined on a site-specific basis. The building ventilation system should provide fresh air for normal operation and should take into consideration the possibility of a chlorine leak. Safeguards should be in place to ensure that persons do not remain in nor enter buildings where chlorine is present in the atmosphere due to a leak or equipment failure without the appropriate personal protective equipment.

Chlorine gas is heavier than air and has a tendency to collect at floor level. This property must be considered when locating air openings.

8.3 MATERIAL FOR PROCESSING EQUIPMENT

Materials of construction for handling dry chlorine and wet chlorine are very different. Temperature also plays an important role in material selection (See CI Pamphlets 6, 100, and 164).

Several other chemicals may be associated with the chlor-alkali process. These include hydrogen, sulfuric acid, mercury, certain salts, oxygen and various products of their reaction with chlorine. Materials of construction should be selected to guard against these corrosive or hazardous materials that are present in the manufacturing process.

8.4 VAPORIZERS

High capacity chlorine gas feed systems may need a chlorine vaporizer (evaporator). Vaporizers are designed to convert liquid chlorine into chlorine gas. Steam or hot water jackets are used to provide the heat needed for vaporization. Temperature control is critical. Pressure relief through the use of a safety valve with a rupture disk is required for vaporizers. Careful attention must be given to the design and operation of such systems. Periodic cleaning is necessary and the manufacturer's recommendations should be followed (See CI Pamphlet 9).

8.5 SUPPORT EQUIPMENT

8.5.1 General

Most equipment used in chlorine service is built to a specific design code or regulation. Such codes or regulations include ANSI, API, ASME and TEMA standards and OSHA regulations.

8.5.2 Vessels

The minimum fabrication standard for metal vessels operating at greater than 15 psig is that given in the ASME Code (Reference 11.5.1) for pressure vessels. Vessels operating at less than 15 psig have no ASME code requirements, but should be designed according to manufacturer's specification. Vessels in vacuum service require special designs to prevent collapse.

8.5.3 Heat Exchangers

Heat exchangers should be designed and fabricated in accordance with the TEMA Standard and proper ASME material classifications and codes.

8.5.4 Pumps

Pumps for chlor-alkali service are constructed of a wide range of materials. A supplier of such pumps should be contacted before use.

8.5.5 Compressors and Blowers

Compressors and blowers should be built in accordance with the applicable ASME Code and supplier specifications.

8.5.6 Scrubbers

While scrubbers are an effective means of absorbing chlorine, the need for a scrubber should be based on a site-specific hazard assessment. The design of the scrubber depends on the quantity of chlorine to be absorbed, the flow rate of air through the scrubber and the scrubbing liquid (See CI Pamphlet 89).

8.6 Piping Systems for Dry Chlorine

Piping as described in this section pertains only to above ground fixed piping (See CI Pamphlet 6).

8.6.1 Materials

In general, ASTM A106 Grade B Schedule 80 seamless carbon steel piping is recommended for handling dry chlorine when the process temperature range is from -20°F to 300°F (-29°C to 149°C). Stainless steels of the 300 series have useful properties for low temperature service but can fail due to chloride stress corrosion cracking, particularly in the presence of moisture at ambient or elevated temperatures. Certain metal piping materials, including titanium, aluminum, gold, and tin, cannot be used with dry chlorine.

Some plastics can be used under certain conditions (See CI Pamphlet 6). Plastic piping can become brittle in chlorine service and has a limited service life. Periodic inspection and replacement is recommended.

8.6.2 Design and Installation

8.6.2.1 General Design

Piping arrangements should be routed for the shortest distance practical with respect to flexibility, line expansion, and good engineering practice.

Periodic inspection and replacement is recommended for all piping systems in chlorine service.

For detailed information on piping material selection and general design, see CI Pamphlet 6. Items that should be considered for piping design and are in CI Pamphlet 6 include:

- Liquid Expansion
- Condensation
- Installation
- Routing
- Valves
- Inspection and Maintenance
- Other Components
- Preparation of Systems for Use

8.7 PIPING SYSTEMS FOR WET CHLORINE

Wet chlorine is very corrosive to all of the more common construction metals. Materials must be selected with care

At low pressures, wet chlorine can be handled in chemical stoneware, glass, or porcelain equipment and in certain alloys.

Hard rubber, unplasticized polyvinyl chloride, fiberglass reinforced polyester, polyvinylidene chloride or fluoride and fully halogenated fluorocarbon resins have been used successfully.

For higher pressures, lined metallic or compatible metallic systems should be used.

Hastelloy® C, titanium, and tantalum have been used.

Titanium may only be used with sufficiently wet chlorine but must not be used with dry chlorine under any circumstances, as it burns spontaneously on contact.

Tantalum is inert to wet and dry chlorine at temperatures up to 300°F (149°C).

8.8 STATIONARY STORAGE

Consumers receiving chlorine in barges, tank cars or trucks may require stationary storage facilities. The facilities should be properly designed and should be operated and periodically inspected in accordance with CI Pamphlet 5.

A tank should not be filled beyond its rated chlorine capacity because liquid chlorine will expand as it warms. At normal storage temperatures, the thermal expansion rate of liquid chlorine is high and, if room for expansion is not provided, could increase the hydrostatic pressure enough to rupture the tank. The maximum chlorine level should be determined by the filling density as discussed in Section 2.5.11.

8.9 EQUIPMENT MAINTENANCE

8.9.1 General

All chlorine piping and equipment should be carefully inspected on a regular basis. Inspections can be done using ultrasonic thickness testing, eddy current testing, magnetic flux testing, and other non destructive testing (See CI Pamphlet 6).

Maintenance of chlorine equipment and tanks should be under the direction of trained personnel. All precautions pertaining to safety education, protective equipment, health, and fire hazards should be reviewed and understood. Workers should not attempt to repair chlorine piping or other equipment while it is in service. When a chlorine system is to be cleaned or repaired, tanks, piping and other equipment should always be purged with dry air or non-reactive gas. All significant piping or process changes must be followed by compliance with the "Management of Change" guidelines in the OSHA Process Safety Management (PSM) regulations.

Decontamination is especially important where cutting or welding operations are undertaken because iron and steel will ignite in chlorine near 483°F (251°C). Immediate drying of chlorine equipment, piping, or containers into which water has been introduced or which has been opened for repairs or cleaning is essential to prevent corrosion.

Cleaning of piping and other equipment is addressed in CI Pamphlet 6.

8.9.2 Entering Tanks

Chlorine tank inspection, cleaning and repair are discussed in CI Pamphlet 5. OSHA has specific regulations concerning the entering of confined spaces. These regulations should be thoroughly understood and followed. See OSHA standard 29 CFR 1910.146.

9. U.S. REGULATIONS AND CODES

Note: The purpose of this section is to provide a list of some of the regulations that significantly affect the production, storage, packaging, distribution, or use of chlorine in the United States.

Additionally, information is provided on some of the Fire Codes that similarly affect chlorine. This section is not meant to cover all regulations affecting chlorine.

9.1 OCCUPATIONAL SAFETY AND HEALTH REGULATIONS -29 CFR

9.1.1 Part 1904 – Recording and Reporting Occupational Injuries and Illnesses

9.1.2 1910 Subpart E: Exit Routes, Emergency Action Plans, and Fire Prevention Plans

9.1.3 Section 1910.38 – Emergency Action Plans

9.1.4 1910 Subpart G: Occupational Health and Environment Control

9.1.5 Section 1910.95 - Occupational Noise Exposure.

9.1.6 1910 Subpart H: Hazardous Materials

9.1.7 Section 1910.119 - Process Safety Management of Highly Hazardous Chemicals

9.1.8 Section 1910.120 - Hazardous Waste Operations and Emergency Response

9.1.9 1910 Subpart I - Personal Protective Equipment

9.1.10 1910.132 – General Requirements

9.1.11 1910.133 – Eye and Face Protection

9.1.12 1910.134 – Respiratory Protection

9.1.13 1910.135 – Head Protection

9.1.14 1910.136 – Occupational Foot Protection

9.1.15 1910.137 – Electrical Protection Devices

9.1.16 1910.138 – Hand Protection

9.1.17 1910 Subpart J: General Environmental Controls

9.1.18 1910.146 – Permit-Required Confined Space Entry

9.1.19 1910.147 – The Control of Hazardous Energy (Lockout/tagout)

9.1.20 1910 Subpart K: Medical and First Aid

9.1.21 Section 1910.151 - Medical Service and First Aid

9.1.22 1910 Subpart Z: Toxic and Hazardous Substances

9.1.23 Section 1910.1000 – Air Contaminants

9.1.24 Section 1910.1020 - Access to Employee Exposure and Medical Records

9.1.25 Section 1910.1200 - Hazard Communications

9.2 NAVIGATION AND NAVIGABLE WATER REGULATIONS -33 CFR

9.2.1 Parts 1 to 26, Subchapter A - General delegation of authority, rulemaking procedures, and enforcement regulations.

9.2.2 Part 126 - Handling Explosives or Other Dangerous Cargoes Within or Contiguous to Waterfront Facilities

Requirements for waterfront facilities that handle hazardous materials.

9.2.3 Part 127 - Waterfront Facilities Handling Liquefied Hazardous Gas

Requirements in addition to those in Part 126 for waterfront facilities that handle liquefied hazardous gases including chlorine.

9.2.4 Part 130 - Financial Responsibility for Water Pollution

Requirements for vessel operators to demonstrate the ability to meet financial liability resulting from the discharge of oil or hazardous substance(s).

9.2.5 Part 153 - Control of Pollution by Oil and Hazardous Substances; Discharge Removal

Requirements concerning notification of the Coast Guard of the discharge of oil or hazardous substances.

9.2.6 Part 154 - Facilities Transferring Oil or Hazardous Materials in Bulk

Requirements intended to prevent and mitigate pollution and assure safe operations at facilities during marine transfers.

9.2.7 Part 155 - Oil or Hazardous Material Pollution Prevention Regulations for Vessels

Requirements to prevent and mitigate pollution from vessels while in navigable waters.

9.2.8 Part 156 - Oil and Hazardous Material Transfer Operations

Requirements for the operational control of the transfer of oil or hazardous materials between vessels and marine terminals.

9.2.9 Parts 160 to 167, Subchapter P - Ports and Waterways Safety

Requirements for traffic management, port arrival notification, vessel navigational equipment

9.3 ENVIRONMENTAL REGULATIONS - 40 CFR: PROTECTION OF ENVIRONMENT

9.3.1 Part 61 - National Emissions Standards for Hazardous Air Pollutants

9.3.2 Part 68 - Chemical Accident Prevention Provisions

9.3.3 Part 82 - Protection of Stratospheric Ozone

9.3.4 Part 141 - National Primary Drinking Water Regulations

9.3.5 Part 152 - Pesticide Registration and Classification Procedures

9.3.6 Parts 260 to 269 - Hazardous Waste Management System

9.3.7 Part 261 - Identification and Listing of Hazardous Waste

9.3.8 Part 264 - Standards for Owners and Operators of Hazardous Waste Treatment

9.3.9 Part 265 - Interim Status Standards for Owners and Operators of Hazardous Waste

9.3.10 Part 266 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities.

9.3.11 Parts 302 and 355 - Release of Hazardous Substances, Emergency Planning and Notification

Requirements for the planning, reporting, and notification of hazardous and highly hazardous substances.

9.3.12 Parts 370 and 372 - Hazardous Chemicals Reporting: Community Right to Know

Requirements for providing the public with information on hazardous chemicals.

9.3.13 Part 415, Subpart F - Effluent Guidelines/Chlor-Alkali Production

Effluent guidelines for chlorine production facilities.

9.3.14 Subchapter R, Parts 700 to 799 -Toxic Substances Control Act (TSCA)

Requirements for recordkeeping and reporting for various chemical substances.

9.4 SHIPPING REGULATIONS - 46 CFR (WATER TRANSPORTATION)

9.4.1 Part 2 - Vessel Inspections

Requirements and procedures for obtaining vessel certification and approvals.

9.4.2 Parts 10 to 12 - Licensing and Certification of Maritime Personnel

Requirements for licensing and certification of maritime personnel including eligibility, fees, procedures for renewals, and the certification of tankermen. Provides authorization for an individual to act as the person in charge on the vessel of a marine transfer of an oil or hazardous material. Requirements for the minimum manning of vessels.

9.4.3 Parts 30 to 40, Subchapter D - Tank Vessels

Requirements for vessels carrying flammable or combustible liquid cargoes. Subchapter regulates vessel design, operation, fire fighting, and life saving equipment and equipment testing. Generally, vessels carrying nonflammable hazardous materials are also regulated under this subchapter.

9.4.4 Part 151 - Barges Carrying Bulk Liquid Hazardous Materials Cargoes

Requirements for vessels carrying hazardous materials in barges. Regulations include barge design, equipment testing, and special requirements for specific hazardous cargoes including chlorine.

9.5 TRANSPORTATION REGULATIONS - 49 CFR

9.5.1 Part 106 - Rulemaking Procedures

General rulemaking procedures for issuing, amending, and repealing regulations.

9.5.2 Part 107 - Hazardous Materials Program Procedures

Requirements for exemptions, preemptions, enforcement, compliance orders, civil and criminal penalties, registration of cargo tank manufacturers and repairers, registration, and fees.

9.5.3 Part 171 - General Information, Regulations, Definitions

Use and applicability of transportation regulations within and outside the U.S. in addition, reporting requirements for hazardous material incidents.

9.5.4 Part 172 - Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

Requirements for shipping papers, marking, labeling, and placarding and the training of hazmat employees.

9.5.5 Part 173 - Shippers - General Requirements for Shipments and Packagings

Definitions of hazardous materials for transportation purposes. Requirements for preparing hazardous materials shipments, for container inspections, testing, and retesting.

9.5.6 Part 174 - Carriage by Rail

Requirements for handling, loading, unloading and storage of tank cars.

9.5.7 Part 176 - Carriage by Vessel

Requirements for packaged hazardous materials transported by vessel.

9.5.8 Part 177 - Carriage by Public Highway

Requirements on the handling, transportation, loading and unloading and segregation of hazardous materials.

9.5.9 Part 178 - Specifications for Packagings

Specifications for cylinders, portable tanks, and cargo tanks.

9.5.10 Part 179 - Specifications for Tank Cars

Design requirements and specifications for bulk rail tank cars.

9.5.11 Part 180 - Continuing Qualifications and Maintenance of Packagings

Requirements for qualifying existing cargo tanks for hazardous materials.

9.5.12 Part 190 - Pipeline Safety Program Procedures

Enforcement regulations pursuant to the Natural Gas Pipeline Safety Act, the Hazardous Liquid Pipeline Safety Act, and the Hazardous Materials Transportation Act as amended.

9.5.13 Part 191 - Transportation of Natural and Other Gas by Pipeline; Annual Reports, Incident Reports and Safety Related Condition Reports

Requirements for reporting incidents, safety related conditions, and pipeline data.

9.5.14 Part 192 - Transportation of Natural and other Gas by Pipeline: Minimum Federal Safety Standards

Requirements for pipeline facilities and the transportation of gases.

9.5.15 Part 195 - Transportation of Hazardous Liquids by Pipeline

Safety standards and reporting requirements for pipeline facilities used in the transportation of hazardous liquids or carbon dioxide. While the regulations do not currently include chlorine, the Institute recommends adhering to these requirements.

9.6 DEPARTMENT OF HOMELAND SECURITY – 6 CFR

9.6.1 Part 27 - Chemical Facility Anti-Terrorism Standards

This rule establishes risk-based performance standards for the security of facilities producing, handling, storing, or using chemicals of concern. It requires covered chemical facilities to prepare Security Vulnerability Assessments (SVAs), which identify facility security vulnerabilities, and to develop and implement Site Security Plans (SSPs), which include measures that satisfy the identified risk-based performance standards.

9.7 FIRE CODES

Numerous fire and building codes exist that affect chlorine production, storage, packaging, distribution, and use. To properly address these codes, the local government should be contacted to determine what specific fire and building codes, including the code year, were passed by the governing jurisdiction.

Some local or state authorities develop their own codes. However, many jurisdictions adopt a model code or reference National Fire Protection Association (NFPA) Standards. Either of these may serve as the local code(s). The model codes are modified annually and yearly supplements are issued. New editions of the codes are published every third year. The code year is important in determining which code is applicable. The specific requirements are contained in the applicable code.

10. TECHNICAL DATA

For detailed information, refer to the following CI literature:

Pamphlet #	Title
6	Piping Systems for Dry Chlorine
72	Properties of Chlorine in SI Units
121	Explosive Properties of Gaseous Mixtures Containing Hydrogen and Chlorine

10.1 GENERAL

Chlorine has a characteristic penetrating and irritating odor. The gas is greenish yellow in color and the liquid is clear amber. The data on physical properties of chlorine as determined by different investigators show some variations.

10.2 ATOMIC AND MOLECULAR PROPERTIES

Atomic Symbol - Cl

Atomic Weight - 35.453

Atomic Number - 17

Molecular Weight of Cl_2 - 70.906

10.3 CHEMICAL PROPERTIES

Table 6 Physical Properties

Property	Definition	Conditions	Value
Boiling Point (Liquefying Point)	The temperature at which liquid chlorine vaporizes	14.696 psia (101.325 kPa)	-29.15°F (-33.97°C)
Critical Density	The mass of a unit volume of chlorine at the critical pressure and temperature		35.77 lb/ft^3 (573.0 kg/m^3)
Critical Pressure	The vapor pressure of liquid chloride at the critical temperature		1157.0 psia (7977 kPa)
Critical Temperature	The temperature above which chlorine exists only as a gas no matter how great the pressure		290.75°F (143.75°C)
Critical Volume	The volume of a unit mass of chlorine at the critical pressure and temperature		0.02795 ft^3/lb (0.001745 m^3/kg)
Density	The mass of a unit volume of chlorine at specified conditions of temperature and pressure.		See Figure 10.2.
Density of Cl_2 Gas		32°F, 14.696 psia (0°C, 101.325 kPa)	0.2006 lb/ft^3 (3.213 kg/m^3)
Density of Saturated Cl_2 Gas		32°F, 53.51 psia (0°C, 368.9 kPa)	0.7632lb/ft^3 (12.23 kg/m^3)

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Table 6 Physical Properties

Property	Definition	Conditions	Value
Density of Saturated Cl_2 Liquid		32°F, 14.696 psia (0°C, 101.325 kPa)	91.56 lb/ft^3 (1467 kg/m^3)
		60°F, 86.58 psia (15.6°C, 597.0 kPa)	88.76 lb/ft^3 11.87 lb/gal (1422 kg/m^3)
Latent Heat of Vaporization	The heat required to evaporate a unit weight of chlorine	At the normal boiling point	123.9 Btu/lb (288.1 kJ/kg)
Liquid-Gas Volume Relationship	The weight of one volume of liquid chlorine equals the weight of 456.5 volumes of chlorine gas.	32°F, 14.696 psia (0°C, 101.325 kPa)	
Melting Point (Freezing Point)	The temperature at which solid chlorine melts or liquid chlorine solidifies	14.696 psia (101.325 kPa)	-149.76°F (-100.98°C)
Solubility in Water	The weight of chlorine which can be dissolved in a given amount of water at a given temperature when the total vapor pressure of chlorine and the water equals a designated value.	60°F,14.696 psia (15.6°C,101.325 kPa)	6.93 lbs/100gal (8.30 kg/m^3) See Figure 10.3
Specific Gravity of Cl_2 Gas	The ratio of the density of chlorine gas at standard conditions to the density of air under the same conditions:	32°F, 14.696 psia (0°C, 101.325 kPa)	2.485 (Note: The density of air, free of moisture at the same conditions is 1.2929 kg/m^3)
Specific Gravity of Cl_2 Liquid	The ratio of the density of saturated liquid chlorine to the density of water at its maximum density - 39°(4°C)	32°F (0°C)	1.467
Specific Heat	The heat required to raise the temperature of a unit weight of chlorine one degree.		
Saturated Gas at constant pressure		32°F (0°C)	0.1244 Btu/lb·°F (0.521 kJ/kg·K)
		77°F (25°C)	0.1347 Btu/lb·°F (0.564 kJ/kg·K)

Table 6	Physical Properties		
Property	**Definition**	**Conditions**	**Value**
Saturated Gas at constant volume		32°F (0°C)	0.08887 Btu/lb·°F (0.372 kJ/kg·K)
		77°F (25°C)	0.09303 Btu/lb·°F (0.3895 kJ/kg·K)
Saturated Liquid		32°F (0°C)	0.2264 Btu/lb·°F (0.948 kJ/kg·K)
		77°F (25°C)	0.2329 Btu/lb·°F (0.975 kJ/kg·K)
Ratio for Saturated Gas	Ratio of gas specific heat at constant pressure to gas specific heat at constant volume	32°F (0°C)	1.400
		77°F (25°C)	1.448
Specific Volume	The volume of a unit mass of chlorine at specified conditions of temperature and pressure.		
Gas		32°F, 14.696 psia (0°C, 101.325 kPa)	4.986 ft^3/lb (0.3113 m^3/kg).
Saturated Gas		32°F (0°C)	1.310 ft^3/lb (0.08179 m^3/kg).
Saturated Liquid		32°F (0°C)	0.01092 ft^3/lb (0.0006818 m^3/kg)
Vapor Pressure	The absolute pressure of chlorine gas above liquid chlorine when they are in equilibrium	32°F (0°C)	53.51 psia (368.9 kPa)
		77°F (25°C)	112.95 psia (778.8 kPa)
Viscosity	The measure of internal molecular friction when chlorine molecules are in motion		
Saturated Gas		32°F (0°C)	0.0125 cP (0.0125 mPa·s)
		60°F (15.6°C)	0.0132 cP (0.0132 mPa·s)
Liquid		32°F (0°C)	0.3863 cP (0.3863 mPa·s)
		60°F (15.6°C)	0.3538 cP (0.3538 mPa·s)

Table 6 Physical Properties

Property	Definition	Conditions	Value
Volume – Temperature Relationship	Volume – Temperature relationship of liquid chlorine in a container loaded to its authorized limit		Figure 10.4
Solubility of Water in liquid chlorine			Figure 10.5 and Figure 10.6

10.3.1 Flammability

Chlorine is neither explosive nor flammable. Chlorine will support combustion under certain conditions. Many materials that burn in oxygen (air) atmospheres will also burn in chlorine atmospheres. Many organic chemicals react readily with chlorine, sometimes violently.

10.3.2 Valence

Chlorine usually forms compounds with a valence of -1 but it can combine with a valence of +1, +2, +3, +4, +5, or +7.

10.3.3 Chemical Reactions

10.3.3.1 Reactions with Water

Chlorine is only slightly soluble in water (0.3% to 0.7%) depending on the water temperature.

10.3.3.2 Reactions with Metals

The reaction rate of dry chlorine with most metals increases rapidly above a temperature which is characteristic for the metal. Consult CI Pamphlet 6 for detailed information on reactivity with metals.

10.3.3.3 Reactions with Other Elements

Chlorine unites under specific conditions with most of the elements; these reactions may be extremely rapid. Consult CI Pamphlet 121 for more information.

10.3.3.4 Reactions with Inorganic Compounds

See CI Pamphlet 21.

10.3.3.5 Reactions with Organic Compounds

Chlorine reacts with many organic compounds to form chlorinated derivatives. Some reactions can be extremely violent, especially those with hydrocarbons, alcohols and ethers. Proper methods must be followed, whether in laboratory or plant, when organic materials are reacted with chlorine.

10.4 PHYSICAL PROPERTIES

Figure 10.1 through Figure 10.6 are for pure chlorine.

Figure 10.1 Vapor Pressure of Liquid Chorine
(Calculated from data in CI Pamphlet 72)

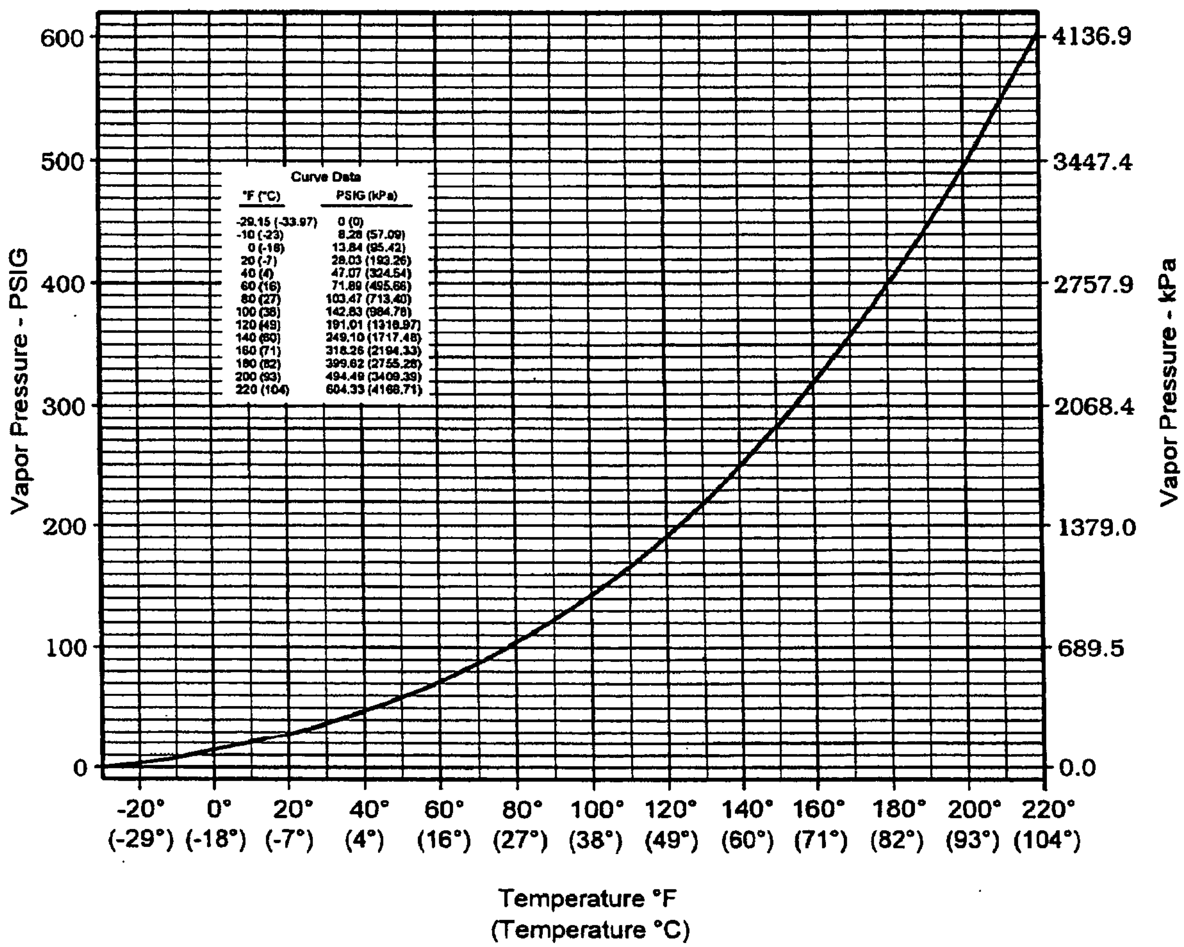


Figure 10.2 Temperature-Density Relation of Liquid Chlorine
(Calculated from data in CI Pamphlet 72)

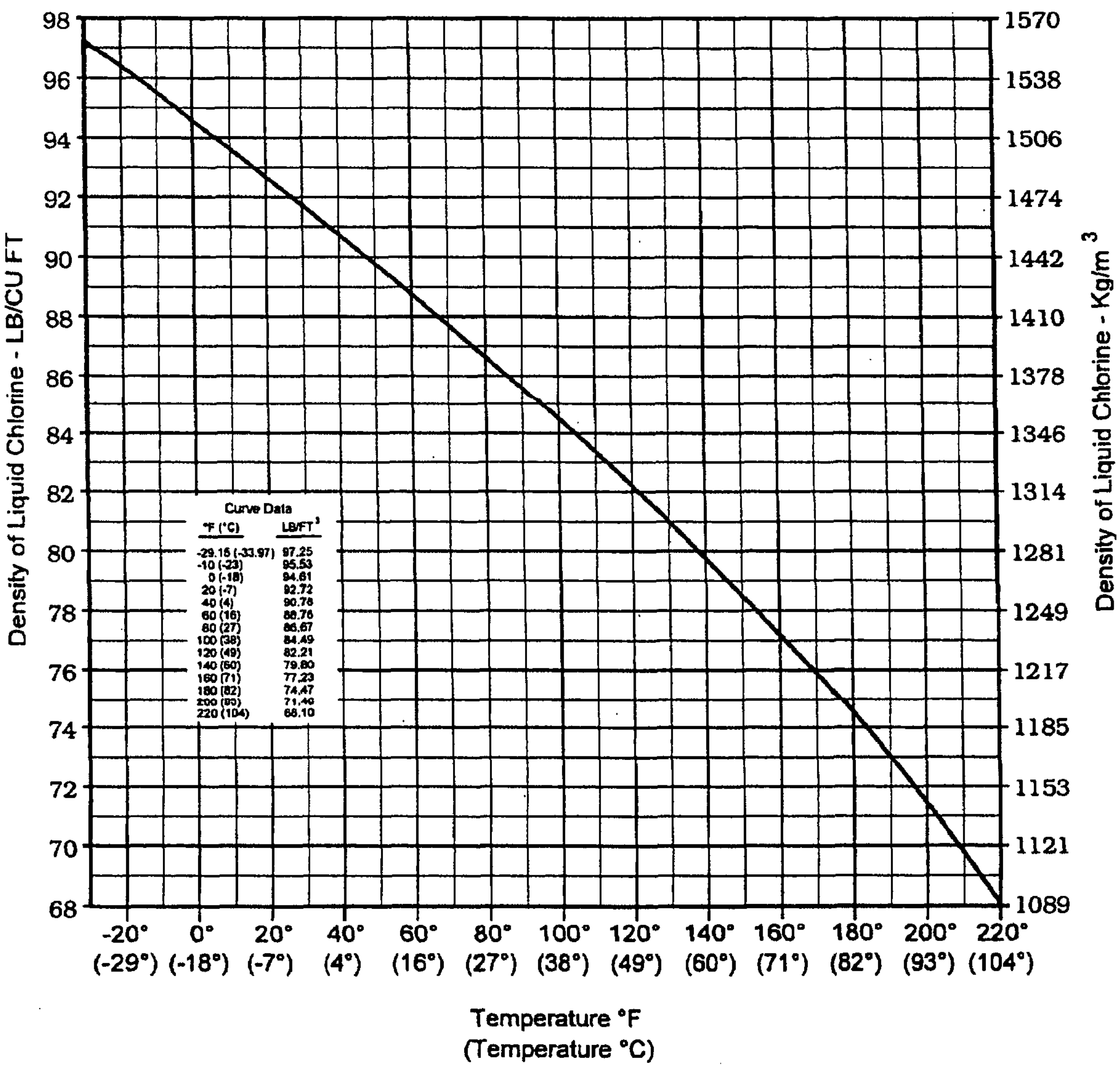


Figure 10.3 Equilibrium Solution of Chlorine In Water
(Reference 11.18.1)

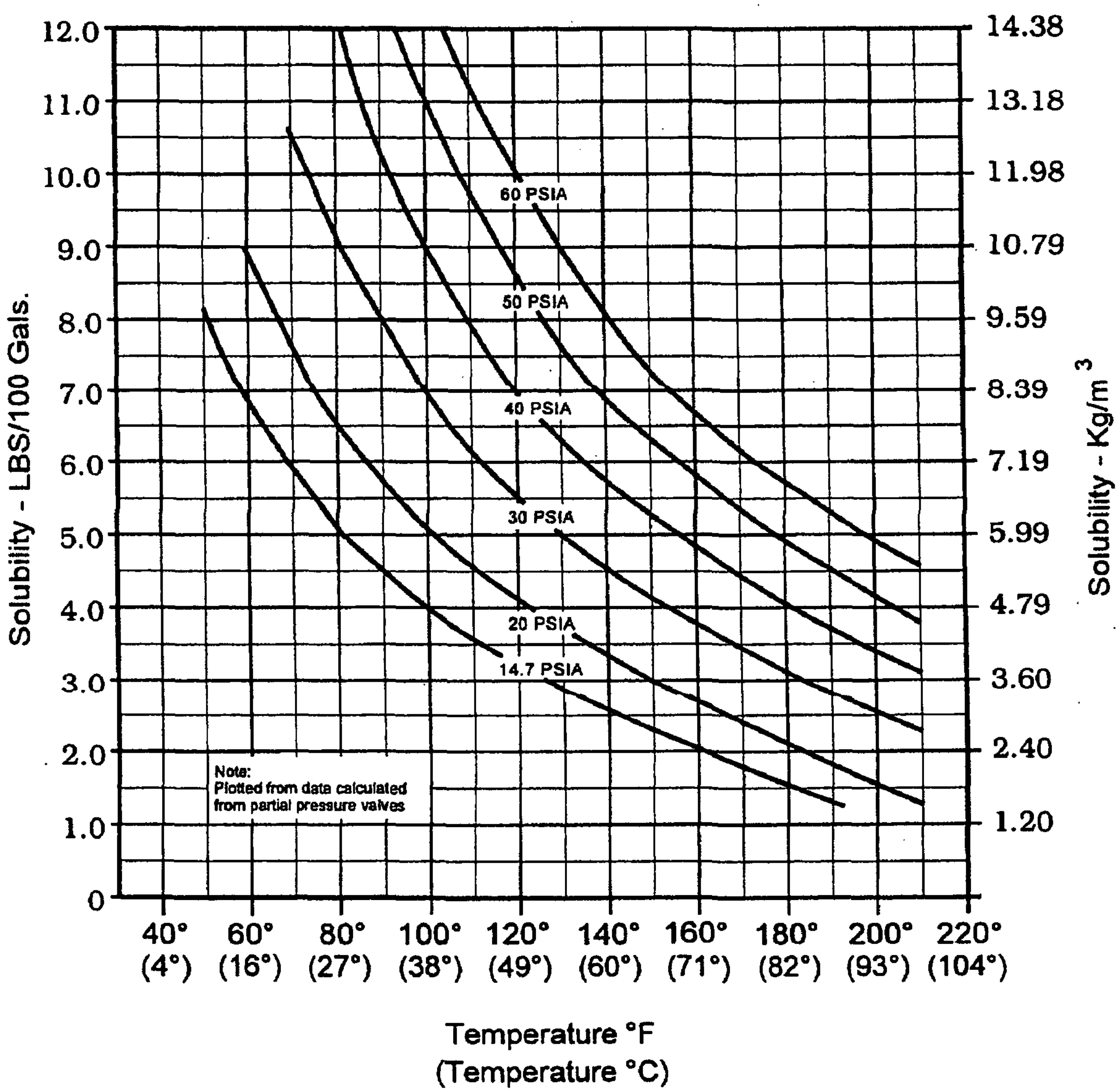


Figure 10.4 Volume-Temperature Relation of Liquid Chlorine in a Container Loaded to its Authorized Limit
(Calculated from data in CI Pamphlet 72)

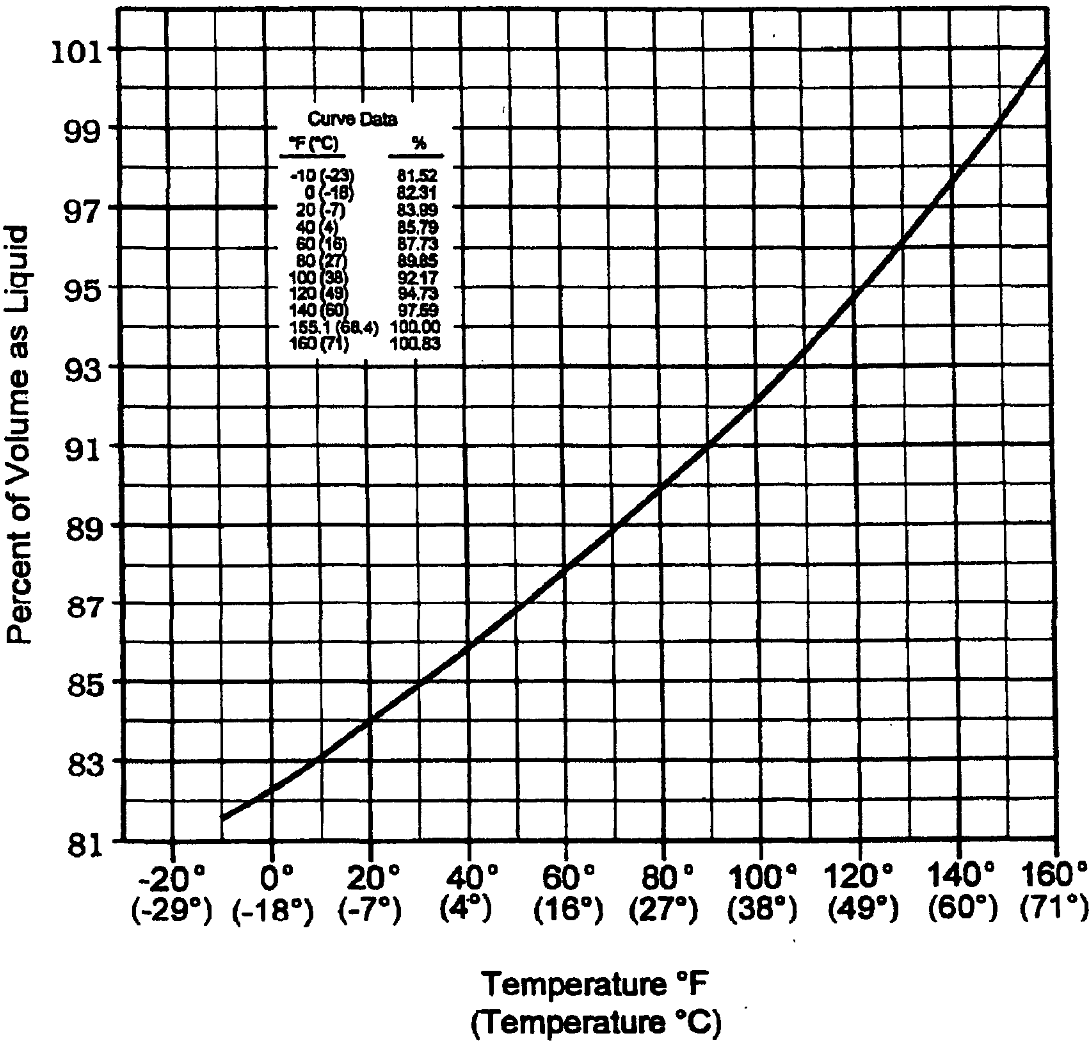
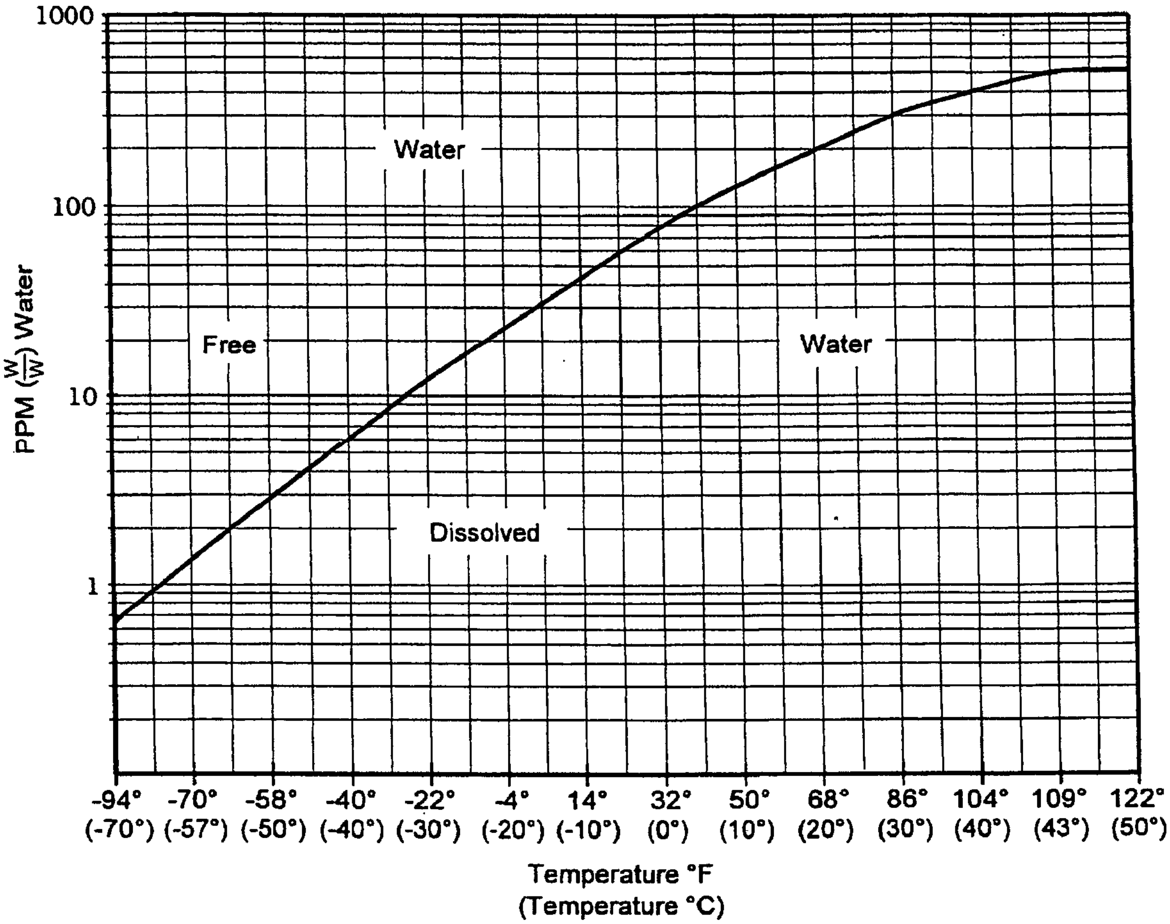


Figure 10.5 Solubility of Water in Liquid Chlorine
(Reference CI Pamphlet 100)

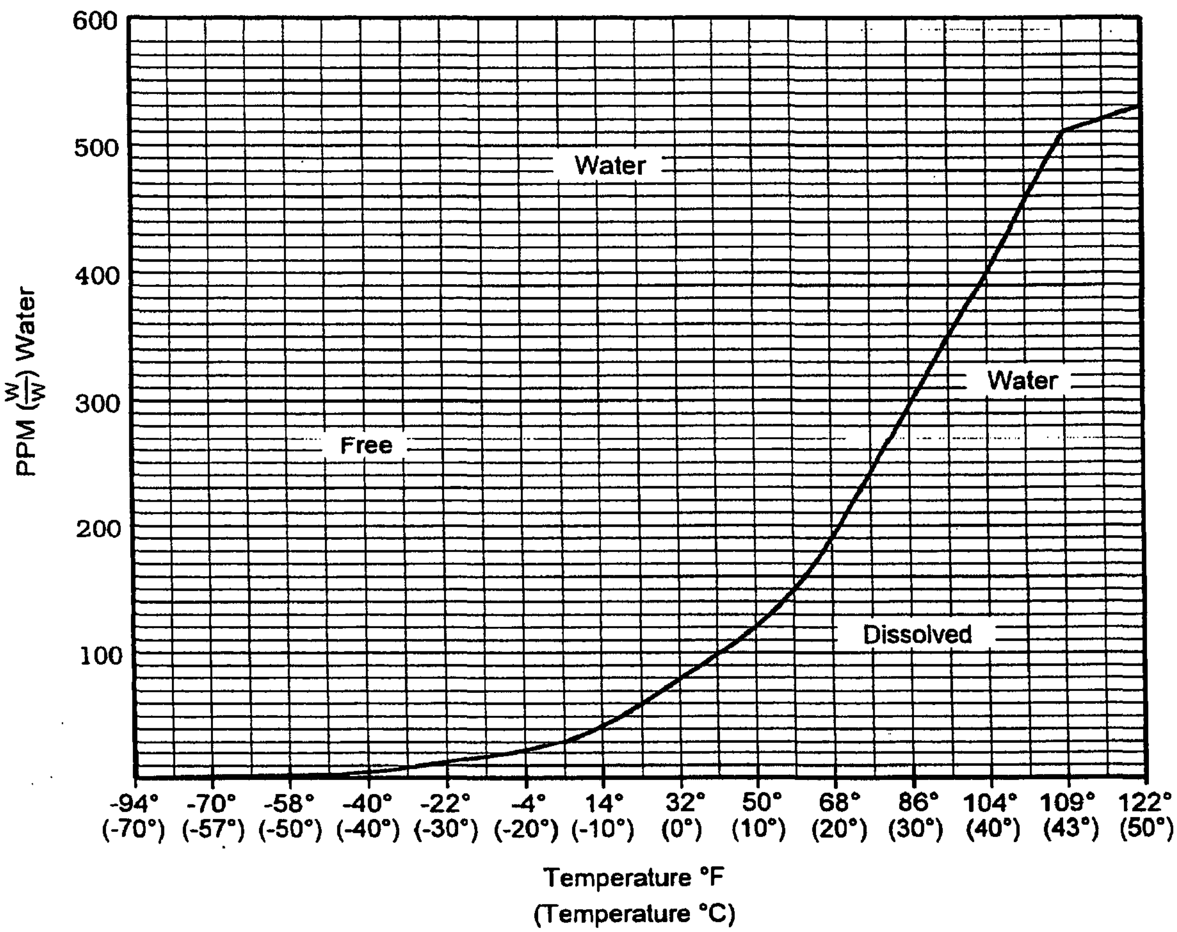


Note: Above the curve, the chlorine is wet. Below the curve, the chlorine is dry.

The following are examples using this figure:

- Chlorine with a water content of 30 ppm at a temperature of 50°F (10°C) is dry. If this same chlorine were at a temperature of -4°F (-20°C) the chlorine is wet.
- Chlorine at 41°F (5°C) is dry if the water content does not exceed 100 ppm.

Figure 10.6 Solubility of Water in Liquid Chlorine
(Reference Cl Pamphlet 100)



Note: Above the curve, the chlorine is wet. Below the curve, the chlorine is dry. The following are examples using this figure:

- Chlorine with a water content of 30 ppm at a temperature of 50°F (10°C) is dry. If this same chlorine were at a temperature of -4°F (-20°C) the chlorine is wet.
- Chlorine at 41°F (5°C) is dry if the water content does not exceed 100 ppm.

11. SELECTED REFERENCES

Many of the following references are cited in the text. Such references are to the editions current at the date of publication of this pamphlet. The reader should be aware that changing technology or regulations may require a change in the reference cited.

11.1 U.S. GOVERNMENT REGULATIONS AND SPECIFICATIONS

All U.S. regulations and specifications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. www.gpo.gov

11.1.1 Code of Federal Regulations (CFR), Various Sections.

11.1.2 Chlorine Technical, Liquid; Federal Specification BB-C 120 C.

11.2 CANADIAN REGULATIONS

Most Canadian regulations can be obtained from the Canadian Government Publishing Center. publications.gc.ca

11.3 CHLORINE INSTITUTE (CI)

1300 Wilson Boulevard
Arlington, VA 22209
www.chlorineinstitute.org

11.3.1 Pamphlets and Instructional Booklets

Refer to the current CI catalog for a complete list of pamphlets.

Pamphlet #	Title
5	Bulk Storage of Liquid Chlorine
6	Piping Systems for Dry Chlorine
9	Chlorine Vaporizing Systems
10	North American Chlor-Alkali Industry Plants and Production Data Reports
17	Packaging Plant Safety and Operational Guidelines
21	Nitrogen Trichloride - A Collection of Reports and Papers
49	Recommended Practices for Handling Chlorine Bulk Highway Transports
57	Emergency Shut-Off Systems for Bulk Transfer of Chlorine
60	Chlorine Pipelines
63	First Aid, Medical Management/Surveillance and Occupational Hygiene Monitoring Practices for Chlorine

Pamphlet #	Title
64	Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities
65	Personal Protective Equipment for Chlor-Alkali Chemicals
66	Recommended Practices for Handling Chlorine Tank Cars
72	Properties of Chlorine in SI Units
73	Atmospheric Monitoring Equipment for Chlorine
74	Guidance on Complying with EPA Requirements under the Clean Air Act Estimating the Area Affected by a Chlorine Release
76	Guidelines for the Safe Motor Vehicular Transportation of Chlorine Cylinders and Ton Containers
85	Recommendations for Prevention of Personnel Injuries for Chlorine Producer and User Facilities
86	Recommendations to Chlor-Alkali Manufacturing Facilities for the Prevention of Chlorine Releases
89	Chlorine Scrubbing Systems
91	Checklist for Chlorine Packaging Plants, Chlorine Distributors and Tank Car Users of Chlorine
95	Gaskets for Chlorine Service
100	Dry Chlorine: Definitions and Analytical Issues
121	Explosive Properties of Gaseous Mixtures Containing Hydrogen and Chlorine
139	Electrical Safety in Chlor-Alkali Cell Facilities
152	Safe Handling of Chlorine Containing Nitrogen Trichloride
155	Water and Wastewater Operators Chlorine Handbook
164	Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials
165	Instrumentation for Chlorine Service
166	Angle Valve Guidelines for Chlorine Bulk Transportation
IB/A	Instruction Booklet: Chlorine Institute Emergency Kit "A" for 100- and 150-lb. Chlorine Cylinders
IB/B	Instruction Booklet: Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers
IB/C	Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks

11.3.2 Drawings

Refer to the current CI catalog for a complete list of drawings.

11.3.3 Audio/Visual Materials

These materials are available in both English and Spanish (except H-VIDEO) and in both video and DVD format.

Video/DVD	**Title**
A-VIDEO	How to Use the Chlorine Institute Emergency Kit "A" for 100-lb. and 150-lb. Chlorine Cylinders
B-VIDEO	How to Use the Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers
C-VIDEO	How to Use the Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks
H-VIDEO	Health Effects from Short-Term Chlorine Exposure
W-VIDEO	Chlorine Safety for Water and Wastewater Operators

11.4 AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

1330 Kemper Meadow Drive
Cincinnati, OH 45240
www.acgih.org

11.4.1 *Threshold Limit Values and Biological Exposure Indices*, Published Annually.

11.4.2 *Industrial Ventilation Manual: A Manual of Recommended Practices*, 22nd Edition, 1995.

11.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

3 Park Avenue
New York, NY 10016-5990.
www.asme.org

11.5.1 *Rules for Construction of Pressure Vessels*, Sections VIII, Division ASME Boiler, and Pressure Vessel Code ANSI/ASME BPV-VIII- 1.

11.6 ASTM INTERNATIONAL (ASTM)

(Formerly American Society for Testing and Materials)
100 Barr Harbor Drive
P.O. Box C700
West Conshohocken, PA 19428-2959
www.astm.org

11.6.1 ASTM-E4 10-92, Standard Method of Testing for Moisture and Residue in Liquid Chlorine.

11.6.2 ASTM-E4 12-86, *Standard Method of Assaying Liquid Chlorine* (Zinc Amalgam Method).

11.6.3 ASTM-E649-94, *Standard Test Method for Bromine in Chlorine*.

11.6.4 ASTM-E806-93, *Standard Test Method for the Determination of Carbon Tetrachloride and Chloroform in Liquid Chlorine by Direct Injection* (Gas Chromatographic Procedure).

11.6.5 ASTM-D2022-89, *Standard Methods of Sampling and Chemical Analysis of Chlorine-Containing Bleaches.*

11.7 AMERICAN WATER WORKS ASSOCIATION (AWWA)

6666 West Quincy Avenue
Denver, CO 80235.
www.awwa.org

11.8 ASSOCIATION OF AMERICAN RAILROADS (AAR)

50 F Street, NW
Washington, DC 20001
www.aar.org

11.9 COMPRESSED GAS ASSOCIATION (CGA)

4221 Walney Road, 5th Floor
Chantilly, VA 20151
www.cganet.com

11.9.1 *Handbook of Compressed Gases* Van Nostrand Reinhold, New York, NY.

11.9.2 Pamphlet C-1, *Methods for Hydrostatic Testing of Compressed Gas Cylinders*.

11.9.3 Pamphlet C-6, *Standards for Visual Inspection of Compressed Gas Cylinders*.

11.9.4 Pamphlet P-1, *Safe Handling of Compressed Gases in Containers*.

11.9.5 Pamphlet V-1, *Compressed Gas Cylinder Valve Outlet and Inlet Connections* (This pamphlet is also designated as ANSI B57.1 and CSA b96.)

11.10 NATIONAL ACADEMY OF SCIENCES (NAS)

Printing and Publishing Office
500 Fifth Street, NW
Washington, DC 20001
www.nationalacademies.org

11.10.1 Water Chemicals Codex, 1982.

11.10.2 *Food Chemicals Codex V*, Fifth Edition, 2003.

11.11 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

Batterymarch Park
Quincy, MA 02169
www.nfpa.org

11.12 NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

1600 Clifton Road
Atlanta, GA 30333
www.cdc.gov/niosh/

Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services: 1994.

11.13 NATIONAL SAFETY COUNCIL

1121 Spring Lake Drive
Itasca, IL 60143-3201
www.nsc.org

11.14 NSF INTERNATIONAL

789 N. Dixboro Road
Ann Arbor, MI 48105
www.nsf.org

ANSI/NSF Standard 60 - *Drinking Water Additives-Health Effects*; updated annually.

11.15 THE HAMNER INSTITUTES FOR HEALTH SCIENCES

6 Davis Drive
Research Triangle Park, NC 27709
www.thehamner.org

11.16 WATER ENVIRONMENT FEDERATION (WEF)

601 Wythe Street
Alexandria, VA 22314
www.wef.org

11.17 WORLD HEALTH ORGANIZATION (WHO)

Avenue Appia 20
1211 Geneva 27, Switzerland
www.who.int

Environmental Health Criteria 21 Chlorine and Hydrogen Chloride, 1982.

11.18 OTHER REFERENCES

11.18.1 Adams, F. W.; Edmonds, R. G.; *I & EC*, 1937, 29, 447.

11.18.2 *Alkali and Chlorine Products and Chlorine and Sodium Hydroxide*; Kirk-Othmer Encyclopedia of Chemical Technology; ed. 4; Editor: John Wiley & Sons, New York, NY, 1991.

CHLORINE

The Essential Element

Over 200 years ago, a young Swedish researcher, Carl Wilhelm Scheele, discovered chlorine. Because of its reactivity and bonding characteristics, chlorine has become a popular building block in chemistry and it is essential in everyone's life. Drinking water, agricultural abundance, disinfected waste water, essential industrial chemicals, bleaches, and fuels all depend on chlorine. Pharmaceutical, plastics, dyes, cosmetics, coatings, electronics, adhesives, clothing, and automobile parts are examples of product groups that depend on chlorine chemistry.

APPLICATIONS OF CHLORINE

Automotive
Foam Seating
Paints
Plastic Bumpers
Molding Instruments
Floor Mats
Fabric
Seat Belts
Tire Cords
Dashboards
Hoses

Construction
Carpeting
Upholstery
Wire Insulation
Pipes
Siding
Flooring
Paints
Coatings

Defense
Bullet-Proof Vests
Helmets
Parachutes
Water Repellant Fibers
Shatter-Resistant Glass
Titanium Aircraft
Jet Engines
Missiles

Electronics
Semiconductors
Computer Disks
Wire Insulation

Food Production & Handling
Herbicides
Vitamins B1 & B6
Cleaners
Disinfectants
Thermal Insulation
Sterile Packaging

Health Care
Electronic Instruments
Sterile Packaging
Surgical Equipment
Cleaning Compounds
Prescription Eye Wear
Laboratory Reagents

Medicines
Antibiotics
CancerTreatment
Pain Relievers
Local Anesthetics
Antihistamines
Decongestants

Metal Production
Magnesium
Nickel
Bismuth
Titanium
Zirconium
Zinc

Outdoor Recreation
Neoprene Wet Suits
Inflatable Rafts
Golf Grip
Surf Boards
Nylon Ropes
Tents
Sleeping Bags
Coats
Backpacks
Waterproof Clothing

Water Treatment
Safe Drinking Water
Wastewater Treatment

64of593

THE CHLORINE INSTITUTE, INC.

THE CHLORINE INSTITUTE, INC. since 1924 A LEGACY OF SAFETY STEWARDSHIP

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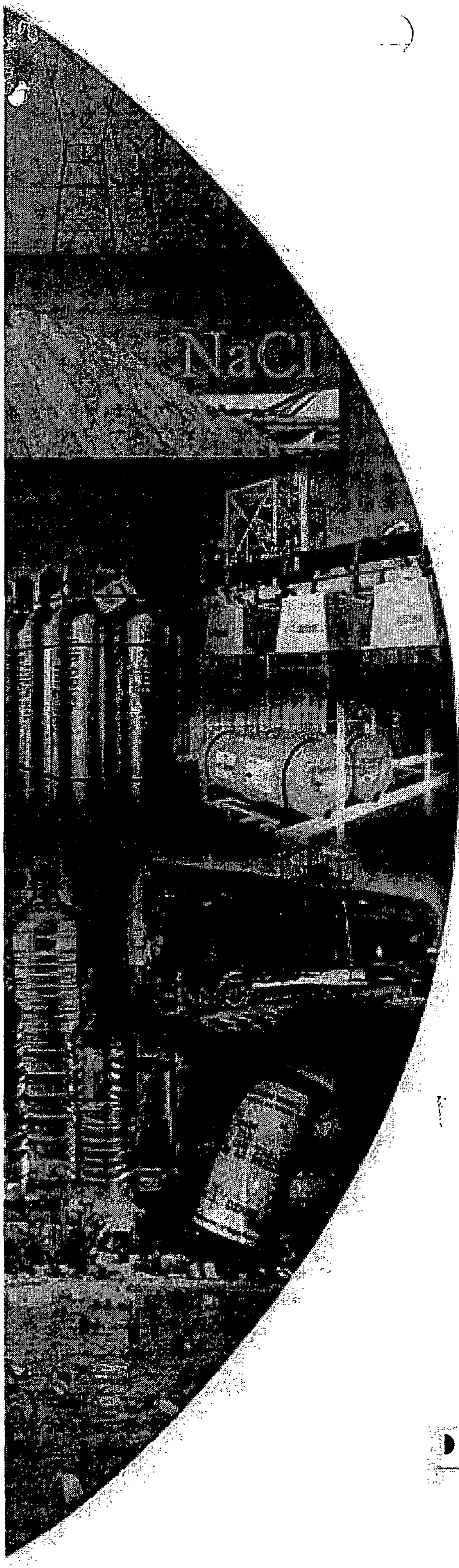

THE CHLORINE INSTITUTE, INC.

Pamphlet 6

PIPING SYSTEMS FOR DRY CHLORINE

EDITION 15

A LEGACY OF SAFETY STEWARDSHIP since 1924

May 2005

66of593

Table of Contents

1. INTRODUCTION

1.1 Scope

This publication is intended to provide useful information concerning chlorine piping systems. This pamphlet's objective is to offer practical suggestions in the selection of material suited for the indicated service. Use of materials other than those recommended herein may be technically desirable in specific producing/ consuming sites. This pamphlet does not intend to override specific technical needs. Underground (buried) chlorine piping system design is beyond the scope of this pamphlet and should be undertaken only by engineers experienced in that field. Recommendations given in Pamphlet 60 (13.1.4) may be a useful reference to the designer.

All parts of this pamphlet should be consulted before deciding on the components of a piping system. Listed are pipe, valves, and fittings suitable for use with dry chlorine in either the liquid or gaseous phase, at temperatures between -150°F (-101°C) and 300°F (149°C). Reference is made to Pamphlet 100 (13.1.8). Material selection based on the recommendations of this pamphlet shall take into consideration the operating conditions and the possible corrosive nature of chlorine, particularly when moisture unintentionally enters systems. Sound engineering principles should be applied in the selection of all equipment.

The Chlorine Institute does not approve, rate, certify, or endorse any product or construction except for certain equipment used in transportation. In each such case, there is an approved Chlorine Institute drawing. If equipment does not comply in every respect with such drawings, its manufacturers are not authorized to use the Chlorine Institute name in advertising.

It is recognized that facilities built prior to the publication of this edition of this pamphlet may be operating successfully without adhering to all recommendations contained herein. Operators of such facilities should evaluate discrepancies and validate that they do not pose disproportionate risks to safe operation or the environment. Continued operation without adhering to all aspects of this pamphlet is generally acceptable provided that:

- Previous successful, long-term operation coupled with periodic hazard evaluations show that risks to safe operations and the environment are sufficiently low
- The system does not violate applicable codes or regulations; and
- Consideration is given to modifying the system to meet recommendations contained in this edition of the pamphlet when redesign or replacement projects are planned.

1.2 Chlorine Institute Stewardship Program

The Chlorine Institute, Inc. 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.

1.3 Definitions

In this pamphlet, the following meanings apply unless otherwise noted:

ANSI	American National Standards Institute, Inc.
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	The American Society for Testing and Materials
chlorine	the chemical element in either the liquid or gaseous state
CPE	chlorinated polyethylene elastomer
CWP	cold working pressure
dry chlorine	dry as defined in Pamphlet 100
ECTFE	ethylene chlorotrifluoroethylene
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
gas purge	the use of clean, dry, oil-free compressed air or nitrogen, dried to a dew point of -40°F (-40°C) measured at the operating pressure
Hastelloy	a registered trademark of Haynes International, Inc.
Inconel	a registered trademark of Inco Alloys International, Inc.
Institute	The Chlorine Institute, Inc.
Kalrez	a registered trademark of DuPont Dow Elastomers
kPa	kilopascal
liquid hammer	a sudden velocity change of a flowing fluid (liquid or gas) which results in a pressure wave that travels through the fluid at the speed of sound for that fluid causing an audible sound; this sudden velocity change in liquid or gaseous chlorine piping is often the result of rapid vaporization

	or condensation due to large temperature differentials and the extremely low heat capacity and low heat of vaporization of chlorine
Monel	a registered trademark of Inco Alloys International, Inc.
MSS	Manufacturers Standardization Society of the Valve & Fittings Industry, Inc.
NPS	nominal pipe size
OD	outside diameter
PFA	perfluoroalkoxy
ppm	parts per million (can be weight or volume basis)
psia	pounds per square inch absolute
psig	pounds per square inch gage
PTFE	polytetrafluoroethylene
PVDF	polyvinylidene fluoride
Sch	Schedule
UNS	Unified Numbering System
Stellite	a registered trademark of Deloro Stellite, Inc.
Viton	a registered trademark of Dupont Dow Elastomers

1.4 Disclaimer

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require changes in the recommendations contained herein. Appropriate steps should be taken to ensure that the information is current when used. These recommendations should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.5 Approval

The Institute's Storage and Transport Committee approved Edition 15 of this pamphlet at a meeting held on March 22, 2005.

1.6 Revisions

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

1.7 Reproduction

2. GENERAL

2.1 Precautions

Chlorine is a hazardous material. It is normally used and processed as a liquid or gas under pressure. For general precautions in chlorine handling, the reader should refer to the Institute's Chlorine Manual (13.1.1).

This pamphlet outlines practices that industry has found to be safe and environmentally sound. Extraordinary practices such as the use of double wall piping are not required as long as the system is installed, maintained and inspected per the recommendations contained herein.

Particular care must be taken as follows:

a) Assure that all piping is thoroughly purged of chlorine before burning or welding. Dry chlorine can support combustion of carbon steel and other metals.

b) Protect piping from over pressure where chlorine can be trapped between closed valves. Liquid chlorine has an unusually high coefficient of thermal expansion that can cause piping to rupture as temperature increases, unless the piping system is protected with items such as expansion chambers, relief devices, or other suitable means.

c) Assure that dry chlorine systems are protected from the intrusion of moisture. Moisture from wet compressed air or from exposure to ambient air can cause severe corrosion and rapid failure of welds, valves, hoses, and fittings.

d) Do not use titanium in dry chlorine service. Dry chlorine reacts with titanium to cause corrosion or combustion. Titanium can only be used with wet chlorine.

e) Assure that dry chlorine systems are thoroughly cleaned and dried and are free of oils, grease, and other materials which would react with chlorine to cause fire, corrosion, pressure increase, or harmful deposits (Section 11).

f) Inspect all chlorine piping systems at regular intervals for signs of leakage, internal or external corrosion, insulation failure, adequate identification and supports (Section 12).

g) Consider fugitive emission issues when designing piping systems for chlorine.

h) Assure liquid chlorine piping is adequately protected from liquid hammer damage. Chlorine liquid has a high density that can result in large hydraulic shock forces.

i) When evacuating liquid chlorine piping systems, ensure nitrogen trichloride is not concentrated to dangerous levels (Pamphlet 152 (13.1.9)).

j) Historically, producers have not designed chlorine piping systems for Category M Fluid Service (ASME B31.3). It is important to note that the decision to design to Category M rests with the system owner. Users may wish to incorporate provisions of Category M requirements that have been found to enhance safety.

2.2 Certification

Manufacturers or suppliers of chlorine piping components must certify to the user, when requested, that their product complies with recommendations in this pamphlet. In addition, limitations and any deviations from the recommendations contained herein shall be specifically noted.

2.3 Materials

This pamphlet provides minimal recommendations for the components of piping systems. In general, carbon steel or alloy steel piping are recommended for handling dry chlorine. The Institute believes these materials are suitable for the indicated service. Where reference is made to specific materials, other materials may be used so long as the user has evidence that the alternate materials are equal or superior in the intended service.

Specific components (e.g. piping, fittings, gaskets, nuts and bolts, valves, etc.) have been organized into service classes in Sections 3 and 4 according to the operating pressure and temperature of the chlorine gas and liquid. These service classes are as follows:

Service Class	Fluid State	Pressure	Temperature
Class I	Gas Only	Vacuum to 150 PSIG (1034 kPa)	-20°F to 300°F (-29°C to 149°C)
Class II	Gas Only	Vacuum to 150 PSIG (1034 kPa)	-50°F to 300°F (-46°C to 149°C)
Class III	Gas Only	Vacuum to 150 PSIG (1034 kPa)	-150°F to 300°F (-101°C to 149°C)
Class IV[1]	Gas or Liquid	Vacuum to 300 PSIG (2068 kPa)	-20°F to 300°F (-29°C to 149°C)
Class V[1]	Gas or Liquid	Vacuum to 300 PSIG (2068 kPa)	-50°F to 300°F (-46°C to 149°C)
Class VI[1]	Gas or Liquid	Vacuum to 300 PSIG (2068 kPa)	-150°F to 300°F (-101°C to 149°C)

[1] Piping classes corresponding to the fluid state "gas or liquid" are to be used for all liquid-only lines and gas lines where the possibility of liquid entry exists or where there is the possibility that gas in a line may liquefy.

Chlorine has a low atmospheric boiling point, and its vapor pressure rises rapidly with increasing temperature. Therefore, it is important to select materials that have adequate strength and maintain ductility at low temperature. The following are several material selection examples based on industry experience:

- For service temperatures above -20°F (-29°C), fine grain carbon steel pipe such as ASTM A587 can be cold bent, but other carbon steel pipe should be normalized after bending. To ensure rigidity and protection from outside abuse, pipe of ¾" nominal size or larger should be used. Nonferrous and nonmetallic tubing and fittings of appropriate size may sometimes be used (Sections 7 & 9). Cast iron or malleable iron fittings and general-purpose valves are not recommended for chlorine service. Ductile iron per ASTM A395 may be used for valves and strainers designed for chlorine gas service (Class I) only.

- Temperatures below -20°F (-29°C) may be encountered in chlorine systems, and below this temperature some steels become brittle. ASTM A333 carbon steel and alloy steel pipe and corresponding fittings are recommended, with grades specific to the expected low temperature. Stainless steels of the 300 series have useful properties for low-temperature service, but can fail due to chloride-stress corrosion-cracking in the presence of moisture, particularly at ambient or elevated temperatures.

- Butt-welded and flanged joints are recommended for all sizes. Screwed and socket-welded joints are alternatives for nominal pipe sizes up through 1½" in some classes (Section 3).

- When thermally or electrically applied coatings are applied to fasteners for corrosion protection, the coating process should be reviewed to ensure against the possibility of hydrogen embrittlement or altered mechanical properties (de-tempering).

- For service temperatures between -20°F (-29°C) and 0°F (-18°C) where thermal shock or liquid hammer is anticipated, the use of impact-tested steels or the use of Class V material is advisable.

- There may be situations where the user contemplates chlorine service outside the process conditions defined in this pamphlet. In those cases, the user is advised to review each aspect of the service class in this pamphlet which is closest in process conditions to the contemplated use, individually determine which aspects of the recommendations are acceptable, and engineer revisions to those portions which are not acceptable.

2.4 Selection

All parts of this pamphlet should be consulted before selecting the components of a piping system. When making design decisions, the designer should consider variable operating conditions including start-ups, upsets, shutdowns, and system evacuation.

The recommendations contained herein are generally in accord with ASME B31.3 (13.2.8). Within that standard there are three fluid classifications. They are "D", "Normal Fluid Service", and "M". Typically, chlorine piping systems have been designed for "Normal Fluid Service", but elements of Category M design have appeal to users.
The Institute position relative to Category M (Appendix B) design is as follows:

- The owner is responsible for determining fluid class

- A single exposure to a very small quantity of chlorine does not cause irreversible harm.

- Current design practices have been adequate to prevent significant releases and several elements of Category M design would eliminate use of currently proven equipment.

- It is good practice for users to develop site-specific chlorine piping specifications that use the recommendations outlined herein as a base and consider including elements of Category M requirements (such as NDT examination) that enhance reliability at their sites.

2.5 Welding

Specific details covering all situations for welding are beyond the scope of this pamphlet. However, welding of pipe must be performed by qualified individuals currently experienced in the specific metallurgy. Procedures and welder qualifications must be in accordance with ANSI/ASME BPV-IX (13.2.10) and ASME B31.3 (13.2.8). Care must be taken to insure the use of proper welding procedures; correct filler metal and adequate preheat or post heat treatment especially where alloy steel piping is used.

A welding non-destructive testing program should be in place where welded systems are contemplated. The program, at a minimum, should follow the examination guidelines outlined in ASME B31.3 (13.2.8).

3. PIPE AND PIPING COMPONENTS

This section provides minimum specifications for pipe, fittings, and components for dry chlorine piping systems. The Institute believes these materials are suitable for the service shown. Specific components have been arranged according to the Service Classes I through VI as indicated in Section 2.3 and according to the following breakdown:

- Threaded Construction
  - Classes I and IV

- Socket-welded Construction
  - Classes I and IV
  - Classes II and V

- Butt-welded Construction
  - Classes I, II and III
  - Classes IV, V and VI

Table 3-1. Threaded Construction				
Component	**Nominal Pipe Size (NPS)**	**Class I**	**Class IV**	**Classes II, III, V & VI**
Pipe	Through 1½"	ASTM A106 Grade B Sch 80 carbon steel seamless ASME B36.10	ASTM A106 Grade B Sch 80 carbon steel seamless ASME B36.10	[See Note 3]
Fittings	Through 1½"	ASTM A105, Class 3000 forged steel threaded ASME B16.11 [See Note 1]	ASTM A105, Class 3000 forged steel threaded ASME B16.11 [See Note 1]	[See Note 3]
Flanges	Through 1½"	ASTM A105, Class 150 forged steel raised-face or tongue-and-groove, threaded ASME B16.5 [See Note 4]	ASTM A105, Class 300 forged steel raised-face or tongue-and-groove, threaded ASME B16.5 [See Note 4]	[See Note 3]
Unions, Flanged	Through 1½"	ASTM A105, Class 150 forged steel, raised-face or tongue-and-groove, threaded ASME B16.5 [See Note 4]	ASTM A105, Class 300 forged steel, raised-face or tongue-and-groove, threaded ASME B16.5 [See Note 4]	[See Note 3]
Unions, Hammer	Through 1½"	ASTM A105, Class 3000 forged steel lug nut unions, threaded	ASTM A105 Class 3000 forged steel lug nut unions, threaded	[See Note 3]
Branch Connections	Through 1½"	Fittings per Table 3-1 threaded tees, reducing tees, tees with swaged nipples or threaded olets. Bushings not recommended.	Fittings per Table 3-1 threaded tees, reducing tees, tees with swaged nipples or threaded olets. Bushings not recommended.	[See Note 3]

Table 3-1. Threaded Construction				
Component	Nominal Pipe Size (NPS)	Class I	Class IV	Classes II, III, V & VI
Bolts	All sizes	ASTM A193 Grade B7 alloy steel quenched and tempered, stud bolts and cap screws ASME B18.2.1 [See Note 6 & 8]	ASTM A193 Grade B7 alloy steel quenched and tempered, stud bolts and cap screws ASME B18.2.1 [See Note 6 & 8]	[See Note 3]
Nuts	All sizes	ASTM A194 Grade 2H carbon steel heavy hex nuts ASME B18.2.2 [See Note 6]	ASTM A194 Grade 2H carbon steel heavy hex nuts ASME B18.2.2 [See Note 6]	[See Note 3]
Gaskets	All sizes	[See Note 7]	[See Note 7]	[See Note 3]
Gaskets Tongue & Groove Flanges	All sizes	Chemical lead with 2-4% antimony	Chemical lead with 2-4% antimony	[See Note 3]
Thread Dope	All sizes	PTFE tape [See Note 2]	PTFE tape [See Note 2]	[See Note 3]
Gasket Dope (if required)	All sizes	Fluorocarbon grease [See Note 5]	Fluorocarbon grease [See Note 5]	[See Note 3]

The complete titles of specifications are listed in Section 13.

Note 1 The number of threaded connections should be minimized.

Note 2 Additional types of thread dopes that have been used successfully include PTFE paste and white lead paste. Paste, if used, must contain only materials suitable for chlorine service. In all cases, care must be taken to prevent the thread dope from entering the interior of the piping system.

Note 3 Except for connections to transportation equipment, instruments and special process equipment, threaded construction should not be used for Classes II, III, V, and VI. In any case, threaded connections should not exceed 1½" NPS.

Note 4 Two bolt flanges are acceptable in bulk container unloading systems (see Drawing 118 (13.1.9)) and have been used in rigid piping systems. Care must be taken to apply the gasket loading forces uniformly by tightening both bolts evenly.

Note 5 Gasket dope must contain only materials which are nonreactive with chlorine. Consideration should be given to the possibility of gasket degradation.

Note 6 Threads shall be to ASME B1.1. Bolts shall have a Class 2A fit and nuts shall have a Class 2B fit.

Note 7 The Institute's Pamphlet 95 (13.1.7) contains a current list of gaskets that have been tested and have performed satisfactorily by member companies.

Note 8 Stud bolts are preferred on in-line piping components that do not have tapped threads. Cap screws may be used for tapped piping components and instrumentation.

Table 3-2. Socket-Welded Construction - Classes I and IV

Component	Nominal Pipe Size (NPS)	Class I	Class IV	Classes III & VI
Pipe	Through 1½"	ASTM A106 Grade B Sch 80 carbon steel, seamless ASME B36.10	ASTM A106 Grade B Sch 80 carbon steel, seamless ASME B36.10	[See Note 4]
Fittings	Through 1½"	ASTM A105, Class 3000 forged steel, socket weld ASME B16.11 [See Note 1]	ASTM A105, Class 3000 forged steel, socket weld ASME B16.11 [See Note 1]	[See Note 4]
Flanges	Through 1½"	ASTM A105, Class 150 forged steel raised-face or tongue-and-groove, socket weld ASME B16.5 [See Note 2]	ASTM A105, Class 300 forged steel raised-face or tongue-and-groove, socket weld ASME B16.5 [See Note 2]	[See Note 4]
Unions, Flanged	Through 1½"	ASTM A105 Class 150 forged steel raised face or tongue-and-groove, socket-weld ASME B16.5 [See Note 2]	ASTM A105 Class 300 forged steel raised face or tongue-and-groove, socket-weld ASME B16.5 [See Note 2]	[See Note 4]
Unions, Hammer	Through 1½"	ASTM A105 Class 3000 forged steel lug nut unions, socket-weld	ASTM A105 Class 3000 forged steel lug nut unions, socket-weld	[See Note 4]
Branch Connections	Through 1½"	Fittings per Table 3-2 socket-welded tees, reducing tees, tees with swaged nipples, or socket-weld olets. Socket-weld inserts are not recommended.	Fittings per Table 3-2 socket-welded tees, reducing tees, tees with swaged nipples, or socket-weld olets. Socket-weld inserts are not recommended.	[See Note 4]

Table 3-2. Socket-Welded Construction - Classes I and IV				
Component	Nominal Pipe Size (NPS)	Class I	Class IV	Classes III & VI
Bolts	All sizes	ASTM A193 Grade B7 Alloy steel quenched and tempered, alloy steel stud bolts and cap screws ASME B18.2.1 [See Notes 6 and 8]	ASTM A193 Grade B7 Alloy steel quenched and tempered, alloy steel stud bolts and cap screws ASME B18.2.1 [See Notes 6 and 8]	[See Note 4]
Nuts	All sizes	ASTM A194 Grade 2H carbon steel heavy hex nuts ASME B18.2.2 [See Note 6]	ASTM A194 Grade 2H carbon steel heavy hex nuts ASME B18.2.2 [See Note 6]	[See Note 4]
Gasket	All sizes	[See Note 7]	[See Note 7]	[See Note 4]
Gasket Dope (if required)	All sizes	Fluorocarbon grease [See Note 3]	Fluorocarbon grease [See Note 3]	[See Note 4]

The complete titles of specifications are listed in Section 13.

For notes applicable to Table 3-2 refer to notes after Table 3-3.

Table 3-3. Socket-Welded Construction - Classes II and V			
Component	Nominal Pipe Size (NPS)	Class II	Class V
Pipe	Through 1½"	ASTM A333 Grade 1 or Grade 6 Sch 80 carbon steel, seamless, ASME B36.10 (Charpy test at -50°F/-46°C)	ASTM A333 Grade 1 or Grade 6 Sch 80 carbon steel seamless, ASME B36.10 (Charpy test at -50°F/-46°C)
Fittings	Through 1½"	ASTM A350 Grade LF2 Class 3000 forged steel, socket-weld ASME B16.11 (Charpy test at -50°F/-46°C) [See Note 1]	ASTM A350 Grade LF2 Class 3000 forged steel, socket-weld ASME B16.11 (Charpy test at -50°F/-46°C) [See Note 1]

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Table 3-3. Socket-Welded Construction - Classes II and V			
Component	Nominal Pipe Size (NPS)	Class II	Class V
Flanges	Through 1½"	ASTM A350 Grade LF2 Class 150 forged steel, raised-face or tongue-and-groove, socket-weld ASME B16.5 (Charpy test at -50°F/-46°C) [See Note 2]	ASTM A350 Grade LF2 Class 300 forged steel raised-face or tongue-and-groove, socket-weld ASME B16.5 (Charpy test at -50°F/-46°C) [See Note 2]
Unions, Flanged	Through 1½"	ASTM A350 Grade LF2 Class 150 forged steel, raised-face or tongue-and-groove, socket-weld ASME B16.5 (Charpy test at -50°F/-46°C)	ASTM A350 Grade LF2 Class 300 forged steel raised-face or tongue-and-groove, socket-weld ASME B16.5 (Charpy test at -50°F/-46°C)
Branch Connections	All sizes	Fittings per Table 3-3 socket-welded tees, reducing tees, tees with swaged nipples, or socket-weld olets. Socket-weld inserts are not recommended.	Fittings per Table 3-3 socket-welded tees, reducing tees, tees with swaged nipples, or socket-weld olets. Socket-weld inserts are not recommended.
Bolts	All sizes	ASTM A320 Grade L7 alloy steel stud bolts and cap screws ASME B18.2.1 (Charpy test at -150°F/-101°C) [See Notes 5, 6 and 8]	ASTM A320 Grade L7 alloy steel stud bolts and cap screws ASME B18.2.1 (Charpy test at -150°F/-101°C) [See Notes 5, 6 and 8]
Nuts	All sizes	ASTM A194 Grade 4 alloy steel heavy hex nuts (Charpy test at -150°F/-101°C) or Grade L7; ASME B18.2.2 [See Notes 5 and 6]	ASTM A194 Grade 4 alloy steel heavy hex nuts (Charpy test at -150°F/-101°C) or Grade L7; ASME B18.2.2 [See Notes 5 and 6]
Gaskets Tongue & Groove Flanges	All sizes	Chemical lead with 2-4% antimony	Chemical lead with 2-4% antimony
Gaskets	All sizes	[See Note 7]	[See Note 7]
Gasket Dope	All sizes	Fluorocarbon grease [See Note 3]	Fluorocarbon grease [See Note 3]

The complete titles of specifications are listed in Section 13.

Note 1 Socket-welded piping is acceptable for chlorine service through 1½" NPS.

Note 2 Two-bolt flanges are acceptable in bulk container unloading systems (see Drawing 118, (13.1.19) and have been used in rigid piping systems. Care must be taken to apply the gasket loading forces uniformly by tightening both bolts evenly.

Note 3 Gasket dope must contain only materials which are nonreactive with chlorine. Consideration should be given to the possibility of gasket degradation.

Note 4 Socket-welded construction should not be used in Classes III and VI.

Note 5 ASTM A193 Grade B7M bolts and ASTM A194 Grade 2H or 2HM nuts may be substituted.

Note 6 Threads shall be to ASME B1.1. Bolts shall have a Class 2A fit and nuts shall have a Class 2B fit.

Note 7 The Institute's Pamphlet 95 (13.1.7) contains a current list of gaskets that have been tested and have performed satisfactorily by member companies.

Note 8 Stud bolts are preferred on in-line piping components that do not have tapped threads. Cap screws may be used for tapped piping components and instrumentation.

Table 3-4. Butt-Welded Construction - Classes I, II and III

Component	Nominal Pipe Size (NPS)	Class I	Class II	Class III
Pipe	Through 1½"	ASTM A106 Grade B Sch 80 carbon steel seamless ASME B36.10	ASTM A333 Grade 1 or Grade 6 Sch 80 carbon steel seamless or welded ASME B36.10 (Charpy test at -50°F/-46°C)	ASTM A333 Grade 3 Sch 80 alloy steel seamless or welded ASME B36.10 (Charpy test at -150°F/-101°C)
Pipe	2" through 4"	ASTM A106 Grade B or A53 Grade B Sch 40 or 80 Type E or S carbon steel ASME B36.10 [See Note 1]	ASTM A333 Grade 1 or Grade 6 Sch 40 or 80 carbon steel seamless or welded ASME B36.10 (Charpy Test at -50°F/-46°C) [See Note 1]	ASTM A333 Grade 3 Sch 40 or 80 alloy steel seamless or welded ASME B36.10 (Charpy test at -150°F/-101°C) [See Note 1]
Pipe	6" through 12"	ASTM A106 Grade B or A53 Grade B Sch 40, Type E or S carbon steel ASME B36.10	ASTM A333 Grade 1 or Grade 6 Sch 40 carbon steel seamless or welded (Charpy test at -50°F/-46°C) ASME B36.10	ASTM A333 Grade 3 Sch 40 alloy steel seamless or welded (Charpy test at -150°F/-101°C) ASME B36.10

Table 3-4. Butt-Welded Construction - Classes I, II and III				
Component	Nominal Pipe Size (NPS)	Class I	Class II	Class III
Fittings, Wrought	Through 12"	ASTM A234 Grade WPB or WPB-W carbon steel (bore to match pipe) ASME B16.9	ASTM A420 Grade WPL 6 or WPL6-W carbon steel (Charpy test at -50°F/-46°C) (bore to match pipe) ASME B16.9	ASTM A420 Grade WPL3 or WPL3-W alloy steel (Charpy test at -150°F/-101°C) (bore to match pipe) ASME B16.9
Fittings, Forged	Through 12"	ASTM A105 forged steel (bore to match pipe) [See Note 4]	ASTM A350 Grade LF2 forged steel (Charpy tested at -50°F/-46°C) (bore to match pipe) [See Note 4]	ASTM A350 Grade LF3 forged alloy steel (Charpy tested at -150°F/-101°C) (bore to match pipe) [See Note 4]
Flanges	Through 12"	ASTM A105 Class 150 carbon steel raised-face, weld-neck or slip-on (bore to match pipe) ASME B16.5	ASTM A350 Grade LF2, Class 150 carbon steel raised-face, weld-neck or slip-on (Charpy test at -50°F/-46°C) (bore to match pipe) ASME B16.5	ASTM A350 Grade LF3 , Class 150 alloy steel raised-face, weld-neck (Charpy test at -150°F/-101°C) (bore to match pipe) ASME B16.5
Branch Connections	Through 12"	Fittings per Table 3-4 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other components	Fittings per Table 3-4 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other components	Fittings per Table 3-4 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other components
Bolts	All sizes	ASTM A193 Grade B7, alloy steel quenched and tempered stud bolts and cap screws ASME B18.2.1 [See Note 3]	ASTM A320 Grade L7, alloy steel stud bolts and cap screws (Charpy test at -150°F/-101°C) ASME B18.2.1 [See Notes 3, 6 and 8]	ASTM A320 Grade L7 , alloy steel stud bolts and cap screws (Charpy test at -150°F/-101°C) ASME B18.2.1 [See Note 3 and 8]
Nuts	All sizes	ASTM A194 Grade 2H carbon steel heavy hex nuts ASME B18.2.2 [See Note 3]	ASTM A194 Grade 4 alloy steel heavy hex nuts to be Charpy tested at -150°F/-101°C or Grade L7 ASME B18.2.2 [See Note 3 and 6]	ASTM A194 Grade 4 alloy steel heavy hex nuts to be Charpy tested at -150°F/-101°C or Grade L7 ASME B18.2.2 [See Note 3]
Gaskets	All sizes	[See Note 5]	[See Note 5]	[See Note 5]

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Table 3-4. Butt-Welded Construction - Classes I, II and III				
Component	Nominal Pipe Size (NPS)	Class I	Class II	Class III
Gasket Dope (if required)	All sizes	Fluorocarbon grease [See Note 2]	Fluorocarbon grease [See Note 2]	Fluorocarbon grease [See Note 2]

The complete titles of specifications are listed in Section 13.

For notes applicable to Table 3-4, refer to notes after Table 3-5.

Table 3-5. Butt-Welded Construction - Classes IV, V and VI				
Component	Nominal Pipe Size (NPS)	Class IV	Class V	Class VI
Pipe	Through 1½"	ASTM A106 Grade B, Sch 80 carbon steel seamless ASME B36.10	ASTM A333 Grade 1 or Grade 6, Sch 80 carbon steel seamless or welded (Charpy test at -50°F/-46°C) ASME B36.10	ASTM A333 Grade 3 Sch 80 alloy steel seamless or welded (Charpy test at -150°F/-101°C) ASME B36.10
Pipe	2" through 4"	ASTM A106 Grade B or A53 Grade B, Sch 80, Type E or S carbon steel ASME B36.10 [See Note 7]	ASTM A333 Grade 1 or Grade 6, Sch 80 carbon steel seamless or welded (Charpy test at -50°F/-46°C) ASME B36.10	ASTM A333 Grade 3 Sch 80 alloy steel seamless or welded (Charpy test at -150°F/-101°C) ASME B36.10
Pipe	6" through 12"	ASTM A106 Grade B or A53 Grade B, Sch 40 or 80 Type E or S carbon steel ASME B36.10 [See Note 1]	ASTM A333 Grade 1 or Grade 6, Sch 40 or 80 carbon steel seamless or welded (Charpy test at -50°F/-46°C) ASME B36.10 [See Note 1]	ASTM A333 Grade 3 Sch 40 or 80 alloy steel seamless or welded (Charpy test at-150°F/-101°C) ASME B36.10 [See Note 1]
Fittings, Wrought	Through 12"	ASTM A234 Grade WPB, or WPB-W carbon steel (bore to match pipe) ASME B16.9	ASTM A420 Grade WPL6 or WPL6-W steel (Charpy test at -50°F/-46°C)(bore to match pipe) ASME B16.9	ASTM A420 Grade WPL3, alloy steel (Charpy test at -150°F/-101°C) (bore to match pipe) ASME B16.9
Fittings, Forged	Through 12"	ASTM A105 forged steel (bore to match pipe) [See Note 4]	ASTM A350 Grade LF2 forged steel (bore to match pipe) (Charpy test at -50°F/-46°C) [See Note 4]	ASTM A350 Grade LF3 forged alloy steel (bore to match pipe) (Charpy test at -150°F/-101°C) [See Note 4]

84 of 593

Table 3-5. Butt-Welded Construction - Classes IV, V and VI				
Component	Nominal Pipe Size (NPS)	Class IV	Class V	Class VI
Flanges	Through 12"	ASTM A105 Class 300 carbon steel raised-face, weld-neck or slip-on (bore to match pipe) ASME B16.5	ASTM A350 Grade LF2, Class 300 carbon steel raised-face, weld-neck or slip-on (Charpy test at -50°F/-46°C) (bore to match pipe) ASME B16.5	ASTM A350 Grade LF3, Class 300 alloy steel raised-face, weld-neck (Charpy test at -150°F/-101°C) ASME B16.5
Branch Connections	Through 12"	Fittings per Table 3-5 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other connections	Fittings per Table 3-5 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other connections	Fittings per Table 3-5 Use tees for size on size, tees or reducing tees for header sizes 2" and less, and stub ins or welding olets for all other connections
Bolts	All sizes	ASTM A193 Grade B7 alloy steel quenched and tempered, stud bolts and cap screws ASME B18.2.1 [See Notes 3 and 8]	ASTM A320 Grade L7 alloy steel stud bolts and cap screws (Charpy test at -150°F/-101°C) ASME B18.2.1 [See Notes 3, 6 and 8]	ASTM A320 Grade L7 alloy steel stud bolts and cap screws (Charpy test at -150°F/-101°C) ASME B18.2.1 [See Notes 3 and 8]
Nuts	All sizes	ASTM A194 Grade 2H heavy hex nuts carbon steel ASME B18.2.2 [See Note 3]	ASTM A194 Grade 4 heavy hex nuts alloy steel (Charpy test at -150°F/-101°C or Grade L7 ASME B18.2.2 [See Notes 3 and 6]	ASTM A194 Grade 4 heavy hex nuts alloy steel (Charpy test at -150°F/-101°C or Grade L7 ASME B18.2.2 [See Note 3]
Gaskets	All sizes	[See Note 5]	[See Note 5]	[See Note 5]
Gasket Dope (if required)	All sizes	Fluorocarbon grease [See Note 2]	Fluorocarbon grease [See Note 2]	Fluorocarbon grease [See Note 2]

The complete titles of specifications are listed in Section 13.

Note 1 The decision to use Schedule 40 or Schedule 80 pipe should be based on sound engineering judgment taking into consideration such factors as internal and external corrosion allowances, the presence of insulation (which may hide and/or accelerate external corrosion), unsupported span versus allowable pipe deflection, and the need for greater mechanical strength in the piping system.

Note 2 Gasket dope must contain only materials which are nonreactive with chlorine. Consideration should be given to the possibility of gasket degradation.

Note 3 Threads shall be to ASME B1.1. Bolts shall have a Class 2A fit and nuts shall have a Class 2B fit.

Note 4 The reference standard will vary depending on the forge fitting used.

Note 5 The Institute's Pamphlet 95 (13.1.7) contains a list of gaskets that have been tested and have performed satisfactorily by member companies.

Note 6 ASTM A193 Grade B7M bolts and ASTM A-194 Grade 2H or 2HM nuts may be substituted.

Note 7 For gas only systems, where system pressure precludes use of Class I components, Schedule 40 pipe is acceptable.

Note 8 Stud bolts are preferred on in-line piping components that do not have tapped threads. Cap screws may be used for tapped piping components and instrumentation.

4. VALVES

Valving for chlorine service require special attention by all associated with the application. This includes the manufacturer, the supplier, the installer, the operator, and the maintainer. Chlorine service valves are highly engineered products and cannot be considered a routine commodity valve application. An understanding by all involved of the following sub-sections will provide for a successful application.

This section will discuss the types of valves currently in service, the criteria for selection of valve features, valve section tables, materials of construction tables, valve testing guidelines, cleaning and packaging guidelines.

The information presented is based on extensive experience of the Institutes membership and relevant information furnished by valve suppliers. There was no intention to exclude the use of other valve types and materials provided there has been sufficient testing to ensure safe operation.

4.1 Types of Valves

The valves commonly employed in dry chlorine service are the globe, ball, plug, and butterfly types. Each valve is available in several basic body patterns, employing different design features often suited to a particular service and/or specific application. For example, globe valves in several angle-body patterns are used extensively for chlorine shipping containers, ranging from small cylinders to 90-ton rail tank cars; whereas, the upright-pattern globe valve is more commonly used in facility piping systems.

4.1.1 Globe Valves

Globe valves offer several important safety features, including tight shut-off in both directions (bi-directional seating) without trapping liquid inside cavities, multi-turn operation that prevents quick (and sometimes accidental) opening and closing, and a positive means to verify valve position (open or closed).

The recommended configuration includes a blow-out proof stem, a bolted bonnet employing four (4) bolts minimum, and a gland with outside screw and yoke (OS&Y) for external packing gland adjustment. Either metal-to-metal seating employing Stellite hard-facing or soft-seating using a PTFE insert will provide satisfactory service.

Particular attention should be paid to the design of the stuffing box since even minute stem leakage will cause corrosion of the valve stem by means of chlorine reacting with humid air. For this reason a bellows seal or a long stuffing box, using either PTFE or flexible graphite packing and a Hastelloy C-276 (UNS N10276) and C22 (UNS N06022) stem, can be chosen for extended service life.

4.1.2 Ball Valves

Ball valves can provide tight shut-off and minimum resistance to flow when fully open. They are generally easier to operate than plug valves of equal size. Some maintain that the 1/4-turn stem movement lends itself to an inherently more reliable stem seal design. Ball valves should incorporate a blow-out proof stem design and a means to externally adjust the stem seal. The sealing material generally is a fluoropolymer resin, although fluoroelastomer O-rings are sometimes employed as the outer secondary seal.

Ball valves may be furnished either full-bore or reduced-bore. Flanged valves may have either a long (standard) or short body pattern. Full-bore ball valves have openings throughout the length of the valve with a diameter equal to their nominal pipe size.

Ball valve design must ensure that excess pressure, resulting from expansion of liquid chlorine trapped in the ball and body cavity when the valve is closed, will relieve spontaneously in the direction of higher line pressure. This relief may be accomplished by providing a relief hole in the ball, providing a passage in the body to the high pressure side, or by using cavity pressure self-relieving seats.

If the relieving method is directional (bored hole or passage), the valve body must be supplied with positive indication of the direction of pressure tightness. If it is possible to reverse this direction through improper reassembly of parts, a stainless steel tag with precautions must be securely attached to the valve.

4.1.3 Plug Valves

Plug valves can be used for chlorine service and have generally provided satisfactory service. Their primary drawback is a need to balance turning torque and shut-off sealing capability. Like the ball valve, this valve can provide tight shutoff and, with the 1/4-turn stem movement, lends itself to an inherently more reliable stem seal design than one employing linear stem travel.

Plug valves have an inherent blow-out proof stem design and should be provided with a means to externally adjust the stem seal. The sealing material generally employed is a fluoropolymer resin.

Plug valves normally have a reduced bore and like the ball valve are also likely to trap liquid chlorine when closed. Therefore, the plug and body cavities also must be provided with a relief hole vented toward the direction of higher pressure.

If the relieving method is directional (bored hole or passage), the valve body must be supplied with positive indication of the direction of pressure tightness. If it is possible to reverse this direction through improper reassembly of parts, a stainless steel tag with precautions must be attached to the valve.

4.1.4 Soft-Seated "High-Performance" Butterfly Valves

Soft-seated, high-performance butterfly valves can be used in chlorine applications, particularly in the larger pipe sizes. These valves are distinguished from fully-lined butterfly valves primarily through their ANSI rated pressure capability.

Most soft-seated high-performance butterfly valves use standard adjustable packing, a wetted shaft/disc arrangement and a one-piece soft-lip seal.

Soft-seated butterfly valves can provide tight shut-off and, with the 1/4-turn stem movement, lends itself to an inherently more reliable stem seal design than the rising stem valve.

4.1.5 Fully-Lined Butterfly Valves

Fully-lined butterfly valves can be used in wet or dry chlorine gas applications. No metallic part comes in contact with the media, as all internal surfaces of the valves are lined with a fluoropolymer resin. The fully lined butterfly valve should incorporate a blow-out proof stem design.

The fully lined butterfly valve can provide tight shut-off and, with the 1/4-turn stem movement, lends itself to an inherently more reliable stem seal design than the rising stem valve.

The fluoropolymer resin liner (seat) is given its resiliency by a fluoroelastomeric back-up liner. This back-up liner is located behind the fluoropolymer resin liner and is not exposed to the media.

4.1.6 Single-Seated Segmented Ball Valves

These valves differ from conventional ball valves in that they do not trap liquid when closed. Seat material and design and the resulting ability to provide tight shut-off is dependent on the application (on-off or control). This valve is typically used as a control valve.

4.1.7 Fully-Lined Ball Valves

Fully-lined ball valves can be used in wet or dry chlorine gas applications. No metallic part comes in contact with the media, as all internal surfaces of the valve are lined with a fluoropolymer resin. Like metal ball valves, the fully-lined ball valve can provide tight shut-off and, with the 1/4-turn stem operation, lends itself to an inherently more reliable stem seal design than the rising stem valve. The fully lined ball valve should incorporate a blow-out proof stem design and a means to externally adjust the stem seal. The stem sealing material is generally a fluoropolymer resin.

Fully-lined ball valves may be furnished in either full-bore or reduced-bore designs with flanged end connections. Due to the thickness of the fluoropolymer lining, full-bore valves will have port openings which are generally less than their nominal pipe size.

Fully-lined ball valves are limited to gas service. However, designs must ensure that excess pressure, resulting from expansion of liquid chlorine inadvertently trapped in the ball and body cavity, will relieve spontaneously in the direction of higher line pressure. This relief is usually accomplished by providing a relief hole in the ball or by providing a cavity relief seat design.

If the relieving method is directional, the valve body must be supplied with positive indication of the direction of pressure tightness. If it is possible to reverse this direction through improper reassembly of parts, a stainless steel tag with precautions must be securely attached to the valve.

4.1.8 Rising Stem Ball Valves

These valves combine the high seating pressure of a globe valve with the ability to achieve full port flow characteristics of ball valves. They do not trap liquid when shutoff. The falling action of the stem acts through a cam device to turn the ball from the open to closed position. When the ball reaches the closed position the final action of the stem/cam forces the ball against the seat. Rising action of the stem reverses the action.

4.2 General Valve Selection Criteria

When specifying valves for chlorine applications it is important to consider the following factors.

4.2.1 Stem Seal

When dealing with applications which have frequent or large temperature fluctuations, the specifier should consider alternative methods of stem sealing such as bellows seal or live-loaded packing to prevent a leak through the stem seal.

4.2.2 Directional Shut-Off

If the application calls for bi-directional shut-off, a unidirectional valve should not be used.

4.2.3 Ambient Temperature

Ambient temperatures and process temperature should be considered during material selection.

4.2.4 Potential for Wet Chlorine

When selecting valves for an application where the chlorine is normally dry but has the potential to become wet as defined in Pamphlet 100 (13.1.8), consideration should be given to choosing materials suited for both applications. Other than in Class 1 service, lined valves that do not have ductile iron bodies may be advantageous if the potential for moisture contamination exists.

4.2.5 Throttling

Valves used in throttling applications can experience extremely low temperatures due to the high differential pressure. When specifying a valve for those applications, consider selecting one that meets the classification for the lowest temperature anticipated.

Engineering principles for sizing the valve should be used to ensure flashing and cavitation does not take place. Modified trim or characterized ports might be required.

4.2.6 Potential of Solids, Impurities and Contaminants

Under certain conditions, impurities and contaminants which can affect valve performance may be present in dry chlorine systems. Consideration should be made for such conditions in the selection of valve type and materials of construction.

4.2.7 Chloride Stress Corrosion

Stressed parts of a valve that are wetted or can be exposed to chlorine due to leakage (i.e. stems, plugs, fasteners and spring washers) should not be made of 300 series stainless steel.

4.3 Valve Selection Tables

A valve selection guide is provided in Tables 4-1 through 4-7. These tables are intended for use in selecting various types of valves that have been found satisfactory in chlorine service. It is not intended to prevent the use of valve types other than those designated as "satisfactory" in a particular service class. However, the user is cautioned against such practice unless ample testing has been conducted, with documentation, to assure safe operation.

Table 4-1. Globe Valves

Nominal Pipe Size (NPS)	Common End Connect	Primary Form & Rating	Class I	Class II	Class III	Class IV	Class V	Class VI
Through 1½"	Threaded [See Note 1]	Forged API Class 800	S	--	NR	S	NR	NR
	Socket-Welded	Forged API Class 800	S	S	NR	S	S	NR
All sizes	Flanged	Forged or Cast ANSI Classes 150 or 300	S	S	S	S	S	S
	Butt-Welded	Forged or Cast ANSI Classes 150 or 300	S	S	S	S	S	S
Legend:	**S = Satisfactory**			**NR = Not Recommended**			**-- = Insufficient Experience**	

Note 1 Except for connections to transportation equipment, instruments, and special process equipment, flanged valves are recommended for Classes II, III, V, and VI.

Table 4-2. Unlined Ball Valves								
Nominal Pipe Size (NPS)	**Common End Connect**	**Primary Form & Rating**	**Class I**	**Class II**	**Class III**	**Class IV**	**Class V**	**Class VI**
Through 1½"	Threaded [See Note 1]	Forged or Cast ANSI Classes 150 or 300 minimum pressure rating	S	S	NR	S	NR	NR
All sizes	Flanged	Forged or Cast ANSI Classes 150 or 300	S	S	S	S	S	S
Legend:	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

Note 1 Except for connections to transportation equipment, instruments, and special process equipment, flanged valves are recommended for Classes II, III, V, and VI.

Table 4-3. Unlined Plug Valves								
Nominal Pipe Size (NPS)	**Common End Connect**	**Primary Form & Rating**	**Class I**	**Class II**	**Class III**	**Class IV**	**Class V**	**Class VI**
Through 1½"	Threaded [See Note 1]	Forged or Cast ANSI Classes 150 or 300 minimum pressure rating	S	S	NR	S	NR	NR
All sizes	Flanged	Cast ANSI Classes 150 or 300	S	S	S	S	S	S
Legend:	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

Note 1 Except for connections to transportation equipment, instruments, and special process equipment, flanged valves are recommended for Classes II, III, V, and VI.

Table 4-4. High-Performance Butterfly Valves

Nominal Pipe Size (NPS)	Common End Connect	Primary Form & Rating	Class I	Class II	Class III	Class IV	Class V	Class VI
All sizes	Wafer	Plate or Cast ANSI Classes 150 or 300	S	S	--	S	S	--
All sizes	Lugged	Plate or Cast ANSI Classes 150 or 300	S	S	--	S	S	--
All sizes	Flanged	Cast ANSI Classes 150 or 300	S	S	--	S	S	--
Legend:	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

Table 4-5. Fully-Lined Butterfly Valves

Nominal Pipe Size (NPS)	Common End Connect	Primary Form & Rating	Class I	Class II	Class III	Class IV	Class V	Class VI
All sizes	Wafer	Cast ANSI Class 150 psig CWP	S	--	NR	NR	NR	NR
All sizes	Lugged	Cast ANSI Class 150 psig CWP	S	--	NR	NR	NR	NR
Legend:	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

Table 4-6. Single-Seated Segmented Ball Valves

Nominal Pipe Size (NPS)	Common End Connect	Primary Form & Rating	Class I	Class II	Class III	Class IV	Class V	Class VI
All sizes	Wafer	Cast ANSI Classes 150 or 300	S	S	--	S	S	--
All sizes	Flanged	Forged or Cast ANSI Classes 150 or 300	S	S	--	S	S	--
Legend	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

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Table 4-7. Fully-Lined Ball or Plug Valves								
Nominal Pipe Size (NPS)	Common End Connect	Primary Form & Rating	Class I	Class II	Class III	Class IV	Class V	Class VI
All sizes	Flanged	Forged or Cast ANSI Class 150	S	NR	NR	NR	NR	NR
Legend	**S = Satisfactory**		**NR = Not Recommended**			**-- = Insufficient Experience**		

4.4 Valve Materials Table

Table 4-8 lists materials recommendations that have proven to be suitable for valve parts in dry chlorine service. Materials are listed by the applicable standard/ material designations. This guide is not intended to prevent the substitution of other materials known to be suited for the intended chlorine service as agreed upon between the manufacturer and purchaser.

Table 4-8. Valve Material Selection Guide				
Product Forms	Parts	Classes I & IV	Classes II & V	Classes III & VI
Castings	Bodies, Bonnets, Covers	ASTM A216 Grade WCB A216 Grade WCC A395 [See Note 1] A352 Grade LCA (to -25°F/-32°C) [See Note 12]	ASTM A352 Grade LCB or LCC (to -50°F/-46°C) A352 Grade LC1 (to -75°F/-59°C) A352 Grade LC2 (to -100°/-73°C) [See Notes 11 and 12]	ASTM A352 Grade LC3 (-150°F/-101°C) [See Note 12]
Forgings	Bodies, Bonnets & Covers	ASTM A105 A181 Classes 60 & 70 A182 Grade F1 A350 Grade LF1 (to -25°F/-32°C)	ASTM A350 Grade LF2 (to -50°F/-46°C) [See Note 11]	ASTM A350 Grade LF3 (-150°F/-101°C)
Rolled Plates & Shapes	Bodies, Bonnets & Covers	ASTM A516 Grade 70	ASTM A516 Grade 55, 60, & 65 (Charpy test at -50°F/-46°C) [See Note 11]	ASTM A203 Grade E (Charpy test at -150°F/-101°C)

Table 4-8. Valve Material Selection Guide				
Product Forms	Parts	Classes I & IV	Classes II & V	Classes III & VI
Body, Bonnet & Cover Bolting	Bolts & Stud Bolts	ASTM A193 Grade B7	ASTM A320 Grade L7 (Charpy test at -150°F/-101°C) [See Notes 13 and 14]	ASTM A320 Grade L7 (Charpy test at -150°F/-101°C)
	Nuts	ASTM A194 Grade 2H heavy hex nuts	ASTM A194 Grade 4 heavy hex nuts (Charpy test at -150°F/-101°C) [See Note 13]	ASTM A194 Grade 4 heavy hex nuts (Charpy test at -150°F/-101°C) [See Note 13]
Other Metal Parts [See Note 3]	Stems (Shafts)	Hastelloy C22 (UNS N06022), C-276 (UNS N10276) Monel 500 (UNS N05500) Monel 400, R405 (UNS N04400 & N04405) [See Note 6]	Hastelloy C22 (UNS N06022),C-276 (UNS N10276) Monel 500 (UNS N05500) Monel 400, R405 (UNS N04400 & N04405) [See Note 6]	Hastelloy C22 (UNS N06022),C-276 (UNS N10276) Monel 500 (UNS N05500) Monel 400, R405 (UNS N04400 & N04405) [See Note 6]
	Balls, Tapered Plugs, & Discs	Monel 400 (UNS N04400) [See Note 2]	Monel 400 (UNS N04400) [See Note 2]	Monel 400 (UNS N04400) [See Note 2]
Other Metal Parts [See Note 3]	Bellows [See Note 8]	Monel 400, R405, (UNS N04400 & N04405) Hastelloy C-276 (UNS N10276)	Monel 400, R405 (UNS N04400 & N04405) Hastelloy C -276 (UNS N10276)	Monel 400, R405 (UNS N04400 & N04405) Hastelloy C-276 (UNS N10276)
	Seats & Discs, Wedge Facings	[See Notes 4 & 5]	[See Notes 4 & 5]	[See Notes 4 & 5]
	Other Parts	[See Note 5]	[See Note 5]	[See Note 5]
Non-Metallic Parts	Seats, Sleeves & Seals	Fluoropolymer Resin	Fluoropolymer Resin	Fluoropolymer Resin
	Packing	Flexible graphite, Fluoropolymer resin or asbestos. [See Note 10]	Fluoropolymer resin or asbestos. [See Note 10]	Fluoropolymer resin or asbestos. [See Note 10]
	Bonnet/Bonnet Gasket	Fluoropolymer resin or asbestos. [See Notes 7, 9, 10]	Fluoropolymer resin or asbestos. [See Notes 7, 9, 10]	Fluoropolymer resin or asbestos. [See Notes 7, 9, 10]

The complete titles of specifications are listed in Section 13.

Note 1 Ductile iron per ASTM A395 may be used for valves in chlorine service in Class I service.

Note 2 Hastelloy C (UNS N10002) and Hastelloy C-276 (UNS N10276) affords superior corrosion resistance over Monel.

Note 3 Use Monel Alloy 400 (UNS N04400) per ASTM B564 (annealed) for forgings and ASTM B127 (annealed) for plates.

Note 4 Hard-faced seating surfaces of Stellite 21 (UNS R30021) and/or Stellite 6 (UNS R30006) are recommended for metal seating surfaces prone to the combined effects of corrosion and erosion. Monel K500 (UNS N05500) also possesses good hard-facing properties. Integral seats eliminate corrosion and leakage associated with screwed in seats.

Note 5 Other parts (such as yokes, yoke nuts, glands, gland bushings, studs, and handwheels) shall be of material suitable for the service and as agreed upon between manufacturer and purchaser. Series 300 stainless steels should not be used for bolts, nuts, and studs (2.3).

Note 6 Valve stems of Hastelloy C22 (UNS N06022) and Hastelloy C-276 (UNS N10276) can improve operability and minimize leakage through the stuffing box by extending the integrity of the stem sealing surfaces which are most prone to moisture penetration and accelerated corrosion. Monel K500 (UNS N05500) also possesses good hard-facing properties. One piece construction for valve stems is preferred.

Note 7 PTFE should only be used in a fully-confined joint.

Note 8 Bellows shall be designed for a minimum of 10,000 cycles and to operate at the maximum allowable working pressure of the valve at ambient temperature.

Note 9 Spiral wound Monel 400 (UNS N04400) or Hastelloy C-276 (UNS N10276) with PTFE, graphite or asbestos filler.

Note 10 Only qualified individuals familiar with proper handling procedures and techniques should be allowed to work with asbestos. Regulations may limit the use of asbestos.

Note 11 Type 316/316L stainless steel (ASTM A351/A744 Gr CF8M/CF3M) valves or components can be used in specialized service based on long term end-user experience. Use in new locations should be limited to installations which have been thoroughly evaluated.

Note 12 Castings shall be traceable, conforming to the ASTM grade listed.

Note 13 ASTM A193 Grade B7M bolts and ASTM A194 Grade Grade 2H or 2HM nuts may be substituted.

Note 14 Stainless steel bolting should not be used. Alloy 20 bolting is recommended for stainless steel valves.

4.5 Valve Preparation - Identification Requirements

All valves identified by the manufacturer as meeting the recommendations in this pamphlet for chlorine service shall meet the following requirements.

4.5.1 Valve Testing

Each valve shall be subjected to the following pressure tests:

- a shell test in accordance with API 598 (13.4.3) at a minimum of 1.5 times the 100°F(38°C) rating rounded off to the next higher 25 psig increment or a body hydrostatic test at 1.5 times the 100°F(38°C) rating rounded off to the next 25 psig increment prior to assembly.
- all shutoff valves shall be closure tested with inert gas or air in accordance with API 598 (13.4). There shall be no leakage for the minimum specified test duration.

4.5.2 Cleaning and Packaging

All valves shall be degreased, specially cleaned, dried, and prepared for use in chlorine service including the use of special chlorine compatible lubricants for valve assembly. Valves shall be packaged in a manner which prevents moisture from entering the ends once preparation is complete. Care should be taken by the receiver to protect the integrity of the packaged valves until they are placed in service.

4.5.3 Identification

If a valve passes the leak testing specified in Section 4.5.1 and has been degreased, cleaned, dried and packaged according to the requirements in Section 4.5.2, then the valve is considered ready for chlorine service. A securely attached tag designating the valve has been cleaned and tested for chlorine service in accordance with Chlorine Institute Pamphlet 6 will be used by manufacturers to indicate the valve has been prepared for service.

5. OTHER COMPONENTS

Components other than pipe, valves, and fittings that commonly are used in chlorine piping systems are addressed in this section.

5.1 Rupture Discs

Rupture discs in chlorine service should be installed with the understanding that these devices do not provide reseating capabilities such as those provided by a pressure relief valve. Once the disc has ruptured, the process fluid will continue to escape through the disc until blocked by some other means. For this reason, these discs are used most commonly in conjunction with a pressure relief device or expansion chamber. They function well under a pressure relief valve as a preventative measure against corrosion.

Rupture discs used in conjunction with expansion chambers are referenced in Drawing 136 (13.1.22). Vacuum support should be included, where appropriate.

Common materials used in the construction of rupture disc components are:

- disc holder — forged carbon or alloy steel (connection type and pressure rating of disc holder should conform to the class specification of the flanges and piping systems)
- disc — Monel alloys K500 and R405 (UNS N05500 and N04405), tantalum, armored impervious graphite, silver, Hastelloy C and C-276 (UNS N1002 and UNS N10276)

CAUTION: If impervious graphite discs are used under pressure relief valves, fragmentation of the disc upon rupture may damage valve parts or plug the valve, rendering it ineffective as a pressure relief device. Disc fragments may be projected out the vent pipe and impede the reseating of the pressure relief valve.

5.2 Pressure Relief Valves

Pressure relief valves are the preferred relief devices since they reseat. Inlet connections should be consistent with pipe class and specifications.

Pressure relief valves should be inspected and/or tested on a scheduled basis. The valves should be installed in a manner that ensures there is no obstruction of flow between the pressure relief valve and the piping system or vessel it is intended to protect. The pressure relief valve vent system should be adequately sized and piped such that the discharge is unrestricted and is exhausted to a safe location (Pamphlets 5, 86 and 89 (13.1).

Rupture discs or breaking-pin assemblies may be installed under pressure relief valves where it is appropriate to protect the valve from corrosion. Where it is necessary to satisfy the ASME Code, a pressure gauge or other suitable telltale indicator must be installed between the rupture disc and the pressure relief valve, and checked for proper operation on a regular basis. Pressure in this section of piping may indicate premature failure or pinholes in the rupture discs.

Types of pressure relief valves include:

- Conventional

  Generally, these have conventional angle body with closed bonnet and a cap over the spring adjusting nut. However, a unique, straight-through design valve (Style JQU) developed for the transportation industry has been adopted for use on stationary equipment (5.4).

  Materials of construction typically used in Class I and IV services are:

  body: carbon steel

  trim: Hastelloy C or C 276 (UNS N10002 or UNS N10276) or Monel alloy 400 and R405 (UNS N04400 and UNS N04405) spring: carbon steel

Materials of construction for other classes should be consistent with piping specifications.

- Soft-seat

  These valves employ a captured plastic insert that is either statically compressed by the metal seats or dynamically loaded between them by the inlet-side pressure to affect optimum seat sealing both prior to opening and upon reseating. The insert usually is an elastomeric O-ring (Viton or Kalrez rubber for chlorine), with a few of the static sealing designs employing PTFE.

  Soft-seated construction, particularly in conjunction with a bellows-sealed valve, may negate the need to provide an inlet-side rupture disc or breaking-pin assembly.

- Bellows

  These pressure relief valves employ a convoluted bellows that isolates the stem-guiding surfaces and valve spring from the flowing fluids (or other foreign materials that may be encountered in the discharge piping) that could contact and accelerate corrosion of these vulnerable parts and render the valve inoperable. The bellows usually is constructed of minimum 2-ply Monel alloys 400 and R405 (UNS N04400 and UNS NO4405) metal for chlorine service. However, Hastelloy C and C 276 (UNS N10002 and UNS N10276) may be a more prudent choice if the discharge system is likely to be humid from water intrusion.

  A balanced-area design valve permits use where high or variable back pressures (equal to or less than 50% of the set pressure) may be encountered. The ASME Code permits the installation of a rupture disc on the outlet of a balanced-area, bellows-sealed pressure relief valve. The burst rating of the rupture disc employed in this manner should not exceed 50% of the valve set pressure.

5.3 Liquid Knockout Pots

A knockout pot or drip leg is useful for the protection of gaseous chlorine systems from damage or process upsets that may result from the entry of liquid chlorine.

Conditions under which liquid may be expected are:

- on start-up, after any period of no flow in a chlorine line
- during periods of low flow and/or cold weather
- in operation at a temperature and pressure which approach saturation (refer to Figure 9.1, The Chlorine Manual (13.1.1)
- in vaporizing systems (Pamphlet 9 (13.1.3))

Minimum requirements for knockout pot installations are:

- Materials of construction and specifications should be consistent with expected operating temperatures and pressures.
- A liquid knockout pot should be sized for maximum gas flow.
- The pot is to have minimum liquid retention before alarm or notification of liquid presence in the pot.
- Insulation should be considered for all above-ground chlorine lines and pots unless operating pressure is low enough to prevent condensation.
- Block valves may be installed on the inlet and outlet of the knockout pot. Automatic valves should be considered depending on the impact of liquid chlorine on the process and equipment. The block valve installation should include provisions for periodic testing; a by-pass with valve may be useful. Where block valves are used, provision should be made for over pressure protection.
- The system should contain a controlled heat source or pressure reducing equipment for vaporizing any accumulated liquid chlorine. The heat source must be controlled to avoid accelerated corrosion and spontaneous ignition of iron and chlorine at elevated temperatures (Pamphlet 1 (13.1.1))
- Nitrogen trichloride can accumulate in the knockout pot due to long term vaporizing of liquid chlorine if the chlorine has trace amounts of nitrogen trichloride. Periodic service of these knockout pots should be planned including evacuation, cleaning and drying. Reference is made to Pamphlet 152 (13.1.9) for additional information.

5.4 Transportation Valves on Stationary Equipment

In general, other types of valves are preferable to transportation valves for use in stationary piping systems.

- Transportation Pressure Relief Valves

  These valves with breaking-pin or rupture disc assemblies have been used in chlorine piping and storage systems. The valves are approved for bulk chlorine transports and are not ASME certified. However the valve can be specified and purchased to meet ASME certification.

  Consideration of local emission standards in relieving to the atmosphere is recommended.

  CAUTION: These valves are not designed to function properly if there is back pressure.

- Standard Tank Car Angle Valves

  Although acceptable for stationary piping systems, these often are not the best valves for the application (Drawing 104 (13.1.12).

- Excess Flow Valves

  Excess flow check valves are suitable for stationary piping systems. However, it should be noted that these valves must be installed in a vertical position to operate properly. Also, these are high-pressure drop-valves and, as such, may not function well as emergency shut-off valves. Their performance is highly dependent upon flows and downstream pressure drop considerations (Drawings 101, 106, 114, 162, and 163 (13.1)).

5.5 Liquid Expansion Chambers

Liquid chlorine has a very high coefficient of thermal expansion. If liquid chlorine is trapped between two valves, the pressure of the blocked-in section will increase as the line temperature increases. The pressure can rise beyond the pressure rating of the line with the potential to cause a connection leak or line failure. An expansion chamber is connected to a pipeline to allow expansion room for the liquid. An expansion chamber should be installed on top of the pipeline and be filled with dry air or an inert gas. The gas in the expansion chamber is compressed as the pressure in the line increases and protects the line from experiencing the extremely high pressure that can be caused by liquid-full hydraulic expansion. Recommended configurations and use conditions for expansion chambers are referenced in Drawing 136 (13.1.22).

5.6 Check Valves

Check valves (spring-loaded or gravity-operated) are not recommended for chlorine service in situations where total isolation or total elimination of reverse flow is desired. In these cases, automatically operated control valves with appropriate instrumentation are recommended.

Check valves may be useful in chlorine service in applications such as pump headers, where a small amount of reverse flow is acceptable. These check valves should be constructed of materials consistent with piping and valve specifications.

Suitable materials of construction are:

body:	carbon steel or alloy steel per service condition, ductile iron for Class I
body liner (optional):	PFA, PTFE, ETFE, ECTFE, PDVF or equally lined carbon steel or alloy steel
disc, metal seal, and trim:	Alloy 20 or Monel alloys 400 and R405 (UNS N04400 and UNS N04405) and Hastelloy C-276 (UNS N10276)
spring (if used):	Inconel alloy 600 (UNS N06600)

5.7 Expansion Joints

Expansion joints should be restricted to Class I gas service only.

Chlorine piping systems shall have sufficient flexibility to prevent failure of the piping system due to thermal expansion or contraction. When flexibility cannot be introduced into the system through pipe routing, bellows expansion joints can be employed to absorb the differential expansion while containing the system pressure.

These joints are engineered products which should not be purchased and used as commodity items. Expansion joints shall be kept to a minimum, but when required shall be metallic with a minimum bellows metallurgy of Hastelloy C and C-276 (UNS 10002 and N10276) or Monel alloys 400 and R405 (UNS N04400 and N04405) and shall comply with ASME B31.3 - Appendix X (13.2.8). Periodic maintenance is recommended.

5.8 Hoses

Neither metallic nor non-metallic hoses are normally used in permanent piping systems and are not recommended for permanent piping connections. Refer to Section 8 and Appendix A for transportation connections.

6. INSTRUMENTATION

Dry chlorine piping systems should be protected against overpressure, overheating, overfilling, etc., by installing dependable instrumentation. This instrumentation may be pressure, temperature, level, or flow type, and may use indicating, regulating, recording, or alarm devices. A new pamphlet, under development as this edition goes to press, *Instrumentation for Chlorine Service* will provide recommendations on critical instrumentation issues related to chlorine applications.

6.1 Electrical Enclosures

NEMA 4 (water-tight) or NEMA 4X (water-tight/corrosion resistant) enclosures should be considered (13.4.1).

7. NONFERROUS METAL TUBING SYSTEMS

Nonferrous metal piping or tubing is generally used for flexible instrument or nonpermanent connections. Aluminum, titanium, and tin must not be used because chlorine reacts with these materials at ordinary temperatures. Where flexible connections are required between transportation containers and rigid piping systems, copper and copper alloy construction may be used.

Because of the reaction between chlorine and tin, no tin should be used in brazing alloys for flexible connection fittings. Therefore, silver brazing alloys must contain no tin and should contain at least 44% silver. In situations requiring protection against external corrosion, protective coatings such as cadmium or zinc plating are recommended. Hydrogen embrittlement is not a typical failure mechanism for non-ferrous metals.

Tubing components should be limited to a single manufacturer since connectors are not compatible between manufacturers.

Table 7-1 identifies some commonly used nonferrous metals and special alloys. Consideration should be given to the mechanical protection of tubing systems from external damage.

Table 7-1. Nonferrous Metal Tubing Systems

Item	Material [See Note 4]	Fluid State	Type	Comments	Common Use [See Note 5]
Tubing	Copper [See Note 1]	Gas or Liquid	ASTM B88	Seamless, Type K or heavier, annealed	Container connections
	Monel [See Note 3]	Gas or Liquid	ASTM B165	Cold-drawn, annealed	Instrument connections, Container connections
Fittings	Monel [See Note 3]	Gas or Liquid	ASTM B165	--	Instrument connections
	Copper	Gas or Liquid	ASTM B75	Solder Type [See Note 6]	Container connections [See Note 2]
Adapters/ Adapter Nuts	Aluminum-Silicon-Bronze (Alloy B)	Gas or Liquid	ASTM B124, B150 UNS C64210	[See Drawing 130]	Interface connections, Container connections
	Leaded Commercial Bronze	Gas or Liquid	ASTM B140 UNS C31400	--	Interface connections, Container connections, Piping

Note 1 An external coating (e.g. cadmium or zinc plating) is recommended in situations requiring additional corrosion resistance. Hydrogen embrittlement is not a typical failure mechanism for nonferrous metals.

Note 2 Gasketed-type fittings are preferred where connections are disconnected and reconnected frequently. Flared type fittings are not recommended.

Note 3 Instrument tubing of ¼ - to ½-inch (6.35 to 12.7 mm) OD shall be ASTM B165 Monel alloy annealed, seamless tubing with a .035-inch (0.89-mm) wall minimum, to be used with ASTM B165 Monel alloy (UNS N04400 and N04405) ferrule-type tubing fittings.

Note 4 Other alloys may be used based on specific experience such as Alloy 20 and Hastelloy C-276.

Note 5 For periodic disconnect/reconnect connections, such as container applications, the yoke and adaptor (CGA Connection 820 or 820C) is recommended. For connections between tubing and stationary piping, a union nut connection (such as CGA Connection 660) is acceptable.

Note 6 Silver brazing alloys must contain no tin and should contain at least 44% silver.

8. TRANSPORTATION CONTAINER CONNECTIONS

Connectors and fittings to permit unloading chlorine transportation containers are, in general, considered nonpermanent installations. These connectors and fittings are identified below in Table 8 and some of their uses are cited. Details on each item can be found in the indicated drawings. Non-permanent installations should use yoke-type or flanged connections since threads that are used repeatedly and exposed to a chlorine atmosphere may fail prematurely. Two bolt flanges are often used on unloading loops (Drawing 118 (13.1.19)). Care must be taken to apply the gasket loading forces uniformly by tightening both bolts evenly.

The information in Table 8-1 is generally for liquid or gas service between -20°F and 150°F (-29°C and 66°C) and from vacuum to 300 psig. Some components, notably transfer hoses, are rated for higher pressure.

Table 8-1. Connectors to Transportation Containers Guide

Item	Fluid State	Comments	Common Use
Tank Car Unloading Connection	Gas or Liquid	Unloading loops [See Drawing 118]	Connects permanent piping system with barge, truck or rail car
Chlorine Transfer Hose	Gas or Liquid	Metallic reinforced and special non-metallic with protection [See Appendix A]	Transfer hose is more flexible than tank car unloading connector and may be more adaptable for special needs
Small Union Connection	Gas or Liquid	[See Drawing 171]	Connect flexible connectors to auxiliary cylinder valves or manifolds
Cylinder Valve Adapter	Gas or Liquid	Brass or Alloy "B" [See Drawings 112, 130 and 189] Lead commercial bronze ASTM B140	Connects valves to flexible connectors

Table 8-1. Connectors to Transportation Containers Guide			
Item	Fluid State	Comments	Common Use
Cylinder Valve Yoke	Gas or Liquid	[See Drawings 131 and 189]	Yokes may be used for non-permanent connections to cylinders, ton containers or piping systems with cylinder valves
Header Valve	Gas	[See Drawing 113 for valve parts and Drawing 112 for material specifications]	Used on gas pressure headers to permit connection to flexible copper tubing (does not require fusible plugs)
Gasket [See Note 1]	Gas or Liquid	[See Pamphlet 95]	Gasket replacement is recommended after each disconnect

Note 1 Joint design is a critical factor in selection of gasket material and should be limited to a confined joint, such as tongue and groove.

9. PLASTIC MATERIALS OF CONSTRUCTION

For purposes of this section "plastic piping systems" refers to fabrications other than valves where plastic is used as a liner.

Because relatively inexpensive, high strength metals can be used successfully in dry chlorine service, plastics are rarely used as piping materials to handle chlorine under pressure. On the other hand, in wet chlorine service (e.g. cell gas, chlorinated water, vent collection systems, etc.), or in vacuum service (dry or wet), where most metals are subject to rapid corrosion, and where pressures are relatively low, plastic piping systems can be used very successfully.

Plastics are also used extensively as lining materials for metallic piping components and valves. The plastic protects the metal from corrosion and the metal protects the plastic from external forces and enables the system to operate at higher pressures than would be possible with an all plastic component.

Since plastics can offer good resistance to wet chlorine, when properly specified and used, plastic piping systems offer many benefits. However, they do have limitations that must be taken into account. These include:

- Many plastics (generally those that are not fluorinated or chlorinated to a high degree) will react with chlorine and may fail rapidly and catastrophically as a result.

- Many plastic piping materials have limited pressure retaining capabilities and are subject to rapid degradation of structural properties (strength) with increasing temperature. Use should therefore be limited to temperatures well below those at which the physical properties of the plastic are reduced to the point where the pressure rating of the pipe does not have an adequate margin of safety.

- Many plastics are subject to degradation on exposure to UV light. Additives and coatings should therefore be employed to minimize the effect and exposure to UV light. Chlorine has the ability to permeate through the microstructure of many plastics. When using plastics that exhibit this phenomenon, precautions must be employed to account for the permeation (e.g. the need for vents should be considered on piping lined with plastic materials, proper precautions should be taken when using such plastics in poorly ventilated areas, etc).

- Because many solid plastic piping systems (Solid plastic meaning that the entire piping component is plastic, as opposed to lined piping) can shatter when they are over-pressurized, they are not recommended for use in pressurized chlorine gas service (e.g. PVC, CPVC, PVDF, ABS, others). Pressure in gas service should be limited to 6 PSIG when using plastic materials that are prone to this type of failure. Gas service at pressures higher than 6 PSIG should be considered only after a thorough evaluation of the piping system.

- Liquid chlorine is usually handled at high pressure or low temperature and it has physical properties (high specific gravity, high coefficient of expansion) that could damage plastic components. Therefore, solid plastic piping systems should not be used to handle liquid chlorine.

- Plastics are subject to damage by external forces. Plastic piping systems should therefore be well supported and should be protected from impact.

- Plastic tubing is sometimes used to transfer small quantities of chlorine for sampling, instrument inputs, etc. When using tubing, care should be taken to provide generous radii of curvature, to protect the tubing from physical damage and to avoid contact with hot surfaces. Tubing should be heavy wall, limited to ½" maximum OD. Use with appropriate fluoropolymer tubing fittings.

- Plastic Lined piping systems may be subject to external corrosion. In such cases, care should be taken to protect the pipe with suitable coatings and frequent maintenance.

Typical limitations on the use of plastics in chlorine service are shown in Tables 9-1 and 9-2.

Table 9-1. Plastics in Gas or Liquid Chlorine Service Piping Systems (Note 3)

Plastic	Abbreviation	Pressure	Maximum Temperature	Common Uses
Polytetrafluoroethylene (ASTM D1457)	PTFE	[See Note 6]	400°F (204°C) limit on plastic	Transfer hose, instrument tubing, valve parts, pipe and fitting liners, gaskets and packing

Table 9-1. Plastics in Gas or Liquid Chlorine Service Piping Systems (Note 3)

Plastic	Abbreviation	Pressure	Maximum Temperature	Common Uses
Perfluoroalkoxy (ASTM D3307)	PFA	[See Note 6]	400°F (204°C) limit on plastic	Valve parts, pipe and fitting liners
Fluorinated Ehylene Propylene	FEP	[See Note 6]	300°F (149°C) limit on plastic	Valve parts, pipe and fitting liners
Polyvinylidene difluoride (ASTM D3222)	PVDF	[See Note 6]	280°F (138°C)	Pipe [See Note 4], valve parts, tube fittings, pipe and fitting liners
Ethylene chlorotrifluoroethylene (ASTM D3275)	ECTFE	[See Note 6]	300°F (149°C)	Valve parts, pipe and fitting liners
Ethylene tetrafluoroethylene	ETFE	[See Note 6]	300°F (149°C)	Valve parts, pipe and fitting liners

Table 9-2. Plastics in *Gas Only* Chlorine Service Piping Systems

Plastic	Abbreviation	Pressure	Maximum Temperature	Common Uses
Polyvinyl chloride (ASTM D1784)	PVC	[See Note 5]	130°F (54°C)	Pipe [See Note 2], pipe fittings, tube fittings, valve parts
Chlorinated Polyvinyl chloride (ASTM D1784)	CPVC	[See Note 5]	212°F (100°C)	Pipe [See Note 2], pipe fittings, valve parts
Acrylonitrile butadiene styrene (ASTM D3965)	ABS	[See Note 5]	150°F (66°C)	Pipe [See Note 2], pipe fittings, tube fittings, valve parts
Fiberglass-reinforced polyester [See Note 1]	FRP	[See Note 5]	212°F (100°C)	Chlorine cell covers, duct work
Polyethylene (ASTM D3350)	PE	[See Note 5]	130°F (54°C)	Tubing, valve parts
Polypropylene	PP	[See Note 5]	130°F (54°C)	Tube fittings, valve parts

Note 1 Resin must be specifically selected for chlorine service.

Note 2 Schedule 80 with screwed joints. May be schedule 40 with solvent cemented socket joints.

Note 3 Do not use solid plastic pipe in liquid chlorine service.

Note 4 Schedule 80 with screwed joints. May be schedule 40 with thermally fused socket joints.

Note 5 Limited to from full vacuum to 6 psig (41 kPa) maximum in solid plastic pipe. For lined pipe, see note 6.

Note 6 Consult manufacturer of piping component for temperature/pressure limitations.

10. PIPING LAYOUT DESIGN CONSIDERATIONS

Good piping layout will enhance safety, reduce maintenance costs, and provide efficient operations at effective costs. The following are several important considerations in designing piping layout.

- Pipe sizing should be engineered to minimize the possibility of corrosion / erosion that may be caused by high fluid velocities. Particular attention should be paid to sections of the system where local velocities can be excessive such as downstream of valves, bends, pump discharge lines and orifice plates. However, with proper design, high velocities have been employed successfully in many cases.

- Avoid trapping liquid chlorine between closed valves and/or provide expansion chambers (see Dwg # 136 (13.1.22)) or pressure relief. Although the intent is to reduce risk, in some cases, small expansion bottles can increase the risk of leaks because they add complexity and are themselves subject to failure. Therefore, expansion bottles may be omitted if all the following apply:

    - If the chlorine contained in the trapped section is less than ten pounds of chlorine and if all the block valves needed to trap a section of piping are within arm's reach, so that operating procedures can be used to avoid trapping chlorine.

- Consider a layout of piping to facilitate future clean-out operations. Arrange and support piping to permit removal of process equipment and components.

- Avoid installing chlorine lines next to steam lines, acid lines, etc., that could cause corrosion of the chlorine line. Protect chlorine piping from potential sources of excessive heat or fire.

- The use of vent and drain branches in a chlorine pipeline should be limited to the minimum necessary for the removal of dirt, liquid or gas. However, all sections that can be blocked in should have sufficient connections for clearing the chlorine.

- Provide for linear thermal expansion, preferably by pipe loops. Bellows-type expansion joints should be avoided.

- In addition to piping design, operational procedures should be incorporated to minimize the possibility of liquid hammer.

- Chlorine lines should be readily identifiable.

10.1 Clearances

Road and walkway clearances should be set to minimize the potential for impact damages. Barriers or guard rails should be considered. Railroad and roadway clearances may be regulated by federal, state, provincial or local laws. If chlorine piping must pass through a wall or bulkhead, proper side clearances must be maintained.

10.2 Supports

Piping should be adequately supported to prevent sagging and resting on structural steel. Do not hang other piping from chlorine lines and, conversely, do not hang chlorine lines from other piping. Piping should be supported with hangers or pipe shoes that do not allow metal to metal wear or corrosion. If located in an area where seismic activity can be significant, review local code requirements to determine if special design considerations are necessary.

10.3 Routing

Chlorine piping should be routed the shortest distance practical with consideration given to flexibility, line expansion and good engineering practice. Changes in elevation should be minimized. This pamphlet considers above ground installations only. If the piping system is buried underground or crosses waterways, then refer to Pamphlet 60 (13.1.4), which contains special requirements for underground protection, etc.

10.4 Valving

It is important all valves and controls be located in accessible areas. Control valves and relief valves should be located where they can be serviced conveniently.

Block valves must be located as close to equipment as possible, preferably on the nozzle.

Block valves should be located in branch lines at the main header and, where practical, located to allow lines to drain away from the valves.

10.5 Hydraulic Thermal Expansion Design Considerations

Liquid chlorine has a high coefficient of thermal expansion. Relatively small increases in liquid chlorine temperature can create enough pressure to cause a blocked-in section of piping to rupture or leak at the connections.

The need for liquid expansion chambers, as shown on Drawing 136 (13.1.22), should be evaluated if liquid chlorine can be trapped between two closed valves. For small trapped volumes, such as around control valves, administrative draining procedure may be preferable to the installation of a small expansion chamber. These expansion chambers should be adequately supported and located in an accessible area for routine inspection and maintenance.

10.6 Design Considerations to Prevent Condensation

Condensation or reliquification can occur in gas lines when the temperature drops below the pressure-temperature equilibrium. To prevent gas condensation, heat tracing and insulation, or the use of a pressure reducing valve is recommended. Any heat tracing installation should be designed such that the surface temperature of the pipe shall not exceed 300°F (149°C) to eliminate the possibility of chlorine-steel reaction which occurs near 483°F (251°C), see The Chlorine Manual (13.1.1).

10.7 Vaporization

Vaporization or flashing can occur in liquid lines due to pressure drop, elevation change, or temperature increase. System design should assure that chlorine remains in its intended state under all operating conditions.

10.8 Insulation

Chlorine pipelines (liquid and gaseous) often operate at pressures and temperatures that cause condensation and ice formation on the outside of the lines. For this reason, the insulation must provide a sufficient moisture barrier to prevent corrosion under the insulation. A water-resistant insulating material such as cellular glass, urathane or foam rubber should be used. Engineered access methods which do not compromise the system moisture barrier may be used to accommodate thickness testing or exterior inspection.

10.9 Painting

Protective coating on the pipe should be considered to limit external corrosion.

11. PREPARATION FOR USE

11.1 Cleaning

All portions of new chlorine systems must be cleaned before use, because chlorine can react violently with cutting oil, grease, and other foreign materials. Cleaning procedures must emphasize the importance of removing all residues, because chlorine may also react vigorously with water and most solvents, including hydrocarbons and alcohols, any equipment received in an oily condition should be cleaned and thoroughly dried before use.

There are several cleaning techniques available, but there is no best method. The appropriate technique will depend on the nature of the system and the type of contamination. For any technique employed, the user must establish a written procedure. Each step of the cleaning procedure should be closely monitored. The procedure should include criteria for written acceptance of the effectiveness of the cleaning. Reference material for developing procedures can be found in CGA's Pamphlet G-4.1 *Cleaning Equipment for Oxygen Service* (13.4.5).

Procedures should be in compliance with all federal, state and local regulations. The recommendations of the manufacturers of the cleaning product and the equipment to be cleaned should be followed as applicable.

Three common methods used to clean chlorine systems are described below. Sometimes, a combination of methods is most useful in a given situation. Particular attention must be paid to joint areas where cleaning solutions could collect. Consideration should be given to valve removal prior to cleaning operations or hydrostatic tests and gasket replacement after cleaning.

11.1.1 Aqueous Cleaning

Aqueous methods are used for both new construction and plant maintenance, particularly for equipment already exposed to chlorine service. Examples include detergents, surfactants, coalescing agents and inorganic solutions. This must be followed by thorough flushing with water to remove the residue. Steam is often used to purge the pipe and raise the temperature to aid in drying. Care must be taken to ensure the system is properly dried.

11.1.2 Abrasive Cleaning

This method is used primarily on large piping sections for new construction. Types of abrasives include sand, dry ice, steel shot, garnet, corn husks, etc. Care must be taken to isolate valves, instruments, and process equipment from potential damage. All blasting residue must be removed from pipe sections prior to installation. If care is taken to exclude moisture, the assembled system will be ready for dry air or nitrogen drying.

11.1.3 Solvent Cleaning

Solvents are most often used for cleaning individual components (e.g. valves, relief valves and instruments), especially parts that can be cleaned in commercial vapor degreasing equipment. For large chlorine systems, this method is not normally used due to the need for addressing environmental and industrial hygiene risks. Many solvents are excellent cleaning agents but pose significant risks due to toxicity, flammability or reactivity with chlorine. The best overall solvent must be available as a liquid in convenient containers, be nearly nonreactive with chlorine, be nonflammable, have relatively low vapor pressure, a low toxicity rating and must be capable of removing the contamination. Although most solvents do not meet the above criteria, the user must prioritize these criteria and select the best solvent for the application.

Historically, the Institute recommended solvents have been chlorocarbons or chlorofluorocarbons. Many of these are suspected ozone-depleting compounds and are subject to bans on manufacture. Solvents suitable in limited applications are methylene chloride, perchloroethylene and trichloroethylene. These compounds have been shown to be carcinogenic in certain animal test systems and, under certain exposure conditions, could be carcinogenic to humans. Because of this potential toxic risk to humans, precautions should be used to keep worker exposures below the recommended amount set forth by OSHA.

There is no known, universally acceptable, solvent. However, new water based, non-toxic, biodegradable solvents are available and continue to be developed. Some are suitable for cleaning chlorine equipment in specific applications. Any solvent usage requires personnel safeguards, good work practices, suitable collection, and safe, environmentally acceptable disposal of residual materials.

11.1.4 Standards of Cleanliness

Potential contaminants include oils and grease and particulate matter. Some method must be used for evaluating the effectiveness of the cleaning process.

Where practical, initial inspection should be done visually to look for gross contamination. For solvent and water washes discoloration or visible particles in the spent liquid may indicate contamination.

Parts that have high surface area and that do not dissipate heat, such as metal packing or mesh pads require special scrutiny. Extra care should be taken to ensure such parts are adequately cleaned and free of residue. Special precautions should be taken and consideration should be given to ensuring that there is no surface contamination. This may be accomplished with black lights (which will cause most oils to fluoresce) via laboratory analysis, or other suitable techniques.
Inspections should be done before and after assembly. An example is inspection of pipe components and spool pieces followed by inspection of the completed piping system.

11.2 Pressure Testing

All chlorine new piping systems must undergo pressure testing. ASME B31.3, Process Piping testing requirements should be applied as a minimum standard. There are three types of acceptable testing methods: hydrostatic testing, pneumatic testing and the alternate test method. Minor repairs and additions made after the piping system is initially tested may have the retest waived by the owner when precautionary measures are taken to assure sound construction. When it is not considered practical to isolate a piping system from a vessel, the piping may be tested with the vessel at the owner's option provided the pressure is not less than 77% of the original piping test pressure.

11.2.1 Hydrostatic Testing

New chlorine piping should be hydrostatically tested to one and a half (1½) times the maximum pressure to which the system may be subjected. Pressure gages, relief valves, automatic control valves and other components which may be damaged should be removed and openings should be blocked off prior to testing. After testing, all moisture-absorbing gaskets and valve packing should be replaced. It is essential chlorine systems be thoroughly dried prior to being put into service. There are some circumstances under which drying cannot be accomplished after hydrostatic testing with water. For situations where hydrostatic testing is undesirable, the pneumatic or alternate testing methods may be used.

11.2.2 Pneumatic Testing

Pneumatic testing involves the hazard of released energy stored in compressed gas. The test pressure shall be 110% of design pressure. The pressure shall be increased until a gage pressure which is the lesser of one half the test pressure or 25 psig is attained, at which time a preliminary check shall be made. The pressure should be gradually increased and leak check made at intermediate pressures.

11.2.3 Alternate Testing Method

As an alternate to pressure testing, weld examination techniques may be used. Circumferential, longitudinal and spiral groove welds shall be 100% radiographed. All other welds shall be tested using the liquid penetrant method or the mag particle method. Additionally, the piping system must undergo flexibility analysis and sensitive leak test. The sensitive leak test is described in the Boiler and Pressure Vessel Code - Section V, Article 10 and involves checking for leaks of a gas such as helium.

11.3 Drying

Chlorine piping systems must always be dried before being placed in service. Even if water has not been purposely introduced into the system for hydrostatic testing or cleaning, drying is required because moisture may enter the system from the atmosphere or other sources. Where steam has been used for cleaning, the steaming can be followed directly by the introduction of nitrogen or dry air. Heating the purge gas will aid considerably in the drying process. The temperature should be limited based on the equipment and insulation type, but 200EF (93EC) is typically an acceptable temperature. The purge gas flow should be started at high volume rates to sweep the moisture out of the piping system, and then reduced. The system should be dried until all the vent gas streams leaving have a -40EF (-40EC) dew point, measured at normal system operating pressure, or reasonably close to the entering purge gas dew point. The purge rates should be at an absolute minimum, allowing adequate time for the purge gas to reach equilibrium when the dew point is taken.

Drying using ambient-temperature dry air or nitrogen purge may take an extended period of time. This time can be decreased and the effectiveness increased by the use of a pressure cycling technique. Consideration can be given to using the services of commercial system dehydrators. These vendors normally dry piping and equipment by circulating or purging with large volumes of heated nitrogen.

11.3.1 Valves

Valves require special attention. Consideration should be given to valve removal for disassembly and drying if water has entered the piping system. Most valves, regardless of style, have pockets where water can be trapped, especially if the valve is fully open. Valves left in the piping system must be fixed in the half-open position when the system is being dried. Valves removed temporarily from the system during the drying operation must also be checked to ensure that water or moisture is not trapped in a cavity. These valves must be dried thoroughly prior to replacement in the piping system if they are not dried with the rest of the system. Personnel responsible for drying the system should be familiar with valve construction and aware of places where water or moisture can be trapped.

11.4 Testing for Leaks

Leak testing should be done once the piping system is completely assembled. The purpose of a leak test is to ensure all connections and components will not leak chlorine when pressurized. Leak testing is not a substitute for pressure testing. If the system was not disassembled and reassembled as part of the pressure testing and drying process, the nitrogen/dry air test (i.e. Step 1) may be omitted.

- Step 1
  Pressurize the system to 150 psig (1034 kPa) or to 110% of design pressure (whichever is lower) with dry air or nitrogen. Use a soap solution to test for leaks at joints.

- Step 2
  Introduce chlorine gas (never liquid chlorine) into the system and raise the pressure to approximately 5 psig.

- Step 3
  Test the system for leaks with aqua ammonia. Care must be taken that chlorine has diffused throughout the piping system before leak checking with ammonia.

  The reaction of ammonia vapor with escaping chlorine forms a dense white cloud. The most convenient way to use ammonia for this purpose is to direct the vapor from a plastic squeeze bottle containing 26 degree Baume' aqua (ammonia solution) at the suspected leak. Do not squirt liquid aqua ammonia on pipe fittings.
  Never attempt to repair leaks by welding until all chlorine has been purged from the system. When detectable leaks have been repaired, the line should be retested by repeating Step 3.

  Any effort to detect the source of a leak should be carried out with full consideration for potential hazards. Appropriate protective equipment must be used.

- Step 4
  Slowly increase the chlorine pressure and continue to check for leaks at several intermediate pressures until the operating pressure is obtained. If leaks are detected repairs should be made and step 4 continued until the operating pressure is achieved.

12. ROUTINE AND PERIODIC INSPECTION AND MAINTENANCE

12.1 Routine Maintenance

Written procedures specific to chlorine piping maintenance are required according to OSHA regulations (29 CFR 1910.119 (13.4.2)) and should be used to ensure long term integrity of the system. Personnel that work on chlorine piping systems should be trained in the proper maintenance procedures. After any routine maintenance, the effected area of piping should be dried as necessary and checked for leaks.

12.2 Preventative Maintenance

As part of a good overall preventative maintenance program, consideration should be given to ensuring that the following items be checked periodically and corrected as needed:

- flange bolt condition and tightness
- valve packing leaks
- valve operation
- insulation condition

- paint condition
- condition of supports

Consideration should be given to repainting on a regular basis, with timing determined by individual site conditions. This will maximize pipe life and minimize leaks by minimizing external corrosion.

12.3 Periodic Inspections

Chlorine piping systems should be inspected on a regular basis. The inspections will help to find problems prior to failure. Criteria for initiating replacement or repair should be developed for each facility. There are multiple ways to inspect these systems. Useful methods include visual inspections, ultrasonic thickness checks and non-destructive radiography checks. A thorough visual inspection is an important activity that can be done by trained operating personnel as well as by qualified Inspectors. Other methods can be used as a supplement. The results of all inspections should be documented.

12.3.1 Visual

A visual inspection should include a leak check of all flanges, valves and other fittings and attachments. The slightest smell of chlorine should initiate a thorough investigation to find and repair the leak. Particular areas of concern should include such things as pipe supports and areas with paint or insulation damage. Where insulation is damaged further inspection is warranted. Special note should be taken of weld areas, as these areas corrode most quickly. Any significant observed pitting or wall loss should be investigated further, and should be corrected as necessary.

12.3.2 Non-Destructive Testing

Non-destructive testing methods detect pipe wall thickness, pit depths and internal and external erosion/corrosion. These methods include ultrasonic thickness measurements and radiographic measurements.

Due to normal variations in pipe dimensions, it is important that the same points be measured each time they are tested. This can be accomplished by developing "maps" or orthographic sketches of the system, with test points clearly identified and marked. Routine testing will show the corrosion rates typical for the system, so that the timing of major repairs can be estimated. Consideration should be given to checking areas of high fluid velocity more frequently due to possible internal erosion.

Radiographic techniques are available to check pipe wall thickness through insulation. This permits checking piping systems without breaking the vapor barrier of the insulation. If test methods are used which require the removal of insulation, care must be taken to restore the insulation vapor barrier integrity.

12.3.3 Inspection Records

Written records are an integral part of the process safety OSHA regulations. These records should include the original inspection report, as well as recommended further inspections and corrective actions. Documentation of all follow-up actions should be appended to the original report.

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APPENDIX A

CHLORINE TRANSFER HOSE

1. Scope: This document describes parameters to be considered in the design, fabrication, installation and maintenance of chlorine transfer hoses used to connect chlorine shipping containers to stationary equipment and piping, or as temporary connections to purge and evacuate chlorine containing equipment and piping.

2. Pressure and Temperature Ratings:

2.1 Maximum Allowable Working Pressure: The minimum MAWP rating shall be equal to the pressure setting of the pressure relief device on the shipping container or system to which the hose is attached, but not less than:

2.1.1 375 PSIG at room temperature for hoses larger than ½" nominal diameter.

2.1.2 500 PSIG at room temperature for hoses equal to or smaller than ½" diameter.

2.2 Vacuum: Hoses shall not collapse or deform when subjected to full vacuum at room temperature in any configuration that does not exceed the minimum dynamic bend radius. Consult hose manufacturer for vacuum capabilities at elevated operating temperatures.

2.3 Test Pressure: Prior to initial use in chlorine service, each hose shall be tested at room temperature to either 2.3.1 or 2.3.2. Any indication of leakage is cause for rejection of the assembly.

2.3.1 Each hose assembly shall be leak tested at two (2) times the MAWP with air, nitrogen, or helium (helium shall not be used for non-metallic hoses) gas for a minimum of three (3) minutes under water. For safety reasons, it is suggested that this be preceded by a hydrostatic test at the same pressure. If the hose is hydrostatically tested prior to gas leak testing, the hose must be subjected to a drying procedure (e.g. for a period of time at an elevated temperature or equivalent) to assure that all moisture is removed from the interior of the hose. If the chafe guard does not allow for visual inspection of the braid, the pressure test is to be done prior to installing the chafe guard.

2.3.2 Each metallic hose assembly shall be pressure tested at two (2) times the MAWP and shall be Helium Mass Spectrometer tested to a maximum leak rate of 5×10^{-6} std cc/sec. If the hose is hydrostatically tested prior to Helium Mass Spectrometer leak testing, the hose must be subjected to a drying procedure (e.g. for a period of time at an elevated temperature or equivalent) to assure that all moisture is removed from the interior of the hose.

2.4 Weld Inspection: All pressure containing welds shall be 100% radiographed and/or dye penetrant tested and/or Helium Mass Spectrometer tested to a maximum leak rate of 5×10^{-6} std cc/sec.

2.5 Burst Pressure: A representative sample hose, at least 18" in length (not including end fittings), and fabricated using the same materials and procedures as the hose to be used in chlorine service, shall be hydrostatically tested to failure (bursting or otherwise breaking at any seam or joint). The sample hose shall not fail at a pressure less than five times the MAWP. A sufficient number of sample hoses are to be tested in this manner, at a frequency sufficient to assure the hose supplier, fabricator, and end user that the integrity of the hose (design and manufacture) is being maintained.

2.6 Design Temperature: The hose shall be capable of operating at the MAWP between -40°F (-40°C) and 122°F (50°C).

3. Hose Dimensions: The length of the hose should be kept to a practical minimum. This will limit the hose weight and minimize the chance of twisting or kinking of the hose.

The nominal hose diameter should be the minimum required to achieve the desired chlorine transfer rate, but not less than ¼" or greater than 2".

4. Materials of Construction: Hoses shall be of either metallic or non-metallic construction as described below:

4.1 Metallic Hoses:

4.1.1 The inner core shall be Monel 400 (UNS N0440) or Hastelloy C-276 (UNS N10276)

4.1.2 The braid shall be Monel 400 (UNS N04400), Hastelloy C-276 (UNS N10276) or Hastelloy C-22 (UNS N06022).

4.1.3 The outer covering (chafe guard) shall be Series 300 stainless steel

4.1.4 The wetted end fittings shall be constructed of the same material as the inner core

4.2 Non-metallic Hoses:

4.2.1 The inner core shall be virgin, unfilled PTFE with or without fiberglass reinforcement. An inner layer of carbon black filled PTFE, or through-thickness carbon impregnated PTFE core (Note: the addition of carbon may increase the permeability of chlorine through the hose), can be used to increase electrical conductivity if static discharge is a concern.

4.2.2 The braid shall be PVDF or Hastelloy C-276 (UNS N10276).

4.2.3 The outer covering (chafe guard) shall be one of the following:

4.2.3.1 Chlorinated polyethylene (CPE) with sufficient openings along the entire length of the hose to permit chlorine, which may permeate the inner core, to be vented.

4.2.3.2 HDPE spiral guard with open pitch to allow inspection of the braid.

1230f593

4.2.3.3 PVDF open weave chafe sleeve.

4.2.4. The wetted end fittings and collars shall be Monel 400 (UNS NO4400) or Hastelloy C-276 (UNS N10276)

4.2.5 Chafe guard collars shall be 300 series stainless steel

5. End Attachments:

5.1 Metallic Hoses: End fittings shall be attached by a welder qualified (per ASME Section IX) to weld the specified materials and to make the required joint(s).

5.1.1 The weld joints shall be either Method 1 or 2, as illustrated in Fig.1.0

5.1.2 Welding dissimilar materials on pressure retaining, wetted joints is not permitted.

5.1.3 The outer covering (chafe guard) shall be attached at both ends of the hose by welding to the end fitting at least 1 inch past the wetted pressure retaining joint.

5.2 Non-metallic Hoses: End fittings shall be attached by crimping the inner core and braid in a Monel or Hastelloy collar. The outer covering (chafe guard) shall be permanently attached to the end fittings.

5.2.1 Dimensions that are used for quality control in hose assemblies should be specified in hose assembly procedures. A crimp dimension should be specified for the collars that are used to secure the end attachments of the hose, braid and guard to the end fitting of the hose. The hose manufacturer should have design and testing documentation that verify that the crimp dimensions when within the specified tolerances will produce a hose assembly that meets the performance requirements.

6. Types of End Fittings: End fittings shall be Schedule 80 stub ends or nipples with hex wrench pads (1 inch minimum width). The end fittings shall be fabricated without elbows or tees and shall have a maximum length of 6 inches. For chlorine cylinders and ton containers the CGA 820 connection is acceptable. The ends shall be one of the following types:

6.1 Male NPT.

6.2 Type A lap joint, 300 Class ANSI flange with carbon steel (ASTM 105) back-up flanges.

7. Miscellaneous Design Requirements:

7.1 Inner Core (metallic hose): Minimum thickness of the inner core is to be as follows:

7.1.1 1 inch diameter and above: 0.010" thick anywhere along the core after forming the core convolutions.

7.1.2 Less than 1 inch diameter and greater than ¼ inch: 0.008 inch thick

7.1.3 ¼ inch diameter: 0.006 inch thick

7.2 Inner Core (non-metallic): One continuous length of convoluted (smooth bore optional for ½ inch and below), virgin PTFE with or without fiberglass reinforcement. Minimum thickness of the inner core is to be as follows:

7.2.1 1 inch diameter and above: 0.045 inch thick

7.2.2 Less than 1 inch diameter: 0.035 inch thick

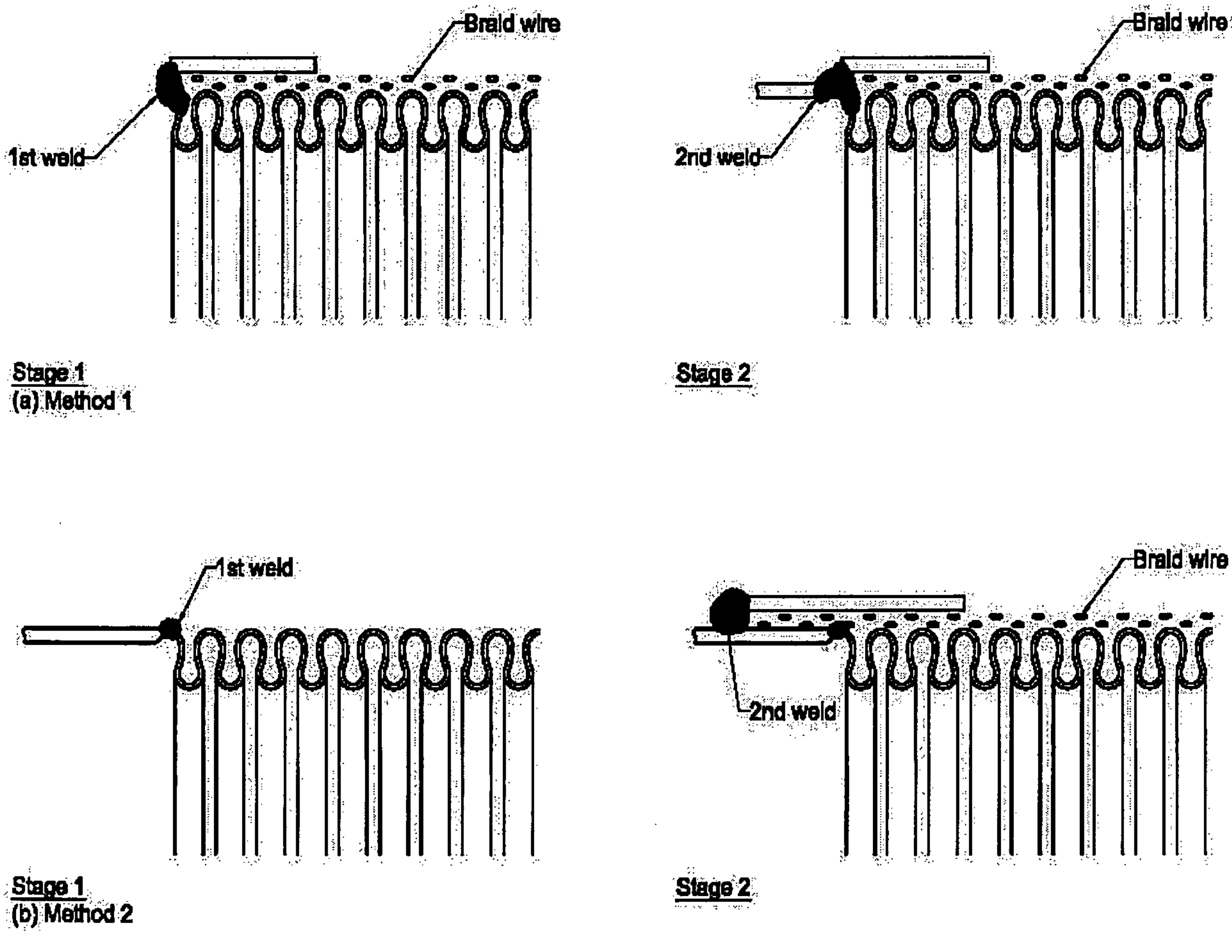


Fig. 1.0
Welding of End Fitting, Ferrule and Braid to Hose

7.3 Braid: Multiple monofilament fibers or wire shall be braided in a diamond or basket weave pattern and permanently attached to both ends of the hose. Multiple layers of braid shall be used to meet the pressure specifications, as required.

7.4 Bending Requirements: The minimum bend radius (for metal hose as defined in SO 10380) shall be no greater than 12 inches for hoses less than 2 inch nominal diameter and no greater than 15 inches for 2 inch nominal diameter hoses.

7.4.1 Hose supports should be designed in such a manner that the hose is not subjected to a bend radius smaller than the manufacture's specification. Hose supports should be designed to prevent kinking when stored but not connected to shipping containers or a process.

7.5 Permeability: The inner core of non-metallic hoses is subject to some degree of permeability of chlorine. The braid and chafe guard shall be designed to allow chlorine which permeates the inner core to escape to atmosphere. Use of non-metallic hoses shall be limited to applications where adequate ventilation has been provided.

8. Cleaning and Shipping:

8.1 Prior to shipping, each hose assembly shall be cleaned to remove hydrocarbons, foreign materials and standing water. (Note: prior to use in chlorine service, the hose shall be cleaned and dried at the site of use as required to meet cleaning specifications of Chlorine Institute Pamphlet 6).

8.2 Hose assemblies shall be wrapped in water tight packaging and boxed in containers that will prevent damage to the hose in transit. Alternatively, hoses may be shipped with securely fitted pipe caps on the end fittings.

9. Marking: Each hose shall be identified with the following information, permanently attached to the hose, by coating, stenciling or stamping:

9.1 A unique serial number, assigned by the final hose assembler that can be used to obtain hose documentation.

9.2 The final assembler company's name

9.3 The date of final assembly (month and year)

9.4 The minimum allowable bend radius

9.5 The statement "Chlorine per C.I. Pam. 6" to indicate compliance with all requirements of this document.

10. Documentation: The following documentation is to be kept by the final hose assembler's company and made available to the customer:

10.1 Hose design qualification (pressure, temperature, vacuum rating, bend radius, materials of construction, etc.)

10.2 Assembler training and certification records

10.3 Positive material identification documents.

10.4 Final crimp dimensions (Non-metallic hoses only)

10.5 Pressure test records and certification that a sample hose, built to the same specifications, has passed the burst test within the last 12 months.

10.6 Radiograph and/or dye penetrant and/or Helium Mass Spectrometer reports for all welds.

10.7 Certification that the hose has been cleaned as required by this document.

10.8 Final inspection reports

10.9 Certification of compliance with Chlorine Institute Pamphlet 6, dated (year)

11. Installation and Use:

11.1 Hoses shall be installed in accordance with Fig.2.0.

11.2 A visual examination shall be carried out prior to each use of the hose to detect any signs of discoloration, excessive bending (kinks), tears or other signs of stress. Hoses with visible signs of deterioration shall be removed from service.

11.3 The use of external supports, such as slings, should be considered to reduce stresses on the hose and to aid in handling of the hose assembly.

11.4 As a preventative maintenance measure, hoses should be replaced on a periodic basis, based on statistical data collected at each user facility. However, hoses should not be kept in service for more than 24 months.

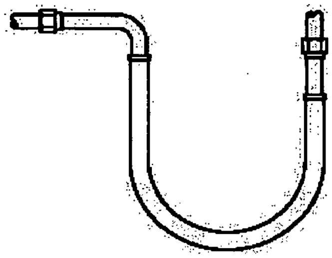
12. Manufacturers, Distributors and Owners

12.1 Dimensional and material specifications should be controlled for the components of the hose assembly and be identical to qualified prototype hose(s).

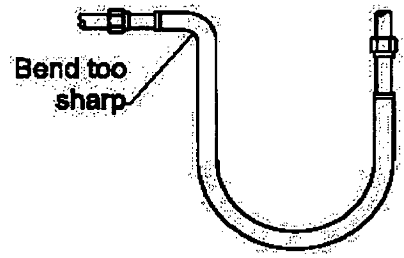
12.2 An acceptance process should be used for component manufacturers.

12.3 Hose component and assembly quality assurance practices need to demonstrate a *"continuous positive material identification of the chlorine hose throughout the supply chain."*

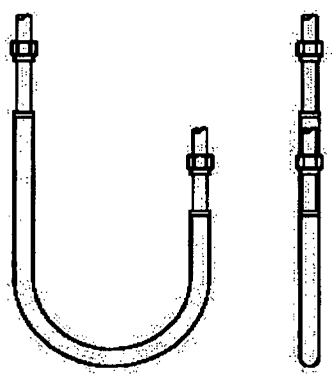
12.4 Hose assembly procedures must be documented and strictly adhered to.



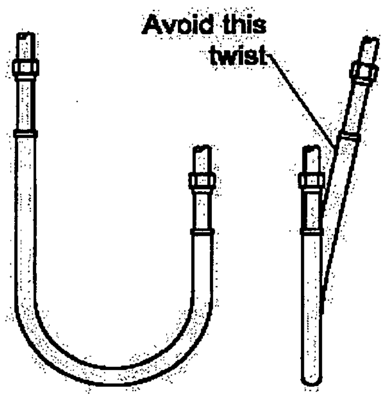
(a) CORRECT. The drawing illustrates the correct way to install a hose assembly in loop form. Note the free bend of the hose and that there are no sharp bends near either of the fittings.



(b) INCORRECT. An illustration of this type is incorrect because there is a sharp bend near the upper fitting. If the hose assembly is installed in this manner, fatigue failure may result near the fitting.



(c) CORRECT. The drawing demonstrates the manner of installing a hose assembly so that the hose during all movement will be in one plane. Note that there are no sharp bends near either fitting.



(d) INCORRECT. A hose assembly should not be installed like this when it will be required to move. Note that the fittings are not in line and that the hose is in torsion. When installed in this manner the twist in the hose may cause premature fatigue failure.

Fig. 2.0
Correct Installation of Hose Assemblies

12.5 Hose testing per the requirements of this Pamphlet must be documented.

12.6 Persons involved in the manufacture, assembly and testing of hose components and assemblies should be trained in the procedures pertaining to these activities. Records of successful completion of training to be available.

12.7 Non-conforming hose components or assemblies should be documented and corrective actions taken to prevent a recurrence.

12.8 <u>Manufacturers' Responsibilities</u>

12.8.1 The hose manufacturer's role is to produce a hose assembly that meets the customer's specifications.

12.8.2 The hose manufacturer will have the systems in place to assure that the hose and its components are correct.

12.8.3 If the hose manufacturer has a distributor assembling hoses from component that it supplies, then, the manufacturer must have a system in place to verify that its quality assurance procedures are being followed.

12.9 <u>Distributors' Responsibilities</u>

12.9.1 The role of a hose distributor that performs hose assembly is to produce a hose assembly that meets the customer's specifications following the manufacturer's procedures.

12.9.2 The hose distributor's role is to use hose storage practices that do not damage or contaminate the hose assembly.

12.9.3 The hose distributor must supply a hose assembly that meets the customer's specifications.

12.10 <u>Owners' Responsibilities</u>

12.10.1 Audit the manufacturer and/or assembler companies to verify that they are complying with the requirements of this Pamphlet.

12.10.2 Upon receipt, owner should make an inspection and verify material via the traceability reports.

12.10.2 Install the hose correctly to avoid excessive stresses on the hose.

12.10.3 Use the hose in applications that do not exceed the hose design criteria and that minimize ingress of moisture into the hose at all times.

12.10.4 Inspect, maintain and replace the hoses on a regular basis.

13. References

ISO 10380 – *Pipework – Corrugated metal hoses and hose assemblies*, Second Edition 2003-02-01

APPENDIX B

CHLORINE SERVICE - FLUID CATEGORY

The Chlorine Institute began issuing detailed recommendations for piping systems in 1960. Since 1976, those recommendations have stated that chlorine piping systems be built to conform to the specifications set forth in the ASME B31.3 *Process Piping* code section (13.2.8).

ASME has recognized that the level of risk is best determined by the system owner and has called for the owner to be ultimately responsible for the system design. That philosophy was formalized in the 1976 edition of the Code, where three categories of fluid service were identified. One of those was Category M.

The Chlorine Institute reviewed the Category M definition in 1981 and formally concluded that chlorine did not meet the criteria outlined for Category M Fluid Service.

Issues of Pamphlet 6, the Chlorine Institute publication on piping systems, continued to recommend design to B31.3, but did not recommend fluid service as that was the responsibility of the system owner.

The Category M issue was reviewed by the Chlorine Institute in 1988 following ASME's Code revision of that year, and the Chlorine Institute did not change its opinion. (The Institute is not aware of anything that has occurred that will change this position.)

A 1998 Institute review has developed the following policy:

The membership of the Institute is against any blanket requirement relative to Category M Fluid Service design for chlorine systems.

This statement is based on the following facts:

The owner is required to determine fluid service based upon a decision process outlined within the ASME code.

It is the policy of the Institute and its members that technical decisions should be made based on detailed risk analysis. While some portions of Category M requirements can lead to safety improvements, there are cases where strict design adherence to Category M service may lead to increased risk due to need to substitute less desirable materials for currently used piping components.

Within the code decision process, two key parameters must be met for the code to require design to Category M service. A copy of the ASME decision chart is attached. Following are comments on those parameters.

The first parameter in the code decision process states "a very small quantity causing irreparable harm, even when prompt restorative measures are taken". ASME has, in the past, formally declined to define a small quantity. Two separate groups have assessed the health effects due to exposure to chlorine. Their findings are summarized below:

On October 30, 1997, EPA proposed in the Federal Register recommendations of its National Advisory Committee pertaining to acute effects of exposure to several substances including chlorine. The committee has developed Acute Exposure Guideline Levels (AEGLs) for four exposure periods (30 minutes, 1 hour, 4 hours and 8 hours) for each of three severity levels: AEGL-1, AEGL-2 and AEGL-3.

Airborne concentrations below AEGL-3 but above AEGL-2 represent average exposure concentrations for the defined time period which may cause irreversible or other serious, long lasting effects or impaired ability to escape in the general population, including susceptible but excluding hypersusceptible individuals. These levels have been developed without consideration of prompt restorative measures which may mitigate any potential health impact. The 30 minute AEGL-3 and AEGL-2 were proposed at 28 ppm and 2.8 ppm, respectively.

The American Industrial Hygiene Association (AIHA), Fairfax, VA has reviewed a similar body of scientific evidence as the EPA advisory committee. AIHA has published an Emergency Response Planning Guideline (ERPG) for chlorine and many other chemicals. Three toxic severity levels are used: ERPG-1, ERPG-2 and ERPG-3. ERPG-2 is 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 serious health effects or symptoms which could impair their ability to take protective action. Prompt restorative measures were not considered when developing the ERPGs. The ERPG-2 for chlorine is 3 ppm.

The IDLH (NIOSH) for chlorine is 10 ppm.

Several researchers have evaluated the effects of chlorine exposure. Ellenhorn and Barceloux (1988) compiled a listing of chlorine exposure thresholds and estimated clinical effects which are listed below:

1 - 3 ppm -- mild, mucus membrane irritation, tolerated up to 1 hour
5 - 15 ppm -- moderate irritation of the respiratory tract
30 ppm -- immediate chest pain, vomiting, dyspnea, cough
40 - 60 ppm -- toxic pneumonitis and pulmonary edema
430 ppm -- lethal over 30 minutes
1000 ppm -- fatal within a few minutes

Clearly, these values indicate that a single exposure to greater than a very small quantity of chlorine does not cause serious, irreversible harm on breathing or bodily contact.

The second parameter deals with system integrity. Through history, chlorine piping systems have not experienced "significant" releases as noted in B 31.3 that would have been prevented by the design changes required under Category M. Chlorine leaks from piping systems historically start from either physical damage or as very small leaks resulting from corrosion due to moisture intrusion.

While many aspects of design requirements listed within Category M can enhance system integrity, several are based on refinery and other high pressure, high temperature applications where mechanical properties of steel become limited. Some of these can introduce safety issues into chlorine systems. There are many examples where system integrity could be compromised or substitutions to less reliable components may be required for strict adherence to Category M. Three of them follow.

- Thermoplastic construction is universally used in drinking and wastewater chlorination. This construction gives the optimum balance of corrosion protection and mechanical integrity in this low pressure, wet chlorine environment. Nonmetallic construction is prohibited within Category M.

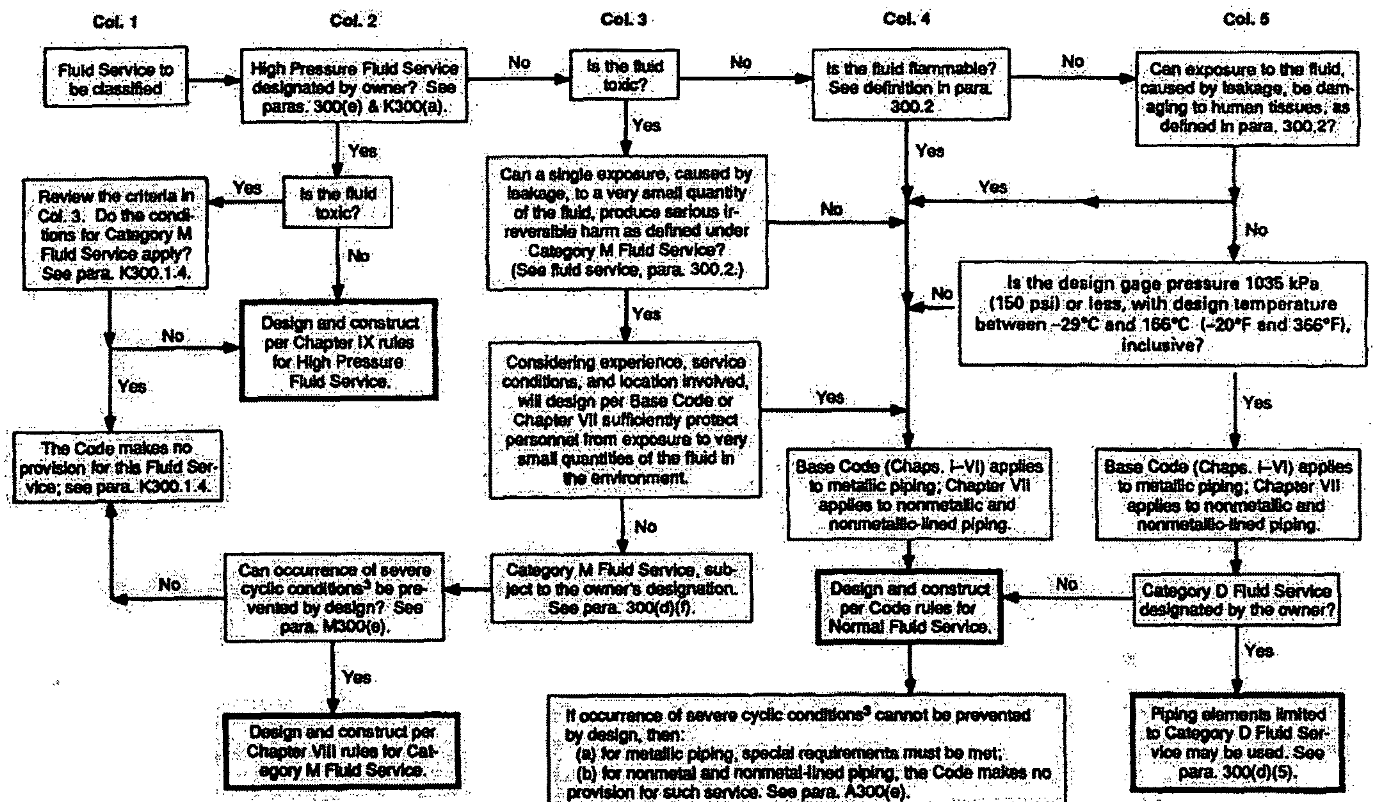
- Connections to chlorine transportation containers are made with either reinforced metallic or reinforced fluoropolymer hose. Depending on type, either nonmetallic pressure containment elements or brazed joints are integral components of the designs. These are not allowed within Category M. Mechanically sealed swivel joint systems would have to be developed.

- Miter bends are often used in pressure relief device vent systems to limit backpressure. Substitution to standard elbow components to comply with Category M will not enhance system safety.

It is good practice for users develop site- specific chlorine piping specifications that use the recommendations outlined in Pamphlet 6 as a base and consider including elements of Category M requirements (such as NDT examination) that enhance reliability at their sites.

In summary, The Institute position relative to Category M design is as follows:

- The owner is responsible for determining fluid class
- A single exposure to a very small quantity of chlorine does not cause irreversible harm.
- Current design practices have been adequate to prevent significant releases.
- Chlorine piping system reliability can only be assured by a combination of site-correct specification and design coupled with proper operation, inspection and maintenance.



NOTES:
(1) See paras. 300(b)(1), 300(d)(4) and (5), and 300(e) for decisions the owner must make. Other decisions are the designer's responsibility; see para. 300(b)(2).
(2) The term "fluid service" is defined in para. 300.2
(3) Severe cyclic conditions are defined in para. 300.2. Requirements are found in Chapter II, Parts 3 and 4, and in paras. 323.4.2 and 341.4.3.

FIG. M300 GUIDE TO CLASSIFYING FLUID SERVICES

APPENDIX C

RECOMMENDATIONS TO MINIMIZE EFFECTS OF MOISTURE IN DRY CHLORINE SYSTEMS

This document addresses concerns of moisture intrusion into dry chlorine systems.

Material Specifications

At ordinary temperatures, dry chlorine, either liquid or gas, does not corrode steel. Wet chlorine is highly corrosive because it tends to form acids. These acids react with the steel.

Dry liquid chlorine is defined as liquid chlorine with its water content dissolved in solution. Dry gaseous chlorine is defined as chlorine which contains moisture exerting a vapor pressure of no more than 2 millimeters of mercury. Application of these definitions and analytical descriptions are given in Chlorine Institute Pamphlet 100, *Dry Chlorine – Definitions and Analytical Issues*.

Carbon steel is the general material of choice for dry chlorine systems. The following Chlorine Institute publications outline detail material choices for chlorine equipment:

Pamphlet 6, *Piping Systems for Dry Chlorine*
Pamphlet 5, *Bulk Storage of Liquid Chlorine*
Pamphlet 9, *Chlorine Vaporizing Equipment*
Pamphlet 95, *Gaskets for Chlorine Service*

Moisture Prevention and Corrective Measures

Chlorine in commerce as produced and shipped contains less than 100 PPM moisture. This moisture level is well below the defined limit for dry chlorine.

Chlorine consumers should take all necessary precautions to keep chlorine and chlorine equipment dry. Moisture might be introduced into chlorine systems under the following conditions:

Start-up and Shutdown: The chlorine system should be thoroughly dried before use and following maintenance. The chlorine system drying procedure usually involves heating the system followed by purging with a dry gas until the gas exiting the system is at a dewpoint of –40°F (-40°C).

Wet pad purge gases: If compressed air is used to pressurize shipping equipment for chlorine transfer, the air system should deliver reliably dry air at a dewpoint below –40°F (-40°C) at the operating pressure.

Exposure to atmosphere: Chlorine systems piping, valves and containers should be closed or capped immediately to keep out atmospheric moisture when not in use.

If the chlorine system becomes contaminated with moisture and corrosion is indicated by buildup of ferric chloride, the system should be emptied, purged of chlorine, washed out and then dried.

Adverse Consequences

Excessive moisture in chlorine results in metal loss and formation of ferric chloride.

Metal loss can affect the system integrity and necessitate component replacement. There should be an inspection program for corrosion products. Periodic thickness checks of system components, particularly at elbows or other potential high turbulence areas should be part of the plant preventative maintenance system.

Ferric chloride can plug small lines, especially instrument connections, leading to potential loss of process indication.

A combination of metal loss and buildup of ferric chloride can cause valves to leak through and/ or stick in position. A periodic valve test program for both manual and actuated valves should be part of the plant operating plan.

APPENDIX D

CHECKLIST

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

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

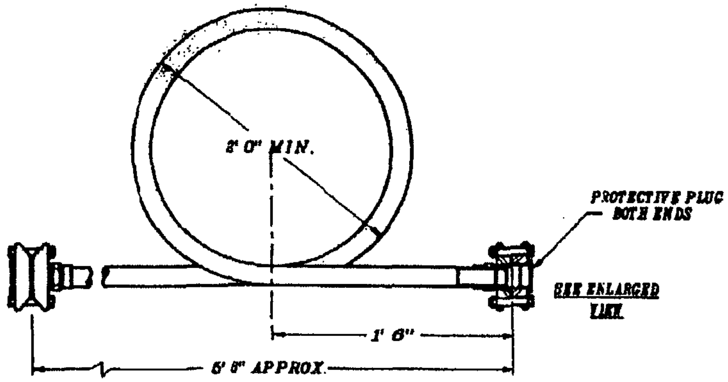
Yes	No	N/A		
☐	☐	☐	1. Systems are in place to assure that no burning or welding is done on piping containing chlorine.	{2.1}
☐	☐	☐	2. Expansion properties of liquid chlorine have been considered	{2.1}
☐	☐	☐	3. Dry chlorine systems are protected from intrusion of moisture	{2.1}
☐	☐	☐	4. No titanium components are used in dry chlorine service.	{2.1}
☐	☐	☐	5. Chlorine systems are properly cleaned and dried prior to being placed into service.	{2.1}
☐	☐	☐	6. A chlorine piping inspection program is in place.	{2.1}
☐	☐	☐	7. Materials of construction are based on temperature and fluid state.	{2.3}
☐	☐	☐	8. Design and construction are appropriate for the intended service class	{2.3}
☐	☐	☐	9. Pipe and piping components are consistent with Institute recommendations.	{3}
☐	☐	☐	10. Valve type and materials are consistent with Institute recommendations.	{4}
☐	☐	☐	11. Pressure relief devices are designed consistent with Institute recommendations.	{5.2}
☐	☐	☐	12. Transportation valve components are only used in appropriate locations.	{5.4}
☐	☐	☐	13. Expansion chambers are installed where required.	{5.5}
☐	☐	☐	14. Non-ferrous system components are consistent with Institute recommendations.	{7}
☐	☐	☐	15. Transportation container connections are consistent with Institute recommendations.	{8}

☐	☐	☐	16. Use of plastic materials is consistent with Institute recommendations. {9}
☐	☐	☐	17. Piping layout and design is appropriate for the intended chlorine service. {10}
☐	☐	☐	18. Proper procedures are in place to assure that systems are correctly prepared for use. {11}
☐	☐	☐	19. A system for periodic inspection and maintenance is in place. {12}
☐	☐	☐	20. Chlorine transfer hoses are consistent with recommendations of Appendix A {App A}

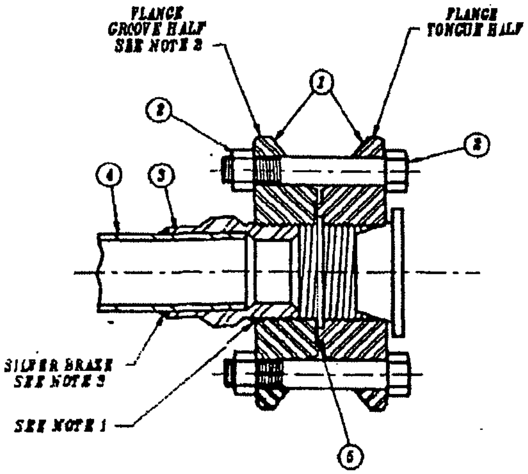
REMINDER:

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

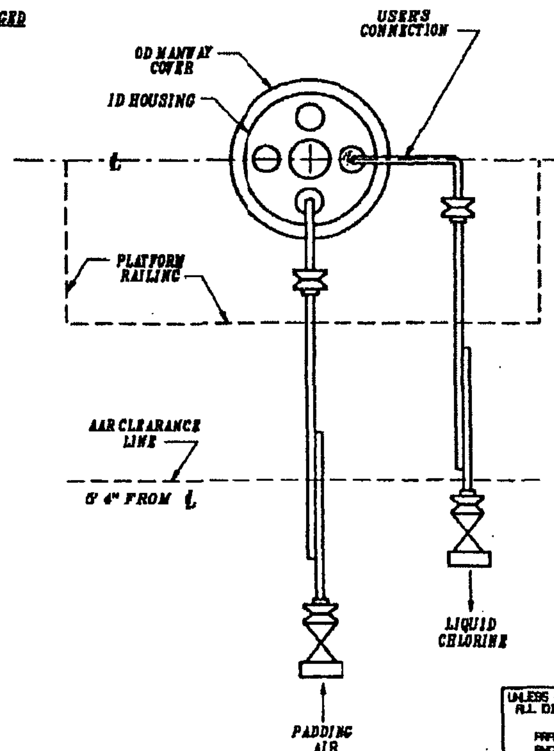
DRAWINGS



TESTING
HYDROSTATIC TEST AT 600 PSIG AND DRY THOROUGHLY.
(SEE NOTE 5)



ENLARGED VIEW



ITEM	NAME OF PART	MATERIAL
1	TWO BOLT OVAL FLANGED UNION TYPE 1500# 1" NPT FEM THD (NOTE 4)	FORGED ST. ASTM A 105
2	BOLTS & NUTS, HVY HEX, BOLTS PER ANSI B18.2.1 NUTS PER ANSI B18.2.2 THREADS PER ANSI B1.1 CLASS 2A & 2B FIT, BOLT DIA. & LENGTH TO SUIT FLANGES.	CARBON ST. ASTM A 307 GRADE B
3	ADAPTER, SOLDER JOINT. PER ANSI B16.22; 1 1/8 OD TUBE TO 1" NPT WALL	WROUGHT COPPER ASTM B 75
4	TUBING TYPE K, ANNEALED SIZE PER ANSI H 23.1 (1 1/8 OD x .065 WALL)	COPPER ASTM B 88
5	GASKET, ASBESTOS COMPOSITION OR 2% TO 4% ANTIMONY LEAD. DIMENSIONS TO SUIT FLANGES	ASBESTOS PER FED. SPEC. HH-P46E LEAD PER ASTM B29

NOTES:
1. USE LITHARGE AND GLYCERINE OR WHITE LEAD PASTE ON PIPE THREADS.
2. ASSEMBLE THE GROOVE HALF OF THE FLANGE TO THE ADAPTER–BOTH ENDS.
3. SILVER BRAZE–FULL PENETRATION REQUIRED. BRAZING ALLOY MUST HAVE A MINIMUM SILVER CONTENT OF 44% AND MUST NOT CONTAIN ANY TIN.
4. ALTERNATE–3000# LARGE TONGUE AND GROOVE FLANGES PER ANSI B16.5 MAY BE USED.
5. MAX DESIGN WORKING PRESSURE IS 400 PSIG.

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

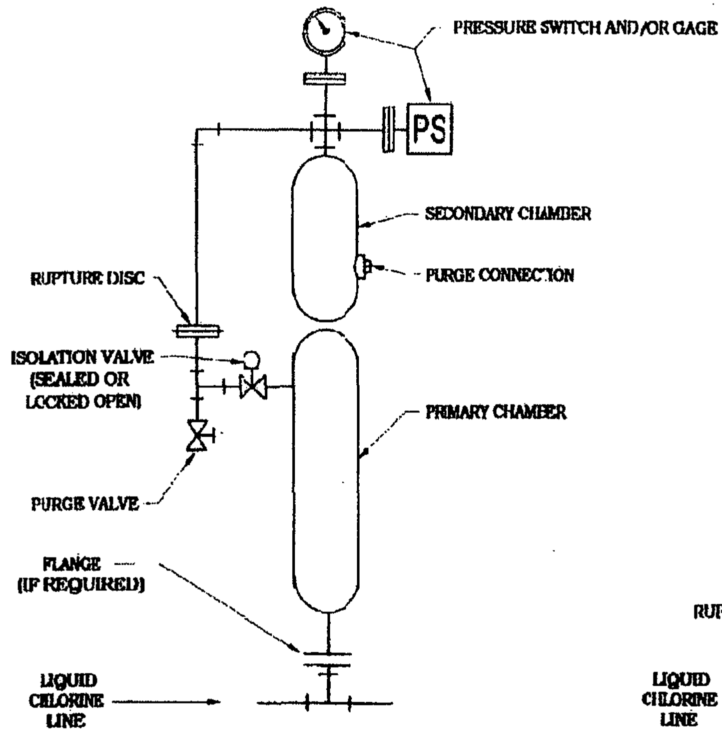
ISS	DATE	REVISION	APPR
6			
5			
4	11/91	REDRAW	—
3	2/85	REV. NOTES, B/M & DETAILS	STC
2	9/77	UPDATE B/M, DEL. DETAILS	C.SS
1	5/61	INITIAL RELEASE	C.SS

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

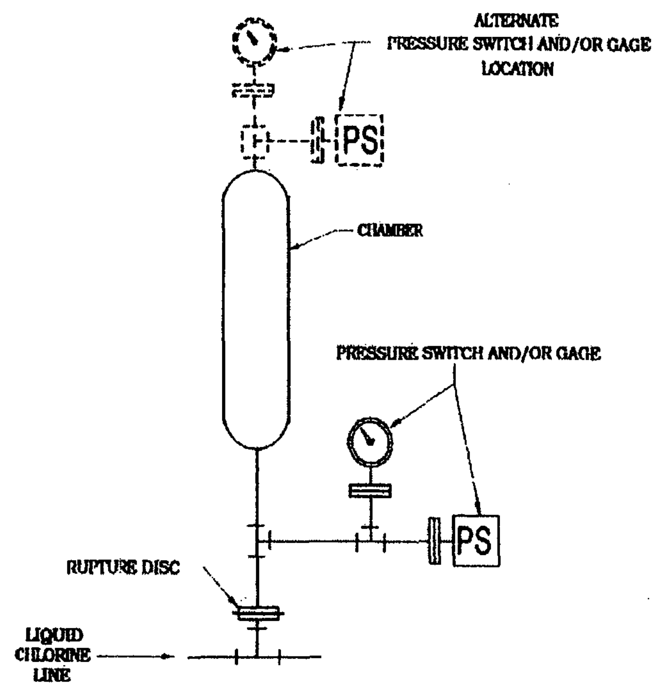
CHLORINE TANK CAR UNLOADING CONNECTION

DRAWN	A. KASS	11-91
TRACED		SCALE = NONE
CHECKED	REP	
APPROVED		
DWG. NO.	118	ISSUE 4

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/64
ANGLES ± 2°
DEC. ± .000



TYPE "A"



TYPE "B"

NOTES:

1. EXPANSION CHAMBERS CAN BE INSTALLED WHERE THERE IS A POSSIBILITY THAT LIQUID CHLORINE WILL BE TRAPPED BETWEEN TWO CLOSED LIQUID LINE VALVES AND THE SYSTEM LEFT UNATTENDED AFTER VALVE CLOSURE. THESE RECOMMENDATIONS ARE BASED ON THERMAL EXPANSION OF LIQUID CHLORINE BETWEEN 0° F (-18° C) AND 140° F (60° C)

2. CHAMBER CAPACITIES:
   TYPE "A" - PRIMARY (BOTTOM) - 20% OF LIQUID CHLORINE LINE VOLUME
   SECONDARY (TOP) - MINIMUM OF 10% OF CHLORINE LINE
   TYPE "B" - ONE TANK - MINIMUM OF 20% OF LIQUID CHLORINE LINE VOLUME

3. 400 PSIG RUPTURE DISC SETTING SUITABLE FOR MANY SYSTEMS. SETTING MUST COMPLY WITH NOTE 6A.

4. PRESSURE GAGES AND SWITCHES SHALL CONFORM TO C.I. PAMPHLET #6.

5. PIPING AND CRITERIA FOR INSTALLATION SHALL CONFORM TO C.I. PAMPHLET #6.

6. EXPANSION CHAMBERS SHALL BE DESIGNED FOR A MINIMUM SERVICE PRESSURE CONSISTENT WITH THE LOWEST PRESSURE RATED COMPONENT OF THE SYSTEM AND SHALL BE CONSTRUCTED:
   A. FROM PIPE AND FITTINGS IN ACCORD WITH C.I. PAMPHLET 6; or
   B. FROM SEAMLESS, DRAWN CYLINDER IN ACCORD WITH U.S. DEPARTMENT OF TRANSPORTATION OR TRANSPORT CANADA SPECIFICATION (WITH A MINIMUM SERVICE PRESSURE RATING OF 480 PSIG [3309kPa]); or
   C. PER ASME CODE SECTION VIII.

7. CHAMBERS SHOULD BE SUPPORTED SEPARATELY.

8. TYPE "A" IS NORMALLY USED ON CUSTOMER CONTINUOUS SUPPLY PIPELINES AND SHOULD BE INSTALLED AT THE HIGH POINT OF THE SYSTEM. THE RUPTURE DISC CAN BE CHANGED WITHOUT SHUTDOWN OF PIPELINE SUPPLY. EVACUATION OF CHLORINE IS ACCOMPLISHED BY CLOSING THE ISOLATION VALVE AND OPENING THE PURGE VALVE. DISCHARGE MUST BE TO A SUITABLE SAFE PLACE. NITROGEN OR DRY AIR IS USED TO DISPLACE CHLORINE FROM THE PRIMARY CHAMBER AS REQUIRED ON A PERIODIC BASIS. THE ISOLATION VALVE MUST BE A LOCK OR SEAL OPEN TYPE WITH VISUAL INDICATION OF POSITION. IT MUST BE KEPT OPEN DURING OPERATION AND CLOSED ONLY FOR MAINTENANCE.

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/64
ANGLES ± 2°
DEC. ± .003

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

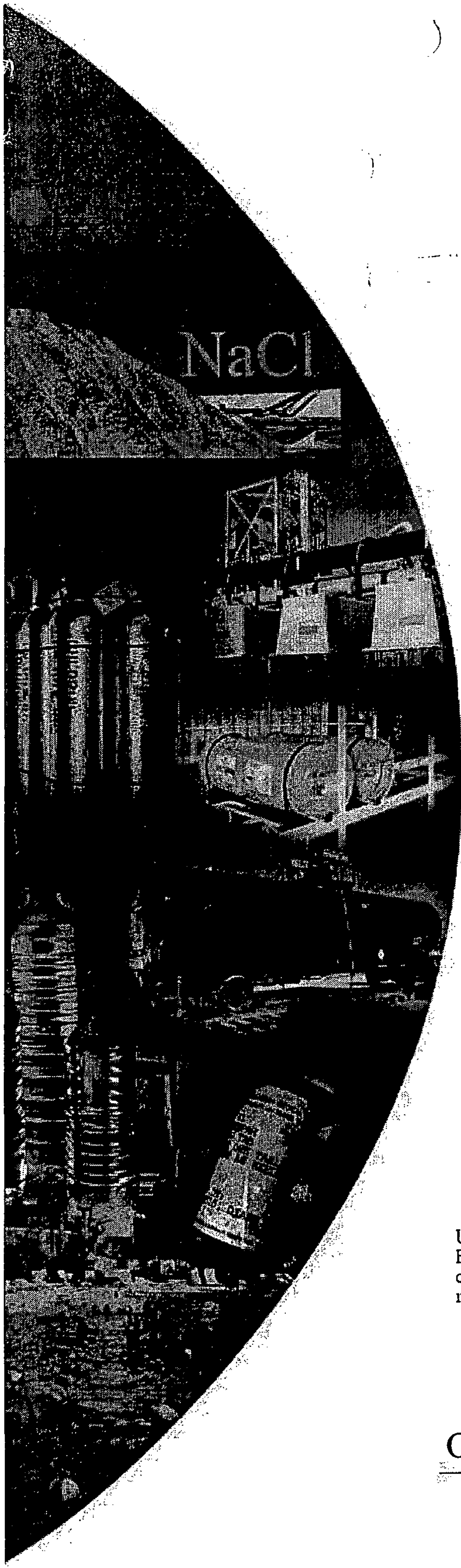
ISS	DATE	REVISION	APPR
7	1/99	NOTES 3 & 6 REVISED	STC
6	4/97	NOTE 6 REVISED	STC
5	3/92	REDRAW	STC
4	3/84	ADD NOTE 6	STC
3	3/79	NEW NOTE 3, RELOCATE 4 & 5	CCSS
2	9/77	PART 4,NOTE 4,FLANGE WAS UNION	CCSS
1	7/68	INITIAL RELEASE	CCSS

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

CHLORINE EXPANSION CHAMBERS

DRAWN	A. KASS	3-92	
TRACED		SCALE = NONE	
CHECKED	MEL		
APPROVED			
DWG. NO.	136	ISSUE	7

142 of 593



THE CHLORINE INSTITUTE, INC.

Pamphlet 17

Packaging Plant Safety and Operational Guidelines

Edition 4 - Revision 1

A LEGACY OF SAFETY STEWARDSHIP
since 1924

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

October 2009

TABLE OF CONTENTS

1. INTRODUCTION

1.1 SCOPE

The purpose of this pamphlet is primarily to provide both operational recommendations and safety information for employees at facilities that package 100-lb and 150-lb cylinders and ton containers of chlorine. The members of The Chlorine Institute have developed these recommendations through a task group, with a review and final acceptance by the Institute's Health, Environment, Safety and Security Issue Team. This pamphlet describes what are believed to be safe methods for carrying out the numerous operations of a chlorine packaging plant. However, they are intended only as recommendations and are not necessarily meant to exclude other procedures designed to safely do the same task.

Many of the operations included in this pamphlet are covered by governmental regulations, applicable Fire and Building Codes and/or standards established by organizations such as the Compressed Gas Association (CGA). The applicable requirements, codes and standards must be reviewed by the facility and any departure from these requirements should be thoroughly analyzed and documented.

Recommendations for security at packaging plants are contained in the *CI Security Management Plan for the Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks,* available to CI members.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. 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 includes 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, which will assist members and members' customers in achieving measurable improvement. For more information on the Institute's stewardship programs, visit CI's website at http://www.chlorineinstitute.org/.

1.3 DEFINITIONS

In this pamphlet, the following definitions apply unless otherwise noted:

ANSI	American National Standards Institute, Inc. - http://www.ansi.org/
Aqua ammonia solution	Also known as ammonium hydroxide ($NH_3[aq]$), ammonia water or aqueous ammonia, it is a solution of ammonia in water. 26° Baumé (about 30 weight percent ammonia at 15.5°C) is the typical high concentration commercial product. Household ammonia ranges in concentration from 5 to 10 weight percent ammonia.

Baumé	The Baumé scale is a hydrometer scale developed by French pharmacist Antoine Baumé in 1768 to measure density of various liquids.
CANUTEC	Canadian Transport Emergency Centre - Operated by Transport Canada to assist emergency response personnel in handling dangerous goods emergencies.
CFATS	Chemical Facility Anti-Terrorism Standards (6 CFR, Part 27)
CFR	Code of Federal Regulations
CGA	Compressed Gas Association, Inc. - http://www.cga.org/
CHLOREP	The Chlorine Emergency Plan - A chlor-alkali industry-wide program formalized by the Chlorine Institute in 1972 to improve the speed and effectiveness of response to chlorine emergencies in the United States and Canada. Responsible for trained emergency teams from chlorine producing, packaging and consuming plants on constant 24-hour alert to assist in handling potential or actual chlorine emergencies. Typically activated through CHEMTREC or CANUTEC. - http://www.chlorineinstitute.org/CHLOREP/index.cfm
CHEMTREC	Chemical Transportation Emergency Center – An American Chemistry Council division dedicated to assisting emergency responders deal with incidents involving hazardous materials - http://www.chemtrec.com/Chemtrec/
chime	The circumferential rim in the shape of a lip on each end of a ton container.
CI	The Chlorine Institute, Inc. - http://www.chlorineinstitute.org/
condemn	To scrap as no longer fit for service.
container	Both cylinders and ton containers when used collectively.
cylinder	Any shipping container with a capacity not exceeding 150 lbs (68 kg) of chlorine that is authorized by regulations for the transportation of chlorine.
DHS	U.S. Department of Homeland Security - http://www.dhs.gov
DOT	U.S. Department of Transportation - http://www.dot.gov/
dry air	Air free from oil and foreign matter, dried to a dew point of -40°F (-40°C) or below and measured at an atmospheric pressure.

dry chlorine	Chlorine that does not meet the definition of "dry" will be considered "wet" and will have a moisture content that can cause a rapid corrosion of steel. See CI Pamphlet 100 for a complete definition and technical summary. The term "dry chlorine" is sometimes incorrectly used to describe a dry chlorinating compound (usually calcium hypochlorite or the chlorinated isocyanurates). This is a misuse of the term and is discouraged by the Institute.
eduction tube/pipe	Eduction tubes (siphon tubes) or pipes are used in both ton containers and rail car tanks for loading and unloading. Ton containers utilize an eduction tube from each valve to withdraw either liquid or gas, depending on the valve used and the orientation of the container. In the case of rail cars, eduction pipes are typically constructed to extend downwardly from the valve at the top of the car and terminate adjacent the bottom of the car, sometimes in the vicinity of a bottom sump area.
EPA	U.S. Environmental Protection Agency - http://www.epa.gov/
fusible plug	A non-reclosing pressure relief device, installed in a cylinder valve or directly into a ton container, designed to function by the yielding or melting of a plug of fusible metal at a temperature lower than the temperature at which a full cylinder or container might rupture.
ICC	International Code Council - http://www.iccsafe.org/
Institute	The Chlorine Institute, Inc. - http://www.chlorineinstitute.org/
MSDS	Material Safety Data Sheet
NGT(CL)	National Gas Taper (NGT) threads for chlorine (CL) valves are specified in Federal Standard H-28 and CGA Pamphlet V-1.
OSHA	Occupational Safety and Health Administration - http://www.osha.gov/
PPE	Personal protective equipment
ppm	Parts per million
pressure relief device (PRD)	A pressure and/or temperature activated device connected to a pressurized container or system used to prevent the pressure from exceeding a predetermined maximum.
psig	Pounds per square inch gauge. Psi is often used incorrectly instead of psig.
PTFE	Polytetrafluoroethylene. A synthetic fluoropolymer with numerous applications. Commonly known as Teflon®.

RQ	Reportable quantity; a weight assigned by the U.S. Environmental Protection Agency to certain hazardous chemicals that is used to define spills reportable to the National Response Center. Spills equal to or exceeding this weight must be reported within a maximum of 24 hours. The RQ for chlorine is 10 lbs.
reject	To designate as not fit for service in present condition; may be requalified either by additional testing to verify adequacy of the container for continued service or by reheat treatment, repair, or rebuilding to correct the defect as specified in 49 CFR Parts 100 to 185.
SCBA	Self-contained breathing apparatus
SERC	State Emergency Response Commission
staging area	A specific area designated for holding returned shipping containers until they are ready for evacuation and further operations.
tare weight	The weight of the empty cylinder or ton container including valves and fusible plugs but excluding the valve protective housing.
ton container	A Class 106A container or a Class 110A multi-unit tank car tank with a typical capacity of 2,000 lbs of chlorine, or a similar container with appropriate exemptions authorized by DOT and TC regulations for the transportation of chlorine. For the purposes of this pamphlet, the term "ton container" will apply to both U.S. tons and metric tons unless otherwise noted. Use of the term "ton cylinder" should be discontinued because, by definition, there is no cylinder with a capacity exceeding 150 lbs of chlorine.
TC	Transport Canada - http://www.tc.gc.ca/en/menu.htm
valve protective housing	A detachable bonnet, hood, or cap that fits over the valve(s).

1.4 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. Safety suggestions are based on the accident experience of members of The Chlorine Institute, Inc. The Institute and its members make no guarantee, jointly or severally, in connection with the information or safety suggestions herein.

Moreover, it should not be assumed that every acceptable safety procedure is included or that abnormal or unusual circumstances may not warrant or require modified or additional procedures.

The user should be aware that changing technology or regulations may require a change in the recommendations herein. Appropriate steps should be taken by the user to assure that the information is current.

These suggestions should not be confused with federal, state, provincial, or municipal regulations, or with national safety codes or insurance requirements.

1.5 APPROVAL

The Institute's Health, Environment, Safety & Security Issue Team approved Edition 4 - Revision 1 of this pamphlet on October 6, 2009.

1.6 REVISIONS

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

1.6.1 Significant Revisions in Current Edition

Edition 4 of this pamphlet was a complete rewrite. Edition 4 - Revision 1 contains specific edits to correct concerns over fusible plug melt temperatures. Fusible plug information can be found in Section 5.1.1, Appendix A and Appendix D.

1.7 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior permission from the Institute.

2. PACKAGING PLANT DESIGN AND MAINTENANCE

2.1 GENERAL

In a chlorine packaging plant, DOT regulated containers are filled to a specified weight with liquid chlorine. Typically, the chlorine is transferred from a pressurized tank car into these containers, which must be inspected, and maintained before filling. The container valves and fusible plugs should be inspected and replaced if necessary. The filled containers that are stored should be inspected again for leaks before shipment.

2.2 STRUCTURES

Buildings and structures to house chlorine equipment or containers should conform to local building and fire codes as well as to the recommendations in this document. Any such structures should be designed and constructed to protect all elements of the chlorine system from fire hazards. Fire-resistive construction is recommended, and combustible materials should not be housed in the same building as chlorine equipment or containers. However, if flammable materials are stored or used in the same building, a fire wall should be erected to separate the chlorine from the flammables.

As of the publication date of this pamphlet, there are no federal regulations within the United States that mandate the installation of ambient chlorine monitors. However, state and local rules may require the use of monitors, and such equipment should be considered for any storage or operating area where chlorine may be released (See CI Pamphlet 73).

At least two exits should be provided from each room or building in which chlorine is stored, handled, or used. Exit doors should not be locked and should open outward. Platforms should be designed to facilitate egress, and two or more access stairways or ladders should be considered. Steel structures should be protected to prevent corrosion.

2.3 VENTILATION

It is recommended that all ventilation systems for buildings that house chlorine equipment or containers conform to applicable building code requirements, American Conference of Governmental and Industrial Hygienists (ACGIH) recommendations found in the *Industrial Ventilation Manual: A Manual of Recommended Practices* and with the guidance found in this document. The building ventilation system should provide fresh air for normal operation and should be designed to handle a situation in which a chlorine leak occurs. Natural ventilation may be adequate; otherwise, mechanical ventilation systems should be provided.

The Institute recommends that ventilation requirements be determined on a site-specific basis. Safeguards should be in place to ensure that persons without the appropriate personal protective equipment, and appropriate training in the use of such personal protective equipment, do not remain in or enter buildings where chlorine is present in the atmosphere due to a leak or equipment failure.

Chlorine scrubbing systems, as described in CI Pamphlet 89, may be appropriate depending on the individual site.

2.4 PROCESS PIPING REQUIREMENTS

The following recommendations provide general knowledge about piping systems for dry chlorine in a packaging plant. For more detailed information or to design a system see CI Pamphlet 6.

- Liquid chlorine has a high coefficient of thermal expansion. If liquid chlorine is trapped between two valves, an increase in the temperature of the trapped liquid will result in high pressures that could lead to a rupture of the line unless the piping system is protected with a pressure relief device.

- Dry chlorine systems must be protected from the intrusion of moisture because moisture from wet compressed air or from exposure to ambient air can cause severe corrosion and failure of welds, valves, hoses, and fittings.

- Dry chlorine systems must be thoroughly cleaned before use because chlorine can react violently with cutting oil, grease, and other foreign materials. New valves or other equipment received in an oily condition should be dismantled and cleaned before use.

- All dry chlorine systems should be inspected at regular intervals for signs of leakage, internal or external corrosion, insulation failure, or support problems. These inspections should be documented.

2.5 FACILITY MAINTENANCE

Good housekeeping practices lead to improved safety performance and more effective responses to emergency situations.

2.5.1 Emergency Equipment

Emergency equipment, such as The Chlorine Institute Emergency Kits A, B, and C (See Section 8.5), should be routinely inspected to assure that all components are still in the kits and are in good working order. Clear areas should be marked around the locations of the kits to assure quick and unrestricted access to them.

Self-contained breathing apparatuses (SCBAs) should be routinely checked to assure that they are ready for emergency use. The respirator portion of the SCBA should be cleaned and disinfected after each use. Air cylinders should be refilled after any use to assure maximum performance for the next use. Clear areas should be marked around the locations of the SCBAs to assure quick and unrestricted access to them.

Federal regulations require that all emergency equipment necessary to respond to a chlorine gas leak must be accessible at all times. Facilities should carefully plan and prepare for such events necessitating the use of emergency equipment at their locations. Emergency equipment, such as, but not limited to the Chlorine Emergency Kits and SCBA's, must be stored in locations that are readily accessible, but not likely to be affected by the chlorine gas in event of a leak.

Emergency escape respirators should be kept clean and free from contamination. The respirator cartridge has an expiration date that should be recorded and checked periodically. Expired cartridges should be discarded and replaced.

OSHA regulations (29 CFR) should be reviewed and followed for the use, inspection, repair and storage of all respirators.

A safety shower should be available in a location that is near, but not likely to be affected by chorine gas in event of a leak.

2.5.2 Scales

Areas around scales should be constantly cleaned and should remain free from debris, such as container valve outlet gaskets, that may become lodged under the scale plate and cause incorrect readings, possibly leading to overfilling the chlorine container. Adequate maintenance includes a written plan for regular calibration of the scale equipment, including written documentation of the periodic testing.

2.5.3 Valving Area

The valving area should be kept clean and dry to prevent slipping and falls.

Equipment used in the valving area such as valving machines should be inspected frequently for excessive wear and calibrated periodically. Any component that shows excessive wear especially the jaws on the valving machine, should be replaced immediately to prevent personal injury, improper valve installation, or damage to the container or valve.

2.5.4 Cylinder and Ton Container Filling Stations

The area around the filling stations should remain clean and clear.

Filled containers should be moved to the storage area as soon as is practical. Containers should not be allowed to accumulate around the filling area. The area around the station should remain clear and marked to allow for emergency egress in case of a chlorine release and to allow emergency response personnel to perform their functions.

2.5.5 Tank Car Station

The area around the tank car stations should remain clean and clear. Do not allow containers to accumulate around the tank car station. Consider marking clear areas around the station to allow for emergency egress in case of a chlorine release. This clear area will also allow emergency response personnel to perform their functions.

2.6 STORAGE OF CYLINDERS AND TON CONTAINERS

2.6.1 Location

Containers may be stored indoors or outdoors and access to storage areas by unauthorized persons must always be controlled. Local fire and building codes may dictate storage requirements, but in general the following guidance should be followed:

If stored indoors, the storage areas should comply with the provisions of Sections 2.2 and 2.3. Containers should not be stored near elevators or ventilating systems because dangerous concentrations of gas may spread rapidly if a leak occurs. Subsurface storage areas should be avoided because chlorine vapors are heavier than air and will not dissipate from low areas in the event of a leak.

All containers should be stored to minimize external corrosion and excessive temperatures. If standing water can collect around the containers, suitable platforms or supports should be in place. Containers should not be exposed to temperatures above 125°F (51.7°C). Exposure of containers to flames, intense radiant heat, or steam lines should therefore be avoided.

Containers should not be stored where heavy objects can fall on them or where vehicles could strike them. Full and empty containers should be stored separately. Even though a container is empty, the valve outlet cap(s) and the valve protective housing should be in place. Provisions should be made to permit routine inspections of all containers.

2.6.2 Accessibility for Installing Emergency Equipment

In the event of a leak, easy access to all containers is important. Accessibility for installing emergency equipment should be considered when designing a storage area for containers. Storing ton containers above the ground and away from walls is recommended.

2.6.3 Leak Detection Equipment

Chlorine gas detection equipment is recommended for the storage areas of a packaging plant if the site is not monitored 24 hours a day. The equipment should be designed and adequately maintained to warn on-site personnel of a release or to signal a remote manned location of a release. Adequate maintenance includes a written plan for regular calibration of the monitoring equipment, including written documentation of the periodic testing (See CI Pamphlet 73).

2.6.4 Compatibility with Other Stored Materials

Chlorine containers should be segregated from other compressed gas containers, flammable and oxidizing materials, and materials such as ammonia and hydrocarbons that are reactive with chlorine.

2.6.5 Cleanliness

Storage areas should be kept clean so that accumulated trash or other combustible material does not present a fire hazard.

2.6.6 Posted Information

The chlorine storage area must be properly posted with signs in accordance with local, state, federal, and provincial laws and regulations. Signs designating whether the storage area contains full or empty containers should be posted. A National Fire Protection Association (NFPA) diamond may be required both at the storage location and near the entrance of the facility.

2.6.7 Securing of Cylinders and Ton Containers

Chlorine cylinders should always be stored in an upright position. An empty 150 lb chlorine cylinder may have a tare weight between 85 and 140 lbs.

They should be secured by placing them securely in containment racks designed for cylinders, or chained to a wall or posts to prevent them from falling. Cylinders should be protected from damage by moving equipment.

The cylinder containment rack should always be secured prior to movement of the rack by a forklift truck. The forklift operator should back down ramps to lessen the chance of a cylinder falling from the containment rack.

Ton containers, which weigh between 1,300 lb (590 kg) and 1,650 lb (750 kg) when empty, are always stored in the horizontal position, above the ground or floor, on steel, concrete or other suitable supports. Individual ton containers or the ton containers at each end of a row of ton containers should be chocked to prevent rolling. Ton containers should be stored with each end accessible so an Emergency Kit B can be applied if necessary.

Moving ton containers within a plant can be accomplished by rolling on a system of rails. Because a full ton container can weigh up to 3,650 lbs (1655 kg), forklift trucks must be designed to handle the weight of a full container. The container must be stabilized on the forklift truck to prevent falling, particularly when stopping or turning. The forklift operator should back down ramps to lessen the chance of a container rolling off the forks.

3. CYLINDER AND TON CONTAINERS

Cylinders and ton containers have many similarities in the way they are handled, and many users of cylinders also use ton containers.

3.1 CYLINDER SPECIFICATIONS

3.1.1 Construction

Chlorine cylinders are constructed of seamless steel and must comply with DOT (or TC, as appropriate) specifications such as: 3A480, 3AA480, 3, 3BN480, or 3E1800.

The regulations permit only one opening in chlorine cylinders (at the top for the cylinder valve connection). However, DOT (BE)-25-type cylinders with a removable plug in the bottom were authorized for use prior to 1944 and a few of these cylinders may still be in service. It is recommended that cylinders with bottom openings be removed from chlorine service.

3.1.2 Styles

Chlorine cylinders may have convex- or concave-style base (bottom) constructions. Those with convex bases have a foot-ring to make them self-standing. Cylinders with an integrally forged bottom are commonly constructed with a concave base that provides a self-standing cylinder without some of the inherent crevice corrosion drawbacks of cylinders having a foot-ring.

Chlorine cylinders may also have a double-bottom base design. This design includes a convex base with the foot-ring supporting another false base, which serves as an indicator to discard or repair the base before corrosion affects the real bottom. Typical base construction styles are shown in Figure 1.

All cylinders must have a valve protective cap in place over the valve except when the cylinder is in use or during cylinder maintenance requiring access to the valve.

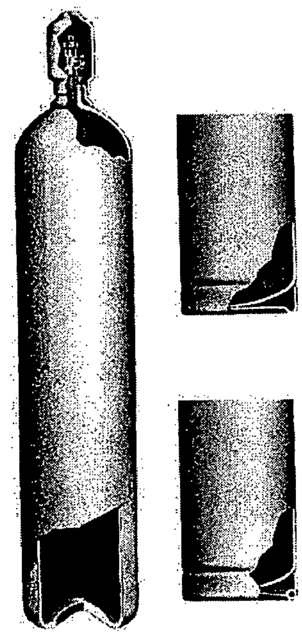


Figure 1 - Chlorine Cylinder
(Left - bump-bottom; Upper right - double-bottom; Lower right - foot-ring)

3.1.3 Threads

The opening in new chlorine cylinders is tapped with a ¾-14NGT(CL)-1 threads. This thread is in compliance with Federal Standard H-28. Over time this thread opening will become enlarged due to the revalving of the cylinder. Therefore, chlorine cylinder valves with oversized inlet threads are provided to extend the life of used cylinders. Oversized threads on chlorine valves are (CL)-2, 4 turns oversize; (CL)-3, 8½ turns oversize; (CL)-4, 14 turns oversize; and (CL)-5, 28 turns oversize. (CL)-1 is not an oversized thread.

Oversize valve thread categories were selected over fifty years ago with the primary purpose of having enough sizes to ensure a proper fit between a new valve and a used cylinder.

3.1.4 Chlorine Institute Emergency Kit A

All 100 or 150 lb chlorine cylinders must be compatible with Chlorine Institute Emergency Kit A (See Section 8.5). Therefore, the user should be aware that changing technology may require a change in the equipment or in the instructions concerning kit use. Appropriate steps should be taken to ensure the device(s) used are compatible with the valve and cylinder.

3.1.5 Stamping

When manufactured, cylinders must be steel-die stamped in the cylinder shoulder (area near the neck-ring) with the following information:

- DOT specification number or DOT exemption number
- Material specification
- Symbol and serial number (of owner or builder)
- Inspector's official mark
- Date of test (month and year)
- Water capacity
- Tare (this is recommended by the Institute)

There may be slight differences in DOT and TC markings. Individual specifications should be checked for proper marking requirements.

<u>Retest Stamping</u>

Each time cylinders are retested, the new test date should be steel-die stamped into the metal near the neck-ring, near the original stamped date. It is also recommended that a new tare weight be stamped if it differs from the original tare weight by more than 5% (See DOT Interpretation, Ref. No. 02-0080 dated July 10, 2003). All retest stamping must be legible for the life of the container, per requirements of 49 CFR Parts 100-185.

3.1.6 Capacity

The DOT and TC regulations limit the maximum amount of chlorine in a cylinder to 1.25 times the weight of water that the cylinder would hold (i.e., water capacity in weight units) at 60°F (15.6°C). Chlorine cylinders are made with capacities of 1 lb (0.45 kg) to 150 lb (68 kg) of chlorine.

3.2 <u>TON CONTAINER SPECIFICATIONS</u>

3.2.1 Construction

Ton containers used for shipping chlorine must comply with one of the following DOT or TC specifications: 106A50X and 110A500W. Older containers must comply with ICC 106A500X, ICC 106A500, ICC 27, BE 27, or with certain DOT exemptions.

The ends of chlorine ton containers form chimes. These provide a substantial grip for safely lifting the container using a lifting beam hooked over the chimes.

3.2.2 Styles

The U.S. DOT specification ton container has a tare weight range of 1,300-1,450 lb (590-660 kg), except for some very old containers that may weigh as much as 1,650 lb (750 kg).

The standard ton container has an outside diameter of about 30 inches (76.2 cm) and is about 82 inches (208.3 cm) long. It is furnished with openings for two valves and six fusible plugs (three at each end at approximately 120 degree intervals).

The *metric ton container* has a tare weight range of 1,425-1,525 lb (648-693 kg), has an outside diameter of about 30 inches (76.2 cm), and is about 89 inches (226.1 cm) long. It is furnished with openings for two valves and eight fusible plugs at approximately 90 degree intervals.

All ton containers must have a valve protective housing in place over the two valves except when the ton container is in use or during container maintenance requiring access to the valves.

3.2.3 Openings

The openings (both for valve and fusible plugs) in new chlorine ton containers are tapped with a ¾-14NGT(CL)-1 thread. These threads are in compliance with Federal Standard H-28. Over time these thread openings will become enlarged due to the revalving of the container. At that time chlorine cylinder valves and fusible plugs with oversized inlet threads (CL)-2 thru (CL)-5 will be used. When the openings have increased past the use of a ¾-14NGT(CL)-5, these openings can be re-tapped to a 1-11½NGT(CL)-1 (See Section 3.11).

3.2.4 Chlorine Institute Emergency Kit B

Ton containers must be designed so that they can accommodate the various devices in the Institute's Emergency Kit B for ton containers (See Section 8.5). Therefore, the user should be aware that changing technology may require a change in the equipment or in the instructions concerning kit use. Appropriate steps should be taken to ensure the device(s) used are compatible with the valve and ton containers.

3.2.5 Stamping

When manufactured, ton containers must be steel-die stamped into the chime of the ton container on the valve end with the following information:

- DOT specification or exemption number
- Material specification
- Symbol and serial number (of owner or builder)
- Inspector's official mark
- Date of test (month and year)

- Water capacity
- Tare (this is recommended by the Institute)

There may be slight differences in DOT and TC markings. Individual specifications should be checked for proper marking requirements.

Retest Stamping

Each time ton containers are retested, the new test date must be steel-die stamped into the metal of the chime near the original stamped date.

It is also recommended that a new tare be stamped if it differs from the original. All retest stamping must be legible for the life of the container, per requirements of 49 CFR Parts 100-185.

3.2.6 Capacity

The DOT and TC regulations limit the maximum amount of chlorine in a container at 1.25 times the weight of water that the ton container would hold (i.e., water capacity in weight units) at 60°F (15.6°C).

The U.S. standard ton container is designed to hold a maximum of 2,000 lb (907 kg) of chlorine, while the metric ton container holds a maximum of 1,000 kg (2,204 lb).

3.3 TRANSPORTING CYLINDER AND TON CONTAINERS

3.3.1 Transporting Cylinders and Ton Containers

Valve outlet caps and valve protective housings must be in place when transporting cylinders and ton containers per 49 CFR Parts 100-185.

Loading cylinders or ton containers into vehicles can be done utilizing lifting beams, pallet racks, and forklifts. The containers must be secured in the truck by means of chains, straps, freight bars, and cradles. See CI Pamphlet 76 for a more detailed discussion of the transportation of cylinders and ton containers.

3.3.2 Receiving Report

When picking up chlorine cylinders and ton containers at the customer's site a receiving report should be developed to document this event. The report could serve as a receipt, with a copy left with the customer to document the type and number of cylinders or ton containers received. The report could include the following information:

- The customer's name
- The date
- Quantity and type of cylinders or ton containers

- Indication as to whether the cylinders or ton containers are full or empty
- Serial numbers of the cylinders or ton containers, if company policy
- Brief description of any visible damage or indication that there is none
- Comments about missing parts, such as valve protective housings or valve outlet caps

3.4 EVACUATION OF CYLINDERS AND TON CONTAINERS

Before conducting any internal inspection, cylinders and ton containers must be evacuated to a suitable absorption system. Close the cylinder or ton container valve(s) then remove the valve outlet cap(s) and check for leaks in accordance with Section 3.4.1.

Using an injection system, the residual chlorine in the containers is usually evacuated into a sodium hydroxide solution. The cylinder or ton container should be under a vacuum after it is evacuated so that when valves or fusible plugs are removed, no residual chlorine is released.

3.4.1 Connecting and Disconnecting Cylinders and Ton Containers for Initial Evacuation

Before attempting to connect or disconnect make sure that the cylinder or ton container is properly secured and that all personal protective equipment is in use as required by company hazard assessment. Follow these steps for connecting to or disconnecting from the cylinder or container valve:

Connecting

1. Remove the valve hood or valve protective housing.
2. Make certain the valve is closed before removing the outlet cap.
3. Make certain that the packing nut is tightened to the proper torque.
4. Remove the outlet cap (for tons with valves vertically aligned the upper valves dispense gas and the lower valves dispense liquid.)
5. Make certain that the valve face is clean and smooth.
6. Use a new appropriate ring gasket when connecting the yoke and yoke adapter to the valve (See CGA Pamphlet V-1 for washer (gasket) dimensions and CI Pamphlet 95 for the latest gasket material experience).
7. It is recommended that a new gasket be installed before tightening the yoke screw. Torque the yoke screw to make a seal without overtightening (See Section 3.13.3).
8. Slowly open the container valve briefly to introduce chlorine into the system, then close it using the ⅜ inch square box end of a wrench no more than 8 inches in length or using a suitable torque wrench with a socket fitting. Never use an extension (cheater) bar.

9. A suitable leak detecting solution should be used to check for leaks at the yoke adapter connection and the packing nut area (See Section 8.2.2). If any leaks are found they must be remedied before proceeding. Repeat this step if a leak is found. If using an aqua ammonia solution, use **ONLY VAPOR** from 26° Baumé aqua ammonia or stronger for leak detection. Weaker solutions may not be concentrated enough to detect minor leaks. It is acceptable to use other concentrations based on successful experience. **CAUTION:** Never allow liquid aqua ammonia solution to come into contact with valves or piping system components as it can cause stress corrosion cracking of copper based alloys such as brass and aluminum silicon bronze that are used in the manufacture of valves.
10. Using the Institute recommended wrench, open the valve one complete turn. This is all that is required to achieve maximum flow rates.
11. Open the appropriate valves in the piping system.
12. Observe for leaks again using the aqua ammonia solution as described in item nine above.

<u>Disconnecting</u>

1. Close container valve and appropriate manifold valves.
2. Evacuate the hose until under vacuum.
3. Disconnect container from the evacuation system.
4. Protect the yoke adapter and evacuation hose from moisture and moist air.

3.5 TON CONTAINER AND CYLINDER GENERAL INSPECTION, CLEANING AND RECONDITIONING

3.5.1 Responsibility

All activities involving the handling of chlorine cylinders and ton containers should be performed by appropriate trained personnel. It is particularly important that venting, inspecting, cleaning and reconditioning should be assigned to trained, responsible, experienced employees.

3.5.2 Evacuating

Before conducting any internal inspection, all ton containers and cylinders must be evacuated into a suitable absorption system until a vacuum is achieved and residual chlorine is removed.

WARNING - After venting some residual chlorine may remain.

3.5.3 Frequency of Inspection

In addition to the periodic retest (See Section 6), the Institute recommends that each ton container and cylinder be externally inspected prior to each filling. This includes inspection of all appurtenances such as valves per Section 3.7.12 and fusible plugs per Section 3.7.13 as specified in this section. The frequency of internal inspection should be determined using the same criteria as found in Section 4.2.

3.6 <u>INSPECTION EQUIPMENT</u>

Some of the equipment referred to below requires specialized training in its use. It may not be part of the site's normal inspection procedures, but there are companies that can provide in-house service with the use of portable equipment.

3.6.1 Depth Gauge, Straightedge, Measuring Rule, etc.

Exterior corrosion, denting, bulging, gouges and/or digs are normally measured by a simple direct measurement with a rule and/or depth gauge. A rigid straightedge of sufficient length is placed across the defect and a rule is used to measure the distance (depth) from the bottom of the straightedge to the bottom of the defect (Figure 2). There are also available commercial depth gauges which are especially suitable for measuring the depth of small cuts or pits.

It is important when measuring such defects to use a straightedge which spans the entire affected area. When measuring cuts, the upset metal should be removed or compensated for so that only actual depth of metal removed from the container wall is measured.

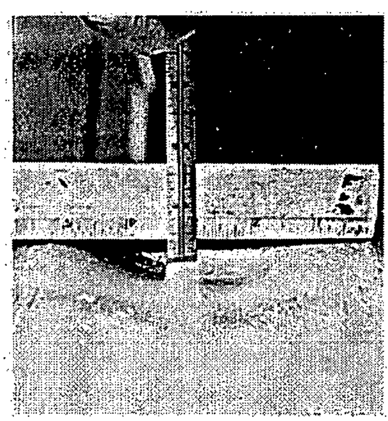


Figure 2 - Measuring the Length & Depth of a Typical Dent
(Figures 2 through 10 courtesy of Compressed Gas Association)

3.6.2 Ultrasonic Devices

There are a variety of commercial ultrasonic devices available. These can be used to detect sub-surface flaws and to measure wall thickness.

3.6.3 Magnetic Particle Inspection

Magnetic particle inspection can be used to quickly locate surface faults not readily visible to the naked eye.

3.6.4 Penetrant Inspection Materials

Dye-penetrant materials are available which show surface faults invisible/or not readily visible to the naked eye.

3.6.5 Inspection Light

Both external and internal inspections must be conducted under good lighting conditions. For internal inspections, there are a variety of illuminated boroscopes available, including fiber optics.

3.7 <u>EXTERNAL INSPECTION</u>

The DOT Hazardous Material Regulations, 49 CFR, Parts 100-185 as well as the regulations of Transport Canada, require that a cylinder be condemned when it leaks; when there is internal or external corrosion, denting, or bulging; and/or when evidence of rough usage exists to the extent the cylinder is likely to be weakened appreciably.

The DOT regulations reference CGA Pamphlet C-6 numerous times. This section is primarily an overview of the external inspection requirements found in Section 6 (Low pressure cylinders subject to hydrostatic testing) of this CGA pamphlet and includes discussion on dents, gouges, corrosion, cracks, fire damage, and missing, damaged or corroded cylinder foot- and neck-rings. For a complete discussion please refer to CGA Pamphlet C-6.

The following definitions apply to terms used in this section:

- Condemn – To scrap, no longer fit for service.

- Reject – To designate as not fit for service in present condition. May be requalified by either additional testing to verify adequacy of container for continued service, or by reheat treatment, repair or rebuilding to correct the defect as specified in 49 CFR Parts 100-185.

3.7.1 Initial Tare Weight Check

After venting, weigh ton container or cylinder and compare with original stamped tare weight. Be sure the cylinder is empty. Loss in weight is a danger signal.

- A cylinder must be condemned when the tare weight at the time of inspection is less than 90% of the original stamped tare weight. A cylinder should be rejected when the tare weight is less than 95% of the original tare weight. A rejected cylinder may be requalified in accordance with 49 CFR Part 180 Subpart C.

- Ton containers must be condemned if the tare weight is less than 90% of the original stamped tare weight. A ton container should be set aside for inspection and disposition when the tare weight is less than 95% of the original stamped tare weight.

- Stamp a new tare weight when the tare weight loss is 5% or greater (See US DOT interpretation letter dated July 10, 2003, Ref. No. 02-0080). Do not obliterate previous recorded tare weights.

Similarly, inspect a cylinder or ton container showing an increase in tare weight. Numerous coats of paint can add significant weight.

3.7.2 Corrosion or Pitting

Corrosion or pitting in cylinders and ton containers involves the loss of wall thickness by corrosive attack to either the outside or inside surfaces of the container.

Isolated Pitting

Isolated pits of small diameter do not effectively weaken the cylinder. Figures 3, 4 and 5 show typical examples of isolated pitting.

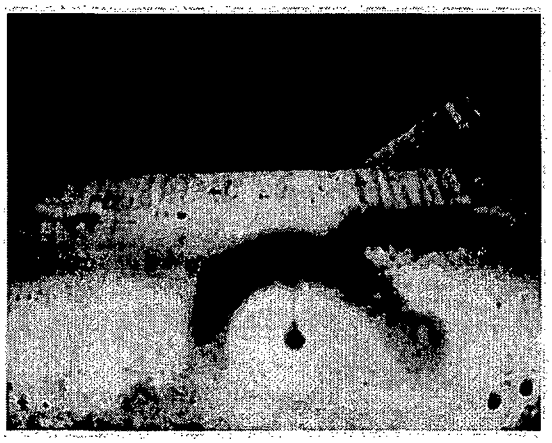


Figure 3 - Isolated Pitting

Figure 4 - Isolated Pitting - Ton Container Wall

Figure 5 - Dent with Isolated Pitting

Line Corrosion

When pits are connected or nearly connected to others in a narrow band or line, such a pattern is termed "line corrosion". This condition is more serious than isolated pitting and generally occurs at the liquid-vapor interface inside the container when moisture is present. An example of line corrosion is shown in Figures 6 and 7.

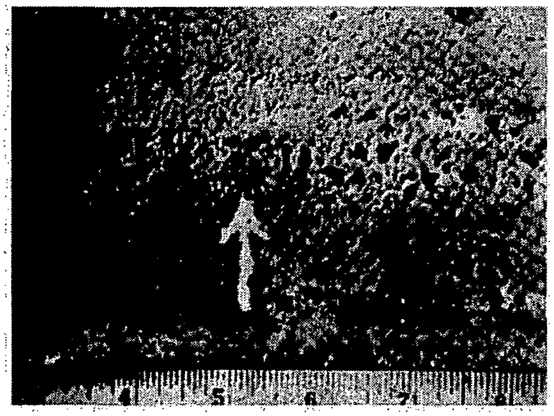


Figure 6 - Line Corrosion

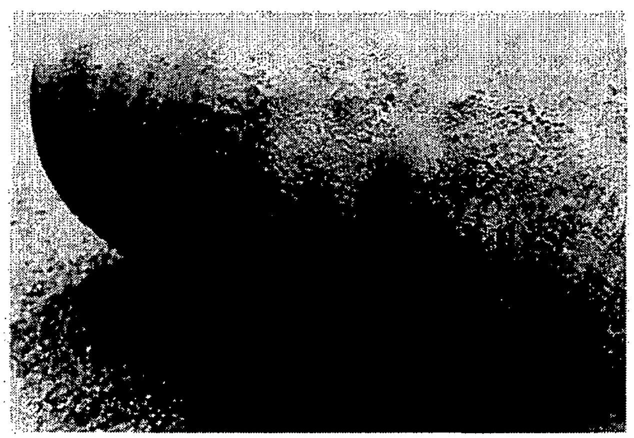


Figure 7 - Line Corrosion - Cylinder Wall

Crevice Corrosion

Corrosion which occurs in the area of contact, or near contact, of the foot-ring or head-ring and the cylinder. Figure 8 is an example of crevice corrosion.

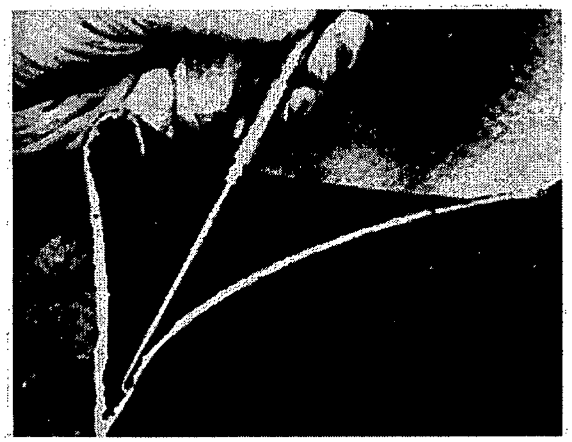


Figure 8 - Crevice Corrosion Near the Cylinder Foot-ring

General Corrosion

General corrosion is that which covers considerable surface areas of the cylinder or ton container. It reduces the structural strength. It is often difficult to measure or estimate the depth of general corrosion because direct comparison with the original wall cannot always be made. General corrosion is often accompanied by pitting. This form of corrosion is shown in Figures 9 and 10.

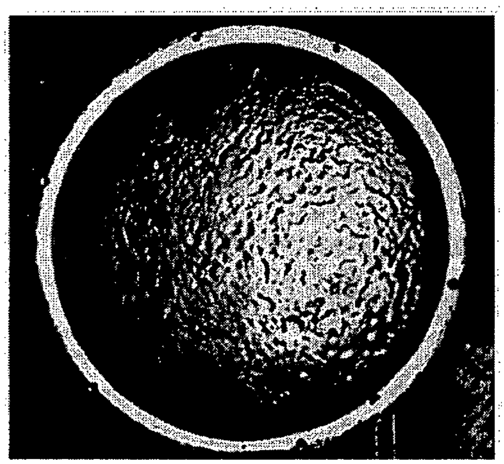


Figure 9 - General Corrosion with Pitting

Figure 10 - General Corrosion with Pitting on Cylinder Wall

3.7.3 General Corrosion Limits

Cylinders and ton containers should be checked as outlined below for corrosion, general distortion or other defect that might indicate a weakness that would render it unfit for service.

Failure to meet any of the following general rules is cause for condemning or rejecting a cylinder and/or ton container:

- A cylinder must be condemned when the current tare weight is less than 90% of the original tare weight.
- A cylinder must be condemned when the remaining wall thickness in an area of general corrosion is less than 50% of the minimum allowable design thickness (t_d) [See Table 1].
- A ton container must be condemned when the current tare weight is less than 90% of the original tare weight.
- Any corrosion that could interfere with the application of an Emergency Kit A or B is cause for rejection. Refer to Figure 11 for an example of chime corrosion.

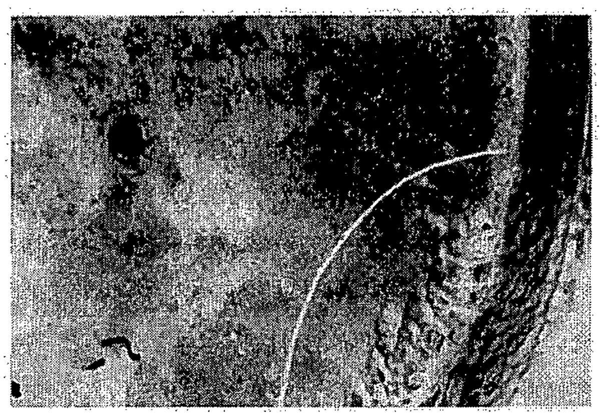


Figure 11 - Chime Corrosion Ton Container Head

3.7.4 Industry Specific Guidelines for Inspection of Corrosion

The corrosion limits in this pamphlet are based on the minimum allowable wall (and head) thickness of a chlorine cylinder and ton container as shown in Table 1.

Table 1: Industry Guidelines for Inspection of Corrosion

Nominal Diameter (In.)	DOT Specification[2]	Original Minimum Allowable Design Wall Thickness, t_d (in.)[1]
10	3A480	0.150
10	3AA480	0.150
30	106A500-X[3]	0.40625 (shell) 0.6875 (head)*
30	110A500-W[3]	0.40625 (shell)
30	E-11808[4]	0.4375 (shell) 0.600 (head)
30	E-7517	0.400 (shell) 0.625 (head)
30	E-11923	0.3438 (shell, for 516GR material) 0.4063 (shell, for 285 GRC material)

*Not the specification's requirement, but the industry's recommendation for 106A500-X.

[1]Some cylinders and ton containers will have thicker walls due to difference in manufacturing methods and inspection procedures. Values shown in Table 1 are absolute minimums allowed by specifications. Higher values may be used if information showing thicker walls than those listed is obtained from the container manufacturer.

[2] E-11808, E-7517 and E-11923 are containers with special renewable DOT permits. Other specially permitted containers may exist. It is suggested that the user contact the manufacturer for data on original minimum wall thicknesses and to verify valid exemption status.

[3]Shell original minimum allowable design wall thickness as per 49 CFR 179.301 (April 2004)

[4]DOT exemption - DOT-SP 11808 (January 9, 2007). Expires 12/31/10

Measuring actual wall thickness is not always feasible. The measurement of corrosion depth (See Figures 2 and 8 for examples) is typically a more practical method for inspection than the determination of remaining wall thickness.

If the original wall thickness is unknown, the remaining wall thickness can be estimated by measuring the corrosion depth and subtracting that value from the minimum allowable design wall thickness (t_d) found in Table 1.

The following should be used when considering the specific type of corrosion:

General Corrosion Accompanied by Isolated Pitting

A cylinder or ton container should be condemned when the depth of a pit is an area or general corrosion results in a remaining wall thickness less than 50% of the minimum allowable design wall thickness (t_d).

Isolated Pits Not in General Corrosion Area

A cylinder or ton container should be condemned when the remaining wall in an area having isolated pitting only is less than 66% of the minimum allowable wall thickness (t_d).

Line or Crevice Corrosion

- A cylinder should be condemned when line or crevice corrosion on the cylinder is 3 inches in length or greater and the remaining wall is less than 75% of the minimum allowable wall thickness or when line or crevice corrosion is less than 3 inches in length and remaining wall thickness (t_d) is less than 50% the minimum allowable wall thickness (t_d).

- A ton container should be condemned when line or crevice corrosion on the ton container is 3 inches in length or over and the remaining wall is less than 75% of the minimum allowable wall thickness (t_d) or when line or crevice corrosion is less than 3 inches in length and remaining wall thickness is less than 50% of the minimum allowable design wall thickness (t_d).

3.7.5 Dents

Dents in cylinders and ton containers are deformations caused by impact with a blunt object in such a way that the thickness of metal is not materially impaired. A typical dent is shown in Figure 2. Dents are of concern where the metal deformation is sharp and confined, or where it is near a weld. Where metal deformation is not sharp, dents of larger magnitude can be tolerated.

Dents at Welds

When denting occurs at the chime weld and the depth exceeds 0.25 inches the cylinder or ton container should be condemned. When denting occurs along the longitudinal weld, the provisions of "Dents Away from Welds" should apply.

Dents Away from Welds

When denting occurs so that no part of the deformation includes a weld, the cylinder or ton container should be condemned if the depth of the dent is greater than 10% of the greatest dimension of the dent but in no case should the dent exceed 0.5 inches.

3.7.6 Cuts, Gouges or Digs

Cuts, gouges or digs in cylinder and ton containers are deformations caused by contact with a sharp object in such a way as to cut into or upset the metal of the cylinder, decreasing the wall thickness and inducing stress at that point.

- A cylinder should be removed from service if the cut, gouge or dig is less than 3 inches long and its depth exceeds 0.075 inches (50% of the minimum allowable wall thickness) or if the defect is more than 3 inches and its depth exceeds 0.0375 inches (25% of the minimum allowable wall thickness).

- A ton container should be removed from service if the cut, gouge or dig is less than 3 inches long and its depth exceeds 0.2 inches (50% of the minimum allowable wall thickness) or if the defect is more than 3 inches long and its depth exceeds 0.1 inches (25% of the minimum allowable wall thickness).

3.7.7 Fire Damage

Ton containers and cylinders should be carefully inspected for evidence of exposure to fire.

<u>Inspection for Fire Damage</u>

Common evidences of exposure to fire are: (a) charring or burning of the paint or other protective coat; (b) burning or scorching of the metal; (c) distortion of the container; (d) melted-out fuse plugs; and (e) melted packing extruding from under valve packing nut.

<u>Evaluation of Fire Damage</u>

DOT Regulations state that cylinders or ton containers that have been subjected to the action of fire must not again be placed in service until it has been properly reconditioned in accordance with 49 CFR Parts 100-185.

3.7.8 Arc and Torch Burns

Cylinders and ton containers with arc or torch burns should be rejected. Evidence of these burns can be recognized by: (a) removal of metal by scarfing or cratering; (b) a scarfing or burning of the base metal; or (c) a deposit of weld metal or displacement of base metal.

3.7.9 Bulges

<u>Obvious Bulges</u>

Ton containers which have any definite visible outward bulges in either the shell or heads of containers should be condemned. It must be remembered that certain containers which were built to ICC-27 specifications have one convex head on the end opposite the two container valves. These containers should be removed from service because they will not accommodate Emergency Kit B.

Measurement

Bulges in cylinders and ton containers can be measured in several different ways:

1. Bulges on the cylindrical wall can be measured by comparing a series of circumferential measurements, or

2. Variations from normal contour can be measured directly by either:

   - Measuring the height of a bulge with a scale, and comparing templates of bulged areas with similar areas not bulged, or

   - With respect to ton containers, noting any change in contour of the heads form the original smooth and regular inward dish.

Ton Container Limits

Outward bulging of the heads of the ton container is rather difficult to measure and the ton container should be condemned when any abnormal bulging is observed. Ton containers should be removed from service when a variation of 1 inch or more is found in the measured circumferences.

Cylinder Limits

Cylinders should be condemned when a variation of 1% or more is found in the measured circumference of in peripheral distance measured form the valve spud to the center seam. For a 10 inch diameter cylinder the maximum circumference (equivalent to a 1% variation) would be 31.73 inches (See calculation below). This would also be equivalent to a variation in the circumference of 0.31 inches.

Normal outside diameter (d)	10"
Circumference [C=Πd)]	31.42"
Maximum Circumference [31.42 + 0.01 (31.42)]	31.73"
Variation in Circumference	0.31"
Equivalent Variation in Diameter	0.100"

If the bulge is uniform around the cylinder, the limiting height of the bulge would be 0.100/2 = 0.05 inch.

3.7.10 Attachments

Cylinders

The foot-ring, neck-ring and valve protective housing of cylinders must be capable of performing their intended functions. The foot-ring should be capable of keeping the cylinder stable and upright and the neck-ring and valve protective housing should protect the valve.

If there is unrepairable damage to these parts, which adversely affect their functions, the cylinder should be condemned. When the cylinder bears a permanent attachment such as a foot-ring or double bottom, which covers a portion of the cylinder surface, proper, periodic inspections of these parts should be made to ensure that they are intact and that it is in the same relation to the cylinder as at the time of its attachment. The attachment of the part to the cylinder should be checked for corrosion. Check cylinder neck-rings for tightness with a light ball peen hammer; if ring is loose, peen the top of the cylinder to make it tight. If the ring is excessively loose, it is advisable to remove the ring and inspect both it and the neck of the cylinder for excessive corrosion.

Ton Containers

Check the condition of all valve protective housing lugs and set screws for continued use. These parts should not be damaged to the degree that they can no longer perform their intended functions.

3.7.11 Markings

Check stamping for legibility and segregate containers due for periodic retest. If no defects are found, proceed with internal inspection.

3.7.12 Cylinder and Ton Container Valves

External inspection of valves should consist of examination for structural cracks due to excessive packing nut torques, corrosive attack or indications of large impact forces. Such cracks are observed sporadically, usually as tight cracks on or near one of the valve body flash lines in the packing nut region. Less frequently, these cracks have also occurred in the packing nut. Valves should also be examined for signs of leakage, excessive ware, deformations that may affect valve operation, tampering and illegible identification markings.

Valves with any of these defects must be replaced. Repairable valves may be replaced with new valves; otherwise they must be reconditioned in accordance with Sections 4.4 – 4.9 before being returned to service. Non-repairable valves; e.g., valves with cracks, deformations that may affect valve operation, exposure to fire, etc. must be condemned. Valves with linear indications, where structural cracks cannot be ruled out, should be condemned.

3.7.13 Cylinder and Ton Container Fusible Plug Pressure Relief Devices

External inspection of fusible plugs should consist of examination for signs of leakage, extrusion of fusible metal, obliteration of markings, corrosion and/or damage that might result in a leak. In accordance with CGA Pamphlet S-1.1, mandated by reference in 49 CFR Part 173, fusible plugs may not be repaired or refilled. Also by regulation, fusible plug pressure relief devices (PRDs) are the only devices permitted to replace faulty or questionable fusible plugs.

3.8 INTERNAL INSPECTION

Remove all valves from cylinders and ton containers and recondition them as described in Sections 4.6 and 4.7. One or more fusible plugs are to be removed from each end of ton containers to facilitate internal inspection. Because of the difficulty in visually examining the remaining four plugs through the two holes, it is recommended that a system be established to ensure that the same plugs are not always removed at each inspection.

3.8.1 Inspection of Fusible Plugs

Fusible plugs removed from a ton container for internal inspection of the container should be examined for corrosion, excessive extrusion of the fusible metal; i.e., over $^{1}/_{32}$ inch, and defects such as separation of the fusible metal from the fusible plug shell, which might result in a leak. Conditions such as these and other abnormal conditions such as, obliteration of markings, severely deformed hex wrench flats, or heavy wear or damage of the plug threads should be cause for replacement of the plugs. It conditions such as these are observed, consideration should be given to removal and examination of additional plugs.

3.8.2 Inspection of Ton Containers and Cylinders

Wearing appropriate personal protective equipment (See CI Pamphlet 65), inspect interiors of cylinders and ton containers from both ends with an illuminated boroscope. Due to both potential vapor release and the introduction of moist air to the container, care must be taken to minimize the exposure time to employees and to the interior of the ton container. Check the inner surface for pitting, line or general corrosion (See Section 3.7), scale, wetness, residue, foreign matter or any condition which might indicate the container to be unsafe for use, or which might contaminate the chlorine which it is intended to contain.

Inspect the eduction pipes in ton containers. Defective eduction pipes can rarely be detected by visual inspection. If defects are suspected, set the container with valves in vertical position and attach a transparent burette to the upper valve via tubing. Ensure that 1-inch of the burette extends above the shell of the container. Fill burette with water. Observe the water level; this is the height of the opening in the eduction pipe. The eduction pipe should extend within ½ inches of the inside of the shell. Rotate the container 180 degrees and test the other eduction pipe. If the water level is lower than the eduction pipe outlet, then the eduction pipes should be replaced or the container condemned (See Section 3.11.2).

After inspection always dry the interior of cylinders and ton containers as per Section 3.9.

Valve and Fusible Plug Openings

At manufacture, cylinder openings are tapped with a ¾-14NGT(CL)-1 thread a minimum of 13¾ full threads. At manufacture, ton container openings are also tapped ¾-14NGT(CL)-1 with a minimum of 8 full threads which are limited by the $^{11}/_{16}$ inch ton container minimum head thickness.

Before valves or fusible plugs are installed, extreme caution should be exercised. The container threads should be inspected and cleaned as necessary to ensure the absence of corrosive deposits, rust, scale, dirt, paint, or other foreign matter that might damage the threads and thus endanger the effectiveness to seal. Cylinders and/or ton containers should be removed from service for repair if less than five full threads are available or if threads are broken, nicked, cut or otherwise damaged.

As ton containers become older and the openings wear larger, oversize valves and fusible plugs (¾-14NGT(CL)-2, -3, -4 and -5) may be used. For even larger openings, 1-11½NGT(CL)-1, -2, -3, -4 and -5 may be used for fusible plugs .

Check the location of the fusible plug openings in relation to the chime of the ton container. The location must be such that a Chlorine Institute Emergency Kit B fuse plug capping device can be effectively applied. If this device can not be applied the container must be rejected.

3.9 INTERNAL CLEANING

There are a number of suitable methods for the internal cleaning of chlorine cylinders and ton containers, some of which are described in the following sections. Regardless of the method used, care should be taken to ensure that the cylinder or container, after cleaning, remain within the dimensional specifications as required by regulation and as noted in this pamphlet. Cylinders or containers that do not conform to specifications should be condemned. **WARNING**: After venting some residual chlorine may remain. This must be removed before cleaning and reconditioning is begun.

3.9.1 Cylinders

If internal inspection shows only loose scale, invert the cylinder on a wooden block and bump out the scale. If scale is removed by bumping, proceed to drying as per paragraph below.

If the internal inspection shows the cylinder to be wet or to contain foreign material that was not removed by bumping, pour approximately one quart of 10% - 20% caustic solution into the cylinder (amount used can vary according to the internal condition of the cylinder) in accord with established safety practices. Immediately fill with water. Heat water by injecting steam into the water-filled cylinder until container is too hot to touch. Invert cylinder and empty. Flush with hot water until discharge is clean. Set upright and reinspect for internal corrosion.

If the above does not remove all of the foreign material, pour approximately 2 quarts of 18° - 20° Baumé inhibited hydrochloric acid into the cylinder, in accord with established safety procedures. Immediately fill the cylinder with water and heat solution in the cylinder by injecting steam until container is too hot to touch.

Shut off steam and allow cylinder to stand 2 to 3 minutes. Invert cylinder and empty. Flush with hot water until discharge water is clear. Set upright and inspect for internal corrosion and cleanliness. If cylinder is clean and free of corrosion defects, proceed to dry as per paragraph below.

If cylinder is dry and free of foreign material and corrosion defects, steam cylinder in inverted position until it is too hot to touch. Purge with dry air at 15 psig maximum until it is warm to the touch. Insert a new or reconditioned valve of the proper size.

3.9.2 Ton Containers

If internal inspection shows only foreign matter consisting of loose scale, place the ton container in a slanting position with an open fusible plug hole down. Blow out eduction tubes with dry air. Remove loose material from the container with an air ejector, vacuum cleaner or similar device. If scale is removed, proceed to drying as per paragraph below; otherwise, continue treatment as described below.

If internal inspection shows the ton container to be wet or to contain impurities that could not be removed by vacuuming; remove all fusible plugs and replace with solid steel or brass plugs. Apply vacuum to the container. Draw approximately two gallons of 10%-20% caustic soda solution into the container by attaching a hose to the bottom valve and putting hose into the container of caustic soda solution in accord with established safety practices. Immediately fill the ton container with water through the bottom valve, venting through the top valve.

Apply steam through a fusible plug opening equipped with an adapter leaving top valve open until water is hot. Apply water through the fusible plug opening until discharge water from the top valve runs clear. Close top valve, open bottom valve and apply air at 15 psig maximum through a fusible plug opening until ton container is empty. Remove pipe plugs and inspect ton container internally for cleanliness and corrosion. If this procedure does not remove foreign material, proceed as below. If ton container passes the inspection, proceed to drying as per paragraph below.

If the procedure does not clean the container, introduce approximately two gallons of 18° - 20° Baumé inhibited hydrochloric acid in accord with established safety procedures. Immediately fill the container with water and heat the solution by injecting steam until the container is too hot to touch. Apply air at 15 psig maximum through fusible plug opening until container is empty. Re-inspect for internal corrosion.

When an inspection shows that the container is clean then introduce steam into the container through the fusible plug opening and discharge the steam through the bottom valve opening until the container is too hot to touch. Apply dry air at 15 psig maximum through a fusible plug opening until the container is warm to the touch. Visually inspect for dryness. Install fusible plugs and valves of the proper size.

3.10 INSTALLING VALVES AND FUSIBLE PLUGS

Only install reconditioned or new valves and fusible plugs that meet the guidance provided in Section 5.1.1 and 5.1.2 as well as the Valve Performance Criteria found in Appendix A. Examine the first thread on the valve or plug to ensure it is free of nicks and deformations. Install the valve or plug about one full thread into the cylinder or container after it has been determined that the threads are clean and free of defects. Apply compatible pipe thread compound PTFE paste with a non-reactive carrier or PTFE tape to the remaining threads. If tape is utilized, then apply carefully to the threads before insertion. Engage the valve or fusible plug hand tight then wrench the valve two to three turns.

3.11 REPAIRS

3.11.1 Cylinders

DOT regulations authorize repairs to Specification 3A and 3AA cylinders, but only to the extent of removing and replacing neck-rings and foot-rings and as long as it does not affect a pressure part of the cylinder. The repair may be made by welding or brazing in conformance with the original specification. Inspection must occur before and after replacement and any defective cylinder must be rejected. An approval issued under the provisions of 49 CFR Part 107.805 is required for any other repair.

Cylinder Valve Opening

If inspection has revealed defective threads, the threads might be repairable with a suitable tap. If the opening has become so enlarged that it does not provide proper engagement with the ¾-NGT(CL)-5 valve, the cylinder must be removed from service. The cylinder can be drilled and tapped for a 1-11½NGT(CL) thread if the neck radius is at least $^{13}/_{16}$ inch, but only by the original cylinder manufacturer (CGA Pamphlet V-1, H-28/29).

49 CFR Part 180.212 states that 3A and 3AA cylinders can only be retapped by the original cylinder manufacturer.

Replacement of Neck-Rings

Owners may replace neck-rings by removing the old neck-ring and peening a new one into the cylinder. Neck-rings with an outside diameter of more than 4 ⅜ inches (11.11 cm) may prevent application of the Emergency Kit A devices and should not be used.

Foot-Ring Replacement

The foot-ring may be replaced by welding (See Section 3.11.1) a new foot-ring to the existing stubs of the original foot-ring as long as the cylinder wall does not reach a temperature of 400°F (204.4°C), as verified by the use of a heat stick indicator. If welding on the actual cylinder wall is involved, a DOT-registered repair facility must do the work.

3.11.2 Ton Containers

Ton containers that have been rejected can sometimes be repaired, including replacing eduction tubes, repairing corroded threads, and replacing valve protective center lugs. Such work must be done by a DOT-certified shop. After welding, the containers must be heat treated and DOT tested. It is recommended that containers requiring these repairs be returned to the manufacturer.

The following repairs can be conducted at the packaging plant. Repairs should only be performed by knowledgeable and experienced personnel.

Ton Container Valve Openings

Threads shown to be defective during inspection can sometimes be repaired with a suitable tap. If the opening has become so enlarged that it does not provide proper engagement of the ¾-NGT(CL)-5 valve, the container may be drilled and tapped to a 1-11½NGT(CL)-1 thread. Extreme care is needed in tapping this opening to prevent thinning or damaging the eduction tube(s).

Ton Container Fusible Plug Openings

Threads shown to be defective during inspection can sometimes be repaired with a suitable tap. If the opening has become so enlarged that it does not provide proper engagement of the ¾-NGT(CL)-5 fusible plug, the opening may be drilled and tapped to a 1-11½NGT(CL)-1 thread.

Ton Container Valve Protection Housing

If inspection has shown that the setscrew holding the valve protection hood has become corroded, owners may weld a setscrew lug to the valve protection bonnet (See Illustration 182 for a typical configuration). This procedure is effective only if the lugs on the ton container are in place.

3.12 DISPOSAL

Containers that cannot be repaired or re-qualified must be condemned. Condemned containers should be evacuated and purged, and then destroyed by cutting away a portion of the container that includes the chime markings.

3.13 PREPARATION FOR FILLING AND FILLING SAFETY PROCEDURES

Prior to refilling, the cylinder or ton container must be completely evacuated and placed under vacuum.

3.13.1 Final Inspection

After a cylinder or ton container is positioned at the filling station, a final inspection should be performed. This inspection will confirm that the required components have been installed on the cylinder or ton container and that all necessary repairs have been completed. Inspect all valves and fuse plugs for proper installation. This includes verification that each valve is tightly installed and that at least two full threads of each valve are exposed above the opening. Check to ensure that there are no container defects such as bulges, fire damage, or corrosion.

3.13.2 Container Tare Weight

Refer to Section 3.7.1 for information on checking actual tare weight versus stamped tare weight.

3.13.3 Connecting Container to Filling Line

Extreme caution must be exercised when filling cylinders or ton containers. Proceed with care as follows:

- Wear or equip yourself with the proper personal protection equipment, (refer to the hazard assessment that was developed for your facility or see CI Pamphlet 65). It is recommended that the flexible filling line be attached to the container valve(s) by means of a CGA 820 or 820C yoke connection. When using a yoke assembly, the following operations should be performed:

    1. The yoke should be inspected prior to use to ensure the operating parts, screw and follower operate freely;

    2. A compatible gasket (See CI Pamphlet 95) should be properly installed on the yoke adapter;

    3. With the yoke screw fully retracted, lower the yoke assembly over the valve until the valve outlet is aligned with the adapter; and

    4. Carefully tighten the yoke screw until the valve is snugly clamped between the gasket and the follower to create a seal. Do not overtighten and check to ensure the gasket is compressed uniformly. Non-uniform compression indicates misalignment of parts and raises the possibility of a leak as the yoke screw is tightened.

- Once the filling line has been connected, slowly allow a small amount of chlorine to pressurize the line. Carefully inspect for signs of leakage at the yoke connection using aqua ammonia vapor (See Section 8.2.2). If a leak is found, close the chlorine valve immediately and repair the leak.

3.13.4 Filling Observations and Leak Testing

Once a leak-tight connection has been established, the filling can proceed. Observe the scale weight before beginning so that the net weight can be determined. In some cases, the scale would be reset to zero at this point. Open the feeding valve and the container valve(s). Observe the rate of weight increase of the container. Inspect again for leaks. If necessary to maintain the filling rate, stop and evacuate excess vapor from the container. Close the valves when the correct weight has been reached.

3.13.5 Evacuating and Disconnecting Filling Lines

Extreme caution must be exercised when disconnecting cylinders or tons that are not empty. This is especially critical in systems feeding liquid chlorine. Proceed with care as follows:

- Wear or equip yourself with the proper personal protection equipment. Refer to the hazard assessment that was developed for your facility or see CI Pamphlet 65;
- Using a torque wrench, close the cylinder or ton valve to a torque of 25 to 30 foot pounds;
- Let the pressure in the system drop to 0 psig and apply a vacuum as appropriate for your system's design. When gauges indicate 0 psig or a vacuum, the appropriate piping system valve can be closed;
- Monitor the pressure gauge to ensure that the system remains at 0 psig or a vacuum. If any leaks exist, increase the torque on the valve stem to 40 foot pounds and retest for leaks. If leaks persist, evacuate the container and replace the valve with a new or reconditioned valve;
- If the pressure in the line connected to the cylinder or ton valve remains constant at or below 0 psig, the yoke can be loosened and disconnected;
- Allow sufficient time to ensure that there are no leaks from the container fixtures;
- Verify that an outlet gasket is in place and replace the valve outlet cap;
- Protect the yoke adaptor and chlorine line from moisture and moist air. Use an air-tight plastic bag, or a suitable plug to protect against moisture;
- Place a valve hood or bonnet on the cylinder or ton container as appropriate being careful to avoid damaging the value, fuse plugs and other fixtures; and
- Place the cylinder or ton container in an appropriate location.

3.13.6 Relocating to Holding Area

All cylinders should be well secured during transport to holding areas. Chains, racks, or similar devices can be employed to secure containers while being transferred by forklift trucks (See Section 2.6.7). Filled containers should not be transported without their protective housings in place. After a minimum time of eight hours in the holding area to allow the container to reach room temperature, a final test can be made to ensure that all fittings are tight and that there are no container leaks.

3.14 PAINTING AND MARKING OF CONTAINERS

Container painting and identification is usually performed before filling. Care must be taken to avoid certain hazards, as described in the following.

3.14.1 Preparation of Containers for Painting

Basic Preparation

When preparing for painting, all loose paint and other surface material should be removed from the container surface. Surface preparation can include washing, wire brushing, mechanical blasting, or other means. Care should be taken so as not to obscure or damage identification marks on the container. Grounding precautions and equipment suitable for use in the presence of flammable vapors should be utilized if the paint is flammable or contains flammable components. If flammable vapors are present, electrical equipment should be rated for the proper electrical classification.

Protecting Valves, Fusible Plugs, and Identification Marks

Painting over valves and fusible plugs may mask defects and very small leaks and hinder other inspection requirements. Special care should be taken to ensure that the last identification marking of the hydrostatic test date is clear and readable.

3.14.2 Methods and Equipment for Spray, Brush, and Roller Painting

When using spray painting systems, care should be taken to protect the operator from the hazards of airborne paint mists. A well-ventilated paint booth and the appropriate respiratory protection are recommended. It is also necessary to prevent over spray on identification marks and fixtures.

Brush and roller painting pose less of a paint mist hazard, but required respiratory protection must still be used. Brushes and rollers should be selected based on the type of paint used.

3.14.3 Installation of Warning Labels and Placards

Where necessary, warning labels and placards can be attached to the valve(s) with wire or plastic connectors. Since valves are protected during shipment by valve protective housings but must be opened during connection, valves are an ideal place for customer warnings and related information.

3.14.4 Reinstallation of Protective Equipment

Check to ensure that valve outlet caps with gaskets have been properly installed before attaching the valve protective housing. Attach covers securely before transporting the container.

3.14.5 Marking Identification Information

Markings and DOT marking labeling requirements change frequently. Packagers should check 49 CFR Parts 100-185 regularly to ensure that they are meeting current requirements. At the time of publication of this document, chlorine ton containers must be marked in 2-inch high letters on two opposing sides: "RQ Chlorine UN 1017 Inhalation Hazard." For shipments involving water transportation, refer to 49 CFR Parts 100-185 for marine pollutant requirements. Other regulations may be applicable, be sure to investigate thoroughly.

4. VALVES

The following sections apply to typical chlorine valve configurations as shown in Appendix B and as designed to satisfy the performance criteria noted in Appendix A.

4.1 <u>TYPES</u>

4.1.1 Cylinder Valves

Chlorine cylinders have a single valve equipped with a pressure relief device. Typical chlorine valve inlet threads comply with Federal Standard H-28 and are ¾-14NGT(CL)-1 with four additional oversize versions: (CL)-2, 4 threads oversized; (CL)-3, 8 ½ threads oversized; (CL)-4, 14 threads oversized; and (CL)-5, 28 threads oversized.

4.1.2 Ton Container Valves

Ton containers have two identical valves near the center of one head. A Ton container valve is identical to the cylinder valve except that it has no pressure relief device and the valve seat orifice diameter may be larger than on most cylinder valves.

The ton container valve inlet threads comply with Federal Standard H-28 and are ¾-14NGT(CL)-1 and 1-11½NGT(CL)-1 with four additional oversize versions in both sizes: (CL)-2, 4 threads oversize; (CL)-3, 8 ½ threads oversized, (CL)-4, 14 threads oversized; and (CL)-5, 28 threads oversized.

Valve Orientation

The Institute recommends that the ton container valves be positioned as shown below. When aligned vertically, the upper valve outlet faces 3 o'clock while the lower value faces 9 o'clock.

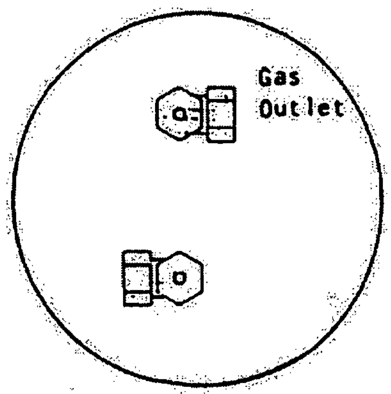


Figure 12 – Ton Container Valve Orientation

4.1.3 Outlet Threads

Outlet threads on cylinder and ton containers are special straight threads (1.030 - 14 NGO - RH - EXT) that comply with Federal Standard H-28 and CGA Connection Numbers 820 and 820C, which utilize a yoke-type connection. These threads are to accommodate the outlet cap only and are not to be used for chlorine filling or unloading line connections.

4.2 FREQUENCY OF VALVE CHANGING

It is recommended that the cylinder and ton container valves be removed, examined, reconditioned or replaced or retested at regular intervals. The frequency of these procedures should be established by each packager and based upon:

- The condition of the valve (e.g., damage, corrosion, legibility of identification markings, absence/existence of structural cracks, signs of leakage, signs of tampering). See Appendix C for additional information regarding the inspection of valves for cracks.

- The performance of the valve (e.g., ease/difficulty of operation, absence/presence of abnormal noises, excessive shut-off torques).

- The condition of the cylinder or ton container (e.g., exposure to fire, bulging, significant dent, etc.).

- Other parameters as established by the packager and other end-use requirements.

4.3 Removal of Valves

Valve removal can be accomplished with either a manual, electric, pneumatic, or hydraulic wrench. In all cases it is important that the jaws gripping the valve fit properly over the wrenching flats on the valve without contacting the outlet or inlet threads or relief device on the valve. Poorly designed, worn, or oversized jaws can deform the wrench flats, possibly obliterating valve markings or incorrectly applying a damaging wrenching force against the fusible plug or valve outlet. The valve should be removed slowly to prevent damage to engaged threads. Before removing the valves, it is important that the container is completely empty of chlorine gas, is under a vacuum, and is secure to prevent toppling during valve removal.

4.4 Valve Reconditioning Facilities

Valve inspection and reconditioning should be performed by trained personnel familiar with the applicable portions of this pamphlet in a dedicated area having the proper tools and equipment and adequate provisions for maintaining the cleanliness of the reconditioned valves.

4.5 Disassembly

Suitable wrenches not over 8 inches in length that fit over the packing nut and outlet cap, with a ⅜-inch square box end that fits over the valve stem are available from valve manufacturers. With the valve disassembled, its individual components should be inspected for structural cracks, gross corrosion, and other significant damage. It is common practice not to remove the fusible plug from the body on cylinder valves unless there is reason to believe it is defective. The packing rings should be inspected for wear and defects. The packing rings should be replaced when required by the facility's operating procedures.

4.6 Cleaning

There are a number of suitable methods for cleaning metal valve parts, some of which are described as follows. Regardless of the method used, care should be taken to ensure that the components, after cleaning, remain within the dimensional specifications provided by the manufacturer. Components that do not conform to specifications should be condemned.

4.6.1 Steam Cleaning

Do not steam valve bodies that contain fusible plugs.

4.6.2 Detergent

Immerse components in detergent (This process is often used in conjunction with steaming). Do no use ammonia solutions because they cause stress corrosion cracking in valve alloys.

4.6.3 Mechanical

Polish components with a power-driven brush, buffer wheel or bead blaster.

4.6.4 Chemical

Immerse components in an acid bath. Extreme care is necessary to minimize the corrosive and etching effect on the valve body and its components. Also, this method has an environmental impact due to the necessity of waste disposal.

Immerse components in a suitable chlorinated or other non-chlorine reactive solvent. Use these solvents in strict compliance with the manufacturer's safety recommendations. Obtain a material safety data sheet (MSDS) and follow all instructions. Solvent disposal can present environmental problems.

4.7 INSPECTION AND RECONDITIONING

4.7.1 Criteria

After cleaning, the valve body and its components should be inspected again for structural cracks or large material losses. See Appendix C for additional information regarding the inspection of valves for cracks. All components should meet the dimensional guidelines found in the Valve Performance Criteria, Appendix A.

4.7.2 Tools and Gauges

The external (inlet, outlet, and packing nut) threads on the valve body should be examined for structural and corrosive damage, heavy wear, and material loss. For the outlet and packing nut threads there are rethreading dies available from tool and die manufacturers that can be passed over the threads on used valves to remove material buildup. Threaded ring gauges ("Go" and "No Go") are also available from thread-gauge manufacturers to check whether threads are within specification. Inspection gauges should only be used on new or re-died threads, otherwise a false reading may result in the gauging process or the gauge could be damaged. The valve outlet sealing face should be checked for nicks and cracks. If defects are observed, reface the surface until it is smooth and flat, taking care to maintain squareness of the outlet face with the threads, reestablish the lead thread chamfer and do not reduce the full thread minimum length to less than 0.375 inch.

Inspection gauges are also available for inlet threads to check if the thread is within specification. However, these gauges should only be used on new valves. Threads on used valves are inspected visually and may be wire brushed to smooth rough finishes and remove burrs before inspection.

The internal valve body should be inspected closely under a bright light, preferably with some magnification. A device such as that used by physicians to examine eyes, ears, and throats is ideal for this purpose.

The internal bores and threads should be inspected for gross corrosion and material loss. Inspection gauges are available for the internal ACME thread. These gauges will indicate if the threads present are within specification. However, inspection will not always indicate if the threads have corroded. A visual inspection of the ACME thread is also required. The threads closest to the valve seat are the most susceptible to corrosion. Loss of these threads could lead to a loss of engagement when the valve is closed, resulting in a "spinner" (a valve with a stem unable to seal at the valve seat due to thread loss or deterioration). If a spinner condition is present, the valve body must be condemned.

The seat opening in the valve body as manufactured is sharp or nearly sharp. Over time, the sharp edge of the seat will become beveled with repeated closing, especially if excessive torque is applied. As the seat becomes more beveled, the torque required to seal the valve will increase. The seat area of the valve may be reconditioned to restore the sharp edge by refacing. Gauges are available from valve manufacturers that indicate the maximum depth the valve body may be refaced. If refacing requires the seat to be lower than the refacing gauge permits, then the valve must be condemned. Due to the difference in orifice size between the cylinder and ton container valve, there are different reconditioning gauges for use with each container. These reconditioning gauges are also used to determine the maximum distance a stem can be refaced and continue to be used in a reconditioned valve body.

4.8 Reassembly and Installation

Assemble valves using new or reconditioned parts that are clean, dry, and in good condition. Trained personnel familiar with the applicable portions of this pamphlet should perform this operation. The area in which the work is done should be clean and have the proper tools and equipment. The valve and its components should be assembled consistent with the Valve Performance Criteria, Appendix A. If non-split packing rings are used, take care that they are not damaged when installing them on the stem. Tighten the packing nut as recommended by the manufacturer, but to not more than 50 foot-pounds. To avoid thread damage, care should be taken when using air tools. Excessive force can increase wear and deformation of the valve and container threads.

4.9 Testing

Connect the valve inlet to a source of oil-free dry air, nitrogen, or carbon dioxide regulated to 500 psig. With the valve closed and without the outlet cap in place, check for leaks at the valve seat, through the fusible plug, past its threaded connection and through the portion of the valve body below the seat by subjecting the valve to 500 psig pressure for at least one minute. Check for leaks by noting any drop in pressure or by observing bubbles when the valve is immersed in water or subjected to a leak detection solution. If there are any leaks, reject the valve, repair it if possible, and retest it. Next, install an outlet cap, open the valve, and test body integrity and packing to 500 psig as before. As an option, the valve may be pressurized through the outlet with the valve closed and check for leaks at the packing nut connection, through the valve body above the seat and again past the valve seat. If there are any leaks, reject the valve, repair it if possible, and retest it. After testing has been completed, remove the outlet cap and dry the valve thoroughly.

5. PRESSURE RELIEF DEVICES

5.1 Types

5.1.1 Cylinders

The pressure relief device on a chlorine cylinder is a fusible metal plug in the cylinder valve located below the valve seat. The fusible metal is cast into a shell of Alloy "B" or Alloy "N" (Refer to Valve Performance Criteria, Appendix A). The plug is then screwed into a tapped hole in the valve body. The fusible metal should be designed to melt between 150°F (65.6°C) and 158°F (70°C).

This is a revised melt temperature range and has been developed to assure that during a rise in temperature the fusible plug melts prior to the cylinder reaching its liquid full level, thus preventing a rupture. Cylinder fusible plugs which meet the new melt temperature criteria will typically be marked (located on the side or top of the cylindrical section which extends above the hex nut portion of the plug) with the following information:

- Manufacturer;
- Manufacturer's batch number;
- Maximum temperature at which the fusible plug could remain a solid; and
- Material designation

In addition, to better facilitate identification in the field, this new fusible plug will have a slightly different shape (See Illustration 112 for an example of a new plug).

The recommended melt temperatures were revised August 13, 2009 (Refer to Appendix D for additional discussion). Fusible plugs on cylinder valves should meet this new design recommendation not later than the next cylinder hydro test (required every five years) starting after January 1, 2010 when the fusible plugs are commercially available.

This relief device is thermally activated to relieve pressure only when subjected to temperatures at or above the melting point of the fusible metal. The device does not provide protection from overfilling or other misuse of the cylinder. Some older valves have fusible metal poured directly into the valve body, but this process is no longer used for new valve construction.

5.1.2 Ton Containers

Ton container valves do not have fusible plugs, but the container itself is equipped with six threaded fusible plugs (See Illustration 111 for a typical configuration): three in each head, spaced approximately 120 degrees apart (See Illustration 197 for a typical configuration). The metric ton container is equipped with four fusible plugs in each head spaced approximately 90 degrees apart. The fusible metal is cast into a shell made typically of Alloy "B" or Alloy "N". The plug is then screwed into a tapped hole in the ton container (See Illustration 197 for a typical configuration). The fusible metal is designed to melt between 150°F (65.6°C) and 165°F (73.9°C). This relief device is thermally activated to relieve pressure only when subjected to temperatures at or above the melting point of the fusible metal. The device does not provide protection from overfilling or other misuse of the container.

5.2 INSPECTION AND RECONDITIONING OF FUSIBLE PLUGS

See Sections 3.7.13 and 3.8.1 for fusible plug inspections. Reconditioning of fusible plugs should be limited to inspection and cleaning, which includes removal of corrosion and minor repairs to damaged threads such as removal of burrs. Do not attempt to refill or repair fusible plugs. Replace fusible plugs if they are faulty or their condition is questionable. If in doubt, replace the fusible plug.

5.3 THREAD SIZES

Cylinder valve fusible plug threads are ⅞-27NGT-MOD (See Illustration 111 for a typical configuration).

Ton container fusible plugs are manufactured ¾-14NGT(CL)-1 and 1-11½NGT(CL)-1 threads, which comply with Federal Standard H-28, with four additional versions in both sizes: (CL)-2, 4 threads (or turns) oversize; (CL)-3, 8½ threads oversize; (CL)-4, 14 threads oversize; and (CL)-5, 28 threads oversize.

6. PERIODIC TESTING OF CONTAINERS

DOT and TC regulations require hydrostatic testing at the time of manufacture for chlorine cylinders and ton containers. Fitness for continued service is established by periodic retests required at regular intervals over the life of the cylinder or ton container. Hydrostatic/ultrasonic retesting facilities performing these retests must be DOT or TC approved. Upon expiration of the test period no cylinder or ton container must be filled or transported with product inside without completion of a new test and stamping of retest date.

6.1 FREQUENCY

6.1.1 Cylinders

All chlorine cylinders (except DOT 3E 1800) must be hydrostatically tested every five years from the date of the previous hydro test (49 CFR Parts 100-185). A cylinder may not be filled after it reaches the month and year five years past its last test date.

Retesting is also required after any reheat treatment or if the cylinder shows any signs of weakness, such as a loss in weight of 5% or more (See Section 3.7.1). Additionally, each time a cylinder is retested it must also be visually inspected, internally and externally, in accordance with CGA Pamphlet C-6.

6.1.2 Ton Containers

All ton containers must be hydrostatically tested every five years from the date of the previous hydro test (49 CFR Parts 100-185). A ton container may be filled until the end of the calendar year during which its five-year test is due. Retesting is also required after any reheat treatment or if the ton container shows any signs of weakness, such as a loss in weight of 5% or more (See Section 3.7.1). Retesting is also required when the pressure-bearing portion of a ton container is repaired. Additionally, stress relieving is also required after such repairs have been completed.

6.2 PREPARATION OF CONTAINERS FOR TESTING

6.2.1 Cylinders

Prior to testing, the chlorine cylinder should be cleaned, weighed, and inspected internally and externally in accordance with CGA Pamphlet C-6. The inspection should also include a visual check of the cylinder inlet threads. Cylinders not meeting the requirements of CGA Pamphlet C-6 should be rejected or condemned.

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The cylinder must also be free of chlorine residue. To ensure safe removal of any chlorine, the cylinder should be vented to a suitable absorption system or its contents neutralized with a caustic soda solution. See Section 3.9 for details on internal cleaning procedures.

6.2.2 Ton Containers

Prior to testing, the ton container should be cleaned, weighed, and inspected internally and externally. The inspection should also include a visual check of the valve and fusible plug inlet threads.

The ton container must also be free of chlorine residue. To ensure safe removal of any chlorine, the ton container should be vented to a suitable absorption system or its contents neutralized with a caustic soda solution. See Section 3.9 for details on internal cleaning procedures.

6.3 METHODS

6.3.1 Hydrostatic Testing

The two common methods for testing chlorine containers are the water jacket volumetric method and the direct expansion method (See CGA Pamphlet C-1).

Water Jacket Volumetric Expansion Method

When volumetric expansions are required, the water jacket volumetric expansion method is the recommended method for testing compressed gas cylinders. It consists of enclosing the test container filled with water in a jacket vessel, which is also filled with water.

The jacket has the necessary attachments for measuring the volume of water forced from the jacket on application of pressure to the container, as well as the volume remaining on release of the pressure. These volumes represent the total and permanent expansions of the container, respectively. The difference between the total and permanent expansions equals the elastic expansion of the cylinder during the test. In general, an increase in elastic expansion indicates a reduction of average wall thickness.

Direct Expansion Method

Using the direct expansion method, the total expansion is determined by measuring the amount of water forced into a container to pressurize it to a predetermined test pressure, and the permanent expansion is determined by measuring the amount of water expelled from the container when the pressure is released. In general, an increase in elastic expansion indicates a reduction of average wall thickness.

6.3.2 Ultrasonic Testing for Cylinders

DOT has issued several special permits that allow the hydrostatic test to be replaced with ultrasonic testing for steel cylinders only. This special permit does not apply to ton containers, but only to chlorine and certain other steel containers. CI does not maintain a listing of exemption holders.

Hydrostatic testing provides good information about the quality of heat treatment and gross condition of wall thickness, which is useful for quality control during cylinder manufacture. However, the hydrostatic testing does not really provide any information about fatigue cracks or localized thinning due to corrosion or misuse. Such information is more reliably found by ultrasonic methods for thickness gauging and flaw detection. At present, DOT and TC regulations do not permit the use of ultrasonic test methods as an alternative to the hydrostatic test to requalify. However, cylinder users could employ these methods for their internal cylinder evaluation programs. The experience from these programs could be used to petition the regulatory authorities to accept these methods as alternatives to hydrostatic testing for cylinder retesting.

6.4 Returning Containers to Service

After hydrostatic testing is satisfactorily completed, the water is removed from the container, which is then dried by a dry hot air blast or other suitable means. The container is then inspected internally and externally before returning it to service in accordance with CGA Pamphlet C-6. A pressure test at 100 psig is required after the unit is dried as described in 49 CFR, Part 180.519.

6.5 Record Keeping

A retesting facility must maintain the following records at the facility's location. Review 49 CFR Parts 100-185 for complete up-to-date record-keeping requirements, including:

- Records of authority to inspect and mark containers, and
- Records of visual inspection and hydrostatic retest, which must be maintained until either the expiration of the retest period or until the container is again reinspected or retested, whichever occurs first.

The container manufacturer is required to retain the test report for 15 years from the original test date of the container.

7. TANK CAR HANDLING

7.1 Receiving Tank Cars

7.1.1 Rail Siding

DOT regulations require that chlorine tank cars must be loaded or unloaded on a private track or siding. Derails and a blue flag must be provided for the open end or ends of the siding. A suitable platform should be provided for safe and easy access to the tank car manway area. Special attention should be given to lighting in the area. Even if night operations are not contemplated, effective lighting should be installed as an aid in dealing with possible night emergencies. Emergency lighting should be available in case of power failure.

7.1.2 Securement and Protection of the Car

Setting Car Brakes

When the tank car has been placed at the desired location on the siding, and before connections to the tank car are made, the hand brake must be set, and the wheels properly chocked. Brake shoes should be in contact with the wheels. A check should be made to ensure the brake is holding.

Placing Derails

During the loading or unloading of a car, measures must be taken to prevent the tank car from being hit or moved by another car or locomotive. This is accomplished by using derails or stops 50 feet or more from both ends of the car. Derails should not be removed for any reason until all cars are disconnected from the loading/unloading rack. If a portable derail is used, it should be properly secured.

Caution Signs/Lights

A tank car positioned for loading or unloading must have caution signs (and/or lights) placed at or near each derail or stop to warn persons approaching the car. Caution signs must remain in place until the operation is completed, all connections removed, and angle valve outlets properly closed with pipe plugs.

Transfer Area Securement

It is recommended that warning signs be posted at the transfer area, and that it be cordoned off as necessary from casual passers by.

7.2 TANK CAR UNLOADING

Chlorine tank cars are unloaded by increasing the pressure in the vapor space above the liquid to a level sufficient to force the liquid chlorine up the eduction pipes and out the liquid angle valves. If the pressure in the tank car is not sufficient to unload the car when received or throughout unloading, the tank may be padded (See Section 7.3).

When unloading a chlorine tank car the safety aspects of the operation should be uppermost in the minds of unloading personnel. The unloader must verify that proper spotting and unloading procedures have been completed before beginning transfer operations. Proper personal protective equipment should be worn during the transfer operation (See CI Pamphlet 65). Safety showers and eyewash facilities should be available. In addition all suppliers' recommendations should be followed during product transfer.

7.2.1 Tank Car Inspection Checklist

An inspection checklist should be used for all aspects of the unloading operation. It should include all recommendations contained in this pamphlet plus any company procedures or special requirements specific to each facility. The checklist documents that proper unloading and securement procedures have been completed. The checklist should be retained for records retention as per company policy. See CI Pamphlet 66 for an example of a typical checklist.

The checklist for procedures to be followed after spotting the tank car should at a minimum include the following items:

- Verify the receiving and spotting procedures have been followed.
- Verify the tank car is loaded with chlorine by careful inspection of the bill of lading or other shipping documents, the reporting marks, the car number, commodity marking, placards and the reported shipping cable seal is intact.
- Open the housing cover and inspecting the manway fittings for evidence of a leak.
- If unloading to a storage tank, verify there is sufficient capacity to receive the chlorine to be transferred.
- Verify the angle valve is fully closed before removing the angle valve plug.

7.2.2 Emergency Shut-Off

Excess flow valves cannot be relied upon as a means of mitigating a hose or piping failure during chlorine transfer. CI Pamphlet 57, Emergency Shut-Off Systems for Bulk Transfer of Chlorine, outlines recommended practices for emergency protection against releases during transfers involving chlorine tank handling systems. The pamphlet illustrates emergency shut-off systems that will quickly bring a release situation under control.

Use of an emergency shut-off system that meets the standards in CI Pamphlet 57 is recommended during the unloading of a chlorine tank car. Use of a proper hose suitable for the transfer of chlorine as recommended in CI Pamphlet 6 should be part of the transfer system.

7.2.3 Connections

<u>Valve Connections</u>

Chlorine tank car angle valves are equipped with a 1 inch pipe plug closure secured to the valve body. This plug should be tightly in place when the car is received and spotted for unloading at the facility. Before any connection is made to a chlorine tank car, all piping should be clean, dry, free of oil, and in-test (See CI Pamphlet 6).

<u>Liquid Valve Connections</u>

To prepare a car for unloading, a threaded nipple made from 1 inch schedule 80 carbon steel (experience has shown that a 15 inch long nipple has been found to be adequate in most circumstances), should be tightly screwed into the tank valve outlet. The threads on the nipple should be standard NPT, sharp and clean and prepared with an appropriate sealant. Teflon® tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly. If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed.

To properly apply Teflon® tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug. A thread gauge can be used to ensure the acceptability of the threads. The threads should be of a proper length to prevent damage to the valve seat or stem area. Care should be taken when tightening the nipple to prevent undue strain on the valve.

A flexible transfer hose, per recommendations contained in Appendix A of CI Pamphlet 6 or a flexible copper loop, per Illustration 118 (Appendix B), should be provided between the nipple and the process piping to compensate for the rise of the car during unloading. Valve arrangements, incorporating fail safe features as described in CI Pamphlet 57, mounted at the tank car and on the process piping feeding the chlorine to the process or to storage are recommended.

Inspection and Tests

After all connections are made, it is advisable to allow a small amount of chlorine into the system. Each connection, valve packing and flange should then be checked for leaks with ammonia vapors. If a leak is found, it must be corrected before allowing more chlorine into the line.

Vapor from a squeeze bottle containing a 26° Baumé aqua ammonia solution or stronger can be used to detect a minor chlorine release or leak. Weaker solutions may not be concentrated enough to detect minor leaks. It is acceptable to use other concentrations based on successful experience. A white cloud will form if a leak is present.

To avoid corrosion, the aqua ammonia solution should not be directly sprayed onto connections.

Any efforts to detect the source of a leak should be carried out with full consideration for potential hazards. Appropriate personal protective equipment must be used.

7.2.4 Opening Liquid Angle Valves

Each eduction pipe on the chlorine tank car is equipped with an excess flow valve. The tank car liquid angle valve must be opened slowly until completely open, and left fully open. If opened rapidly, the excess flow valve may close and flow will not occur.

7.2.5 Line Pressurization

A differential pressure must be maintained between the chlorine tank car and the system receiving the chlorine. While slowly opening the tank car liquid angle valve, the pressure gauge located at the beginning of the permanent piping should be observed. A rise in pressure indicates there is liquid flow. The line valve should be in a closed position at this point. As soon as the gauge indicates a steady pressure, the tank liquid angle valve should be opened fully. The line valve should then be opened slowly until the liquid chlorine completely fills the line to the process. The line valve should be opened until the desired flow rate is obtained taking care to ensure the flow does not cause the excess flow valve in the tank car to check.

CAUTION: If liquid chlorine is trapped between two valves, extremely high pressure can develop upon increase in the temperature of the chlorine. Refer to CI Pamphlet 6.

7.2.6 Excess Flow Valve Unseating

With the exception of those cars equipped with pneumatically operated angle/internal check valve combinations, all chlorine bulk transports are equipped with excess flow valves under the liquid angle valves. There may be times, due to opening the angle valve too rapidly or due to unusually high flow rates, the excess flow valve will close. If this occurs, the angle valve on the car should be closed and left closed until the metal ball or plug in the excess flow valve drops back into place. A noticeable click will be heard when it drops. If the ball or plug does not drop, a connection can be made to the other liquid valve on the car. The supplier should be consulted if neither of these two methods is successful.

7.2.7 Monitoring the Unloading

Regulations prior to the issue of HM-223 required that throughout the entire period of unloading, and while the car is connected to the unloading device, the car must be attended by the unloader. CI strongly recommends that, although not required in most cases by current DOT regulation, it is best practice to provide continuous monitoring of unloading operations. If it is necessary to discontinue unloading a tank car for any reason, all valves must be tightly closed and unloading connections disconnected and plugs installed in the tank car valves. Past correspondence from the DOT indicates that "attending" the unloading includes having an employee physically present at the unloading site, electronic monitoring with remote shut-off equipment, television camera monitoring or by any means by which the tank car is monitored and the flow of chlorine can be stopped if unloading difficulties develop. Shippers/receivers have had successful experience utilizing all of these methods.

A number of regulatory exemptions have been issued by the DOT (SP 12443) to permit tank cars containing chlorine to remain standing with unloading connections attached when product is not being transferred. Special provisions must be followed to meet the terms of the DOT special permit including the designation of an employee responsible for on-site monitoring of the transfer facility.

It is anticipated DOT will soon provide additional clarification on the issue of monitoring the unloading of a tank car. It is the responsibility of each unloading site to ensure all applicable regulations are followed.

7.2.8 Leaks During Unloading

Appropriate PPE per CI Pamphlet 65 should always be used and emergency capping equipment must be readily accessible.

<u>Leaks in Connections and Piping</u>

Chlorine piping systems should be pressure tested at regular intervals according to Institute recommendations (See CI Pamphlet 6). Chlorine piping systems should also be inspected at regular intervals for signs of leakage, internal or external corrosion, insulation failure, or support problems. If a chlorine leak should occur in equipment or piping, the chlorine transfer should be stopped immediately by closing the tank car angle valves, and the unloading line pressure relieved so the necessary repairs can be made. When the leak has been located and the faulty equipment repaired, unloading may be resumed.

Leaks at Tank Car Fittings

Leaks around the tank car angle valve stems can usually be stopped by tightening the packing gland nuts. If this does not stop the leak, the angle valve should be closed. Only if a tank car valve leak cannot be stopped by corrective measures should the capping devices in the Emergency Kit C be used. If the pressure relief device must be capped, regular monitoring of the tank car's internal pressure must be established. The shipper should be advised of the problem as soon as possible.

7.2.9 Determining Amount of Chlorine Unloaded

Where chlorine tank cars cannot be unloaded on track scales, and reliable direct gauging devices are not readily available, the most common practice for estimating the quantity of chlorine remaining in the car is from the consumption records of the quantity removed. The contents should be unloaded to the maximum extent practicable.

7.2.10 Disconnecting

As soon as it is determined that the tank car is as empty as possible, the liquid chlorine manifold header valves should be closed followed by the tank car liquid angle valves, and the transfer hoses emptied, before any other valves in the discharge system are closed.

The unloading lines should then be purged, evacuated and disconnected. This should be done with care to ensure the line has been cleared and chlorine will not be released upon disconnection. Appropriate respiratory personal protective equipment should be worn when disconnecting lines that have contained chlorine.

Liquid chlorine should never be trapped in the discharge line between valves, since extremely high pressure can develop from an increase in the temperature of the chlorine. This pressure may lead to hydrostatic rupture of the line. If the car has been padded, the pad gas supply line should be shut-off, evacuated and disconnected.

7.2.11 Prerelease Check

- Inspect angle valves to ensure they are closed.
- Using aqua ammonia (refer to Section 7.2.3), check for leaks from angle valves with the valves closed and the plugs removed, and from the manway plate and the pressure relief device. All leaks must be eliminated prior to the release of the tank car.
- Using an appropriate wrench thread sealant, tighten the outlet plugs of all angle valves.

- Indicate any unusual condition by applying a tag to any of the valves, describing the condition found.
- Close and secure the protective housing cover. A cable seal of not less than $^3/_{16}$ inch thickness should be applied to the protective housing cover locking pin in such a manner that the pin cannot be removed without breaking the seal.
- Check for proper marking and placarding of tank car. Placards must be installed in placard holders in four locations on the car.
- Complete shipping papers.
- Remove derail and make other preparations for tank car removal.
- Notify the railroad agent that the car is empty.
- Refer to 49 CFR 173.31(d) for additional pre-release examination items.

7.3 PRESSURE PADDING

Chlorine tank cars are often unloaded by increasing the pressure in the vapor space above the liquid to a level sufficient to force the liquid chlorine up the eduction pipe and out the liquid angle valves. The process of increasing the pressure in the vapor space is called pressure padding. The reader should refer to CI Pamphlet 66 for a detailed discussion.

7.3.1 Need for Padding

The vapor pressure of chlorine varies with temperature. If more pressure is needed to unload the car, padding of the tank may be necessary. While dry air is commonly used, other suitable, dry, inert gases, such as nitrogen, can be used. To minimize the need for padding, considerations should be given to the following:

- Reducing the pressure at the point of consumption;
- Reducing the pressure drop in the piping system;
- Minimizing the effect of the difference in elevation by using a vaporizer so gas is elevated rather than liquid. Liquid chlorine has a specific gravity of about 1.47, so each foot of liquid chlorine is equivalent to about 0.64 psig. Each foot of gas is equivalent to about 0.005 psig; and/or
- Housing the car in a warm shed to minimize the effect of extremely cold weather.

7.3.2 Air Supply and Drying Requirements

Air Quality

Even small amounts of moisture can cause excessive corrosion to tank car equipment and to piping and handling systems. It is essential the air used for padding be free from oil and foreign matter and be dried to a dew point of -40°F (-40°C) or below measured at the operating pressure. Chlorine and oil can react to produce heat and under certain conditions, the reaction may create a fire.

Moisture Content

To ensure no moisture is entering the chlorine system, the moisture content of padding air should be continuously monitored when the tank car is connected for padding. This is easily done with a commercially available in-line dew point analyzer with alarm. The dew point of the dry air must always be sampled at the operating pressure, not at atmospheric pressure.

Separate System

Padding air should not be taken from the plant air system, but should come from an independent air compressor used solely for this purpose. In a common system, a heavy demand for air elsewhere can lower the overall system pressure below the tank car pressure; chlorine would then feed back into the air system with probable damage to equipment and danger to personnel. Adequate backflow protection should be utilized to prevent contamination of the padding system.

Air Padding

A suitable air compressor and an ASME Code receiver equipped with the appropriate instrumentation such as pressure gauges and switches, temperature gauges and switches, safety valves, automatic electronic drain valves and automatic pressure controls should be used.

The operating conditions and characteristics of the compressor should be considered when designing the system. For example, operating a typical compressor at 60-70% of maximum design rpms will reduce air outlet temperatures, compressor wear and long term oil carryover.

Greater compressor capacity will be required when padding a tank car manually rather than automatically. This larger capacity requirement should be taken into consideration when purchasing an air compressor system.

Depending on the type of dryer system installed with the compressor, dryer system outlet flow rates may be reduced to 85-90% of the compressor output capacity. This reduction must be considered in the final design. Multiple compressors should be considered for continuous duty.

Special consideration should be given to compressor location. Compressor rooms should be well ventilated. Air inlet filters should be considered to ensure clean air. Silencers should be used to reduce the sound level to acceptable standards. The inlet air supply to the compressor should be drawn from an area that is unlikely to be contaminated with chlorine or other chemical fumes that would quickly corrode and damage the compressor internal components.

Air Dryers

Commercial regenerative-type dryers using activated alumina or silica gel as the desiccant are recommended. They can be obtained with any degree of refinement from manual to fully automatic control. If continuous operation is desired, dual units are necessary. See CI Pamphlet 66 for assistance in calculating the required capacity.

7.3.3 Padding Pressure Considerations

To minimize the increased hazards accompanying air padding, pressures should be kept as low as possible. In any case, the total pressure (the vapor pressure of the chlorine plus the pressure of the air pad) should not exceed 125 psig in tank cars equipped with a 225 psig safety relief device and 200 psig in tank cars equipped with a 375 psig safety relief device.

As the tank car is padded the warm air entering the car will raise the temperature of the liquid chlorine and increase its vapor pressure. The heat will also cause the liquid to expand, thus reducing the vapor space with a resulting increase in the vapor space pressure. The combined effects of expansion of the liquid and increase in its vapor pressure may increase the total pressure enough to open the safety valve. For example, if a full car at 33°F (0.56°C) is padded from the vapor pressure of 40 psig to a total pressure of 125 psig and then allowed to warm up to 88°F (31.1°C), the combined effects of the expansion of the liquid chlorine and increase in its vapor pressure will raise the total pressure above 225 psig and a safety relief device set at that pressure will open. For similar reasons as in the example, most chlorine tank cars in North America are equipped with 375 psig safety relief devices.

It is especially important to prevent buildup of excessive pressure over periods when chlorine is not being withdrawn, such as nights, weekends, and plant vacation periods or shutdowns. Under these circumstances, cars should be inspected routinely for leaks and excessive pressure. If necessary, excessive pressure should be vented to a recovery system.

8. CHLORINE EMERGENCIES

8.1 General

A chlorine emergency may occur during any phase of a packaging plant's operation. Trained employees along with a comprehensive, written emergency response plan (See Section 10 and CI Pamphlet 64) are necessary to mitigate the consequences of an emergency.

Federal, state, and provincial regulations, as well as various local fire and building codes, regulate chemical emergency preparedness. All persons handling or responsible for the handling of chlorine must be familiar with the contents of those various requirements.

Regulatory requirements deal generally with the preparation for and response to chemical and other emergencies. This section is intended to provide additional information for use in chlorine emergencies. Help is also available from CHLOREP, through CHEMTREC in the United States and through CANUTEC in Canada.

8.2 RELEASES

8.2.1 General

Chlorine facilities should be designed and operated so that risk of a chlorine release into the environment is minimized. However, accidental releases and leaks of chlorine may occur, and so the overall effects of such incidents must be considered.

8.2.2 Detection of Minor Releases and Leaks

A plastic squeeze bottle containing 26° Baumé aqua ammonia can be used to detect a minor release or leak. Weaker solutions may not be concentrated enough to detect minor leaks. It is acceptable to use other concentrations based on successful experience. **WARNING:** Only the ammonia vapor is directed at a leak, never liquid. A white cloud will form indicating the source of the leak. If a laboratory wash bottle is used, the dip tube inside the bottle should be cut off so that squeezing the bottle directs vapor, not liquid, out of the nozzle. Never allow the aqua ammonia solution to come into contact with valves or piping system components. Portable electronic chlorine monitors can also be used to detect leaks.

If a leak occurs in equipment or piping, the chlorine supply should be shut off, the pressure relieved, chlorine evacuated, and necessary repairs made.

The chlorine supplier should be notified of a leak in a tank car.

8.2.3 Types of Releases

Chlorine releases can be classified as either instantaneous (puffs) or continuous. (See CI Pamphlet 74 for details).

Instantaneous Release

An instantaneous release is characterized by the escape of chlorine to the atmosphere in a relatively short period of time (a few minutes), resulting in a cloud that moves across the downwind range while growing in size and decreasing in concentration. Thus, the concentration of chlorine monitored at any given point downwind will vary over time depending on the position of the chlorine cloud.

Continuous Release

A continuous release is characterized by the escape of chlorine to the atmosphere over a long period of time (usually more than 15 minutes), resulting in a continuous plume that reaches an equilibrium size and concentration gradient. Thus, the concentration of chlorine monitored at any given point downwind from the source will be constant over time for the duration of the release. The failure of a valve or fitting on a large container is an example of a continuous release situation.

8.2.4 Physical Form of the Release

Chlorine exists as a gas or liquid depending on the pressure and temperature. Typically, chlorine is stored and transported as a liquid under pressure. Whether the release source is a liquid or gas significantly affects the downwind dispersion because liquid chlorine expands in volume by nearly 460 times when it vaporizes.

During a release, chlorine can escape as a gas, a liquid, or both. When pressurized liquid or gas is released from a container, the temperature and pressure inside the container will decrease, thus reducing the release rate.

Escaping liquid may collect in a pool and may actually form a running stream. Chlorine will immediately cool to its boiling point (-29°F [-34°C]) as it enters the atmosphere. On contact with any heat source (the air, ground, or water) the heat will cause the chlorine to boil readily. Typically, the boil-off rate will be relatively high initially and then decline as the heat source surrounding the chlorine is cooled by the chlorine.

Water in bulk provides a vast heat source for evaporating liquid chlorine. It should be assumed that any liquid chlorine falling into water will vaporize quickly. For this reason, emergency response personnel should try to prevent water from contacting a liquid chlorine pool as well as chlorine flowing into water drains.

8.2.5 Area Affected

The area affected by a chlorine release and the duration of the exposure depends on the total quantity released, the rate of release, the height of the release point, and the weather conditions, as well as the physical form of the chlorine being released. Chlorine downwind can vary from barely detectable to high concentrations. CI Pamphlet 74 provides information on the area affected by specific chlorine-release scenarios.

8.3 <u>RESPONSE TO A CHLORINE RELEASE</u>

8.3.1 Personnel Considerations

As soon as there is any indication of a chlorine release, immediate steps must be taken to correct the condition. Chlorine leaks always get worse if they are not promptly corrected. When a leak occurs, authorized, trained personnel equipped with respiratory and other personal protective equipment (PPE) should investigate and take proper action. Personnel should not enter into atmospheres containing concentrations of chlorine in excess of the immediately dangerous to life and health (IDLH) concentration (10 ppm) without appropriate PPE and back-up personnel. See Section 11 for basic PPE information. CI Pamphlet 65 provides detailed PPE recommendations for responders to a chlorine release.

Keep unnecessary personnel away and isolate the hazard area. Persons potentially affected by a chlorine release should be evacuated or sheltered in-place as circumstances warrant. Area chlorine monitors and wind direction indicators can supply timely information (e.g., escape routes) to help determine whether personnel are to be evacuated or sheltered in-place. If evacuation is chosen, potentially exposed persons should move to a point upwind of the leak. Because chlorine is heavier than air, higher elevations are preferable. To escape in the shortest time, persons already in a contaminated area should move crosswind.

When inside a building and sheltering in-place is selected, shelter by closing all windows, doors, and other openings (when possible, this includes the taping of cracks, etc), and turning off heating, ventilation and air conditioning systems. Personnel should move to the side of the building farthest from the release.

Because new leaks may occur or the existing leak may get larger, care must also be taken not to position personnel without an escape route.

8.3.2 Corrective Actions

These specific actions may be taken to contain or reduce leaks:

- If chlorine is escaping as a liquid from a container, an attempt should be made to align the container so that only gas will be leaking. In this position, the chlorine release will be greatly minimized.

- If leaks occur around container valve stems or past the packing nut threads, close the valve, then tighten the packing nut.

- If practical, reduce pressure in the container by removing the chlorine gas (not as liquid) to process or a disposal system. **CAUTION:** Do not tighten connections or leaking fittings or attempt other repairs while the system is under pressure (See CGA Pamphlet P-1, *Safe Handling of Compressed Gases in Containers*).

- If simple corrective measures are not sufficient, the appropriate Chlorine Institute Emergency Kit (See Section 8.5) should be applied. If the container is a cylinder it may also be placed in a DOT approved recovery vessel designed to contain the leak.

- If conditions permit, and while employing proper safety techniques and PPE, move the container to an isolated spot where the consequences will be lessened.

- A leaking container must not be immersed or thrown into a body of water; the leak will be aggravated and the container may float when still partially full of liquid chlorine, allowing gas evolution at the surface.

If notification of local authorities is required, the following information should be provided:

- Company name, address, telephone number, and the name of the person(s) to contact for further information;

- Description of the emergency;

- Travel directions to the site;
- Type and size of the container involved;
- Corrective measure(s) being applied; and
- Other pertinent information, such as weather conditions, injuries, etc.

8.4 RESPONSE TO A FIRE

If fire is present or imminent, chlorine containers and equipment should be moved away from fire, if possible. If a non-leaking container or equipment cannot be moved, it should be kept cool by applying water on it.

Water should not be used directly on a chlorine leak. Chlorine and water react to form acids, and the leak will quickly get worse. However, where several containers are involved and some are leaking, it may be prudent to use a water spray to help prevent over pressurization on the non-leaking containers. Whenever containers have been exposed to flames, cooling water should be applied until well after the fire is out and the containers are completely cooled.

8.5 EMERGENCY KITS AND RECOVERY VESSELS

Chlorine Institute Emergency Kits and cylinder recovery vessels are designed to temporarily contain most of the leaks that may be encountered in chlorine shipping containers until the chlorine can be safely transferred to another container. The following are available:

- Kit A for 100- and 150-lb cylinders;
- Kit B for ton containers;
- Kit C for tank cars and tank trucks; and
- Recovery vessels (DOT approved) for cylinders

The kits operate on the principle of containing valve leaks by applying hoods and gaskets. For cylinders and ton containers, patches are provided for sealing off a small hole in the side wall. Capping devices are provided for fusible plugs in ton containers.

Chlorine recovery vessels are commercially available DOT approved equipment designed to hold an entire cylinder. CI Pamphlet IB/RV provides detailed information on recovery vessels for 100- and 150-lb cylinders. A leaking cylinder can be placed in a vessel that is then closed, thus containing the leak. The chlorine can then be recaptured from the recovery vessel.

The U.S. DOT allows chlorine cylinders and ton containers with appropriate Emergency Kit A or B devices installed to be shipped on the highways for transport to a destination for final disposal. See 49 CFR Parts 173.3 for details before shipping.

8.6 REPORTING

Most government agencies have reporting requirements for chlorine releases. Packaging plants must be aware of the reportable quantity (RQ) and of all relevant requirements.

In the United States, any chlorine release of 10 lbs or more, within a 24-hour period not specifically allowed by an operating permit must be reported immediately (within 15 minutes) to the National Response Center (NRC) at 1-800-424-8802 or 202-426-2675, (40 CFR Part 302.6(a) and 49 CFR Part 171.15).

A written follow-up report is required by the U.S. EPA for all RQ releases. The report is usually submitted to the State Emergency Response Committee in a time frame specified by the SERC. Packagers should contact their state emergency services or environmental agency to obtain these requirements.

The Department of Transportation requires all releases of chlorine during transport, loading, unloading or storage to be reported in writing on DOT Form 5800. The DOT specifies no release quantity to trigger written reporting. These reports must be submitted in duplicate within 30 days from the date of the incident (49 CFR Part 171.16).

9. MEDICAL ASPECTS AND FIRST AID

9.1 HAZARDS TO HEALTH

9.1.1 General

Chlorine gas is primarily a respiratory irritant. It is so intensely irritating that low concentrations in the air (well below 1 ppm) are detectable by most people. At low concentrations, chlorine gas has an odor similar to household bleach. As the concentrations increase from the level of detection by smell, so does the symptomatology in the exposed individual. At chlorine concentrations above 5 ppm 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 was trapped or unconscious. The effects of exposure to chlorine may become more severe for up to 36 hours after the incident. Close observation of exposed individuals should be a part of the medical program.

Table 2 lists a compilation of chlorine exposure thresholds and reported responses in humans. It should be noted that there can be a considerable variation in effect among subjects.

Table 2: Chlorine Exposure Thresholds and Effects[1]

Exposure Level (ppm)	Effect
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	TLV-TWA, REL-Ceiling
1	PEL-Ceiling, TLV-STEL, ERPG-1
1 – 3	Mild, mucous membrane irritation, tolerated up to 1 hour
5 - 15	Moderate irritation of the respiratory tract
3	ERPG-2
10	IDLH
20	ERPG-3
30	Immediate chest pain, vomiting, dyspnea, cough
40 - 60	Toxic pneumonitis and pulmonary edema
430	Lethal over 30 minutes
1000	Fatal within a few minutes

[1]CI Pamphlet 63

CI Pamphlet 63 provides detailed information concerning:

- The health hazards of chlorine;
- First aid including the administration of oxygen;
- Medical Management of Chlorine Exposures subsequent to first aid;

- Recommended medical surveillance program for persons potentially exposed to chlorine; and

- Recommended occupational hygiene and exposure assessment monitoring for individuals working with or around chlorine.

In addition, the Institute has developed a video, *Health Effects from Short-Term Chlorine Exposure* (H-DVD).

9.2 FIRST AID

First aid is the immediate temporary treatment given to an exposed individual. Prompt action is essential. Reassurance to the individual will help to alleviate anxiety. When indicated, medical assistance must be obtained as soon as possible. **WARNING**: Effects of chlorine exposure may be delayed. Caution is advised. Chlorine is corrosive and will be converted to hydrochloric acid in the lungs.

Responders should take the necessary precautions to protect themselves from any exposure to chlorine while administering first aid and should move the victim from any contaminated area as quickly as possible.

9.2.1 Inhalation Exposure

See CI Pamphlet 63 and the chlorine gas label for inhalation first aid instructions. At a minimum, move the victim to fresh air. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures. Transport to a health care facility.

9.2.2 Dermal/Eye Exposure

See CI Pamphlet 63 and the chlorine gas label for detailed dermal/eye first aid instructions. At a minimum, remove victims from exposure. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support. Remove contaminated clothing as soon as possible. If eye exposure has occurred, eyes must be flushed with lukewarm water for at least 15 - 20 minutes. Wash exposed skin areas for at least 15 - 20 minutes with soap and water. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures. Transport to a health care facility.

9.2.3 Ingestion

See CI Pamphlet 63 and the chlorine gas label for detailed ingestion first aid instructions.

10. EMERGENCY PLANNING AND EMPLOYEE SAFETY TRAINING

10.1 PLANNING

10.1.1 Hazard Communication

A packaging plant must have a hazard communication plan in place in order to satisfy OSHA's Hazard Communication Regulation 29 CFR Part 1910.1200. The plan must be developed, implemented, and maintained as a written hazard communication program. Every member of the management team should be familiar with the location of this document so that he or she can readily access it in the event of an emergency or an audit.

The plan should include the following elements:

- Provisions for providing employees with effective information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new physical or health hazard the employees have not been previously trained about, is introduced to the work area.
- Explanations of labeling requirements. Each container must be properly labeled with the appropriate hazard warning. The warning should include the name of the material and the hazards involved, and safety precautions in reference to the MSDS for more detailed information.
- Management of MSDS. The material safety data sheets for each material are to be provided by the manufacturer of that material, and they must be available to the employee in the workplace.
- Provide a list of hazardous chemicals known to be present using an identity reference on the appropriate MSDS.
- Methods for informing employees of the hazards of non-routine task and the hazards associated with chemicals contained in unlabeled pipes in the work area.

A written hazardous communication program must be made available to all employees, or their designated authorized representative, upon request.

10.1.2 Emergency Response Plan

A packaging plant must have an emergency response plan, which may be part of the contingency plan for the facility. The written plan should include details regarding the following:

- Pre-emergency planning and coordination with outsiders;
- Personal roles, lines of authorities, and communication; and
- Evacuation procedures, site control, and places of refuge.

For more detailed information, see CI Pamphlet 64.

10.2 TRAINING

10.2.1 General

Training is needed for packaging plant employees for two distinct reasons: to ensure the safety of the employees and to comply with the laws requiring such training. This section describes some of the chlorine specific training necessary for employees.

Job Specific Elements

Each employee involved in operating chlorine process equipment is to be trained in the overview of that process. The training should emphasize specific safety and health hazards, emergency operations, and safe work practices applicable to the employee's job tasks. Training topics include, but are certainly not limited to:

- Chlorine physical properties and hazards;
- Health hazards;
- Container construction and inspection;
- Container transportation;
- Connecting and disconnecting containers and tank cars;
- Chlorine leaks;
- Personal protective equipment and first aid;
- Emergency procedures; and
- Coordination with outside emergency responders.

Refresher Training

Refresher training is to be provided every three years, and more often if necessary, for each employee involved in the chlorine process operations.

10.2.2 Personal Protective Equipment

A personal protective equipment (PPE) program is required by 29 CFR Part 1910.132. Employers are required to conduct a hazard assessment of the workplace and define applicable PPE to be worn by the employees. A written program must be developed to certify that this hazard assessment has been completed. Employees, in the absence of a suitable, economical engineering control to mitigate the hazard, are to be trained regarding the following:

- When the use of PPE is necessary;
- What PPE are necessary;

- How to properly put on, take off, adjust and wear PPE; and
- The proper care, maintenance, useful life, and disposal of the PPE.

Retraining of employees must be conducted in the following situations:

- When changes in the workplace render the previous training obsolete;
- When changes in the types of PPE to be used render the previous training obsolete; or
- When it becomes obvious that an employee has not retained the required understanding or skills necessary to use the prescribed PPE.

All training is to be documented. The training record must include:

- Name of the employee;
- Date of training;
- Identification of training subject matter; and
- Written certification that the employee received and understood the training.

See Section 11 for additional information about PPE.

10.2.3 Emergency Responder Training

The type of training needed for an emergency responder varies as to the level of responsibility of that responder, per 29 CFR Part 1910.120(q). There are seven types of responders requiring different types or amount of training:

1. First Responder, Awareness Level: a person who may discover the problem and who will only notify the proper authorities; requires understanding of the materials, including their risks, and of how to secure the site and of whom to notify.

2. First Responder, Operations Level: a person involved in the initial response to a release or potential release of hazardous substance for the purpose of protecting nearby persons, the environment, or property from the effects of the release. This person responds defensively to contain the release from a safe distance, keeps it from spreading, and prevents exposures without trying to actually stop the release. This level requires eight hours of training, including awareness-level topics.

3. Hazardous Materials Technician: a person who aggressively responds to leaks to try to stop the release by plugging or patching; requires 24 hours of training, including operations-level topics.

4. Hazardous Materials Specialist: a person having specific knowledge about the products involved in the emergency, who supports the technician, and who may also act as the site liaison with federal, state, local, and other government authorities regarding site activities. This level requires 24 hours of training equal to technician-level competency.

5. On-Site Commander: a person who directs and coordinates all aspects of the emergency response; requires 24 hours of training equal to operational-level competency, plus competency in implementing and directing emergency responses.

6. Skilled Support Personnel: persons who are skilled in operating specialized equipment; requires pre-entry briefing.

7. Specialized Employees: persons who work regularly with the products involved in the emergency and who may be called on to provide technical advice or assistance; requires annual training and competency in the area of specialization.

Employees must be provided with annual refresher training of sufficient duration to maintain the skill levels that are necessary. This training must be documented.

Recordkeeping

All emergency responder training must be documented. Written documentation must include:

- Employee's Name;
- Course Title;
- Course Date;
- Statement that the employee has successfully completed the course;
- Name and address of person or organization providing the training;
- An individual identification number for the document or certificate; and
- A list of the levels or personal protective equipment used by the employee to complete the course.

All emergency responder training documentation is to be maintained for a minimum of five years.

10.2.4 HAZMAT Transportation Training

According to 49 CFR Subpart H, Parts 172.700-704, employees affecting the transportation of hazardous material (HAZMAT) must be trained in four areas:

1. *General awareness and familiarization.* Employees must receive training designed to provide familiarity with the requirements of the Hazardous Material Regulation (HMR) and to enable the employee to recognize and identify hazardous materials consistent with the DOT's hazard communication standard.
2. *Function-specific training.* Each employee must receive function-specific training concerning regulatory requirements that are applicable to his or her job functions.
3. *Safety training.* Each employee must receive safety training concerning his or her job, (i.e. hazardous communication, personal protective equipment, emergency action, etc.).
4. *Security Training.* Each employee must receive training that provides an awareness of security risks associated with hazardous material transportation and methods designed to enhance transportation security. The training must also include how to recognize and respond to possible security threats, as well as company organization security structure, specific security objectives and procedures, actions to be taken in the event of a security breach, and employee responsibilities.

Employees requiring training include, but are not limited to, supervisors, tank car unloaders, ton and cylinders loaders, hydrostatic testers, visual inspections, plant personnel loading and unloading the transport vehicles, drivers and dispatchers.

All training is to be documented. The training record must include:

- Employee's name;
- Training date;
- Description, copy or location of training materials used;
- Name and address of person providing the training; and
- Certification that the employee has been trained and tested.

Refresher Training

All hazmat employees must receive refresher training at least once every three years.

11. PERSONAL PROTECTIVE EQUIPMENT

11.1 AVAILABILITY AND USE

Exposure to chlorine can occur whenever chlorine is handled. Personal protective equipment (PPE) must be provided for employee use for specific job tasks. PPE for emergency use must be available for employee use away from areas of likely contamination during an emergency event. If chlorine is handled in widely separated locations, PPE for emergency use should be available near each area.

CI Pamphlet 65 provides recommendations on PPE for specific tasks including loading and unloading, initial line entry, material sampling, and emergency response.

11.2 RESPIRATORY EQUIPMENT

All personnel entering areas where chlorine is stored or handled should carry or have immediately available an emergency escape respirator.

Respiratory equipment should be selected based on evaluation of hazards and degree of potential exposure. For selection considerations as well as other requirements, please refer to the hazard assessment that was developed for your facility or see CI Pamphlet 65.

11.3 OTHER PPE

The facility should also specify other PPE requirements that are site specific and protect against other hazards that may be encountered on the job. For selection considerations as well as other requirements, please refer to the hazard assessment that was developed for your facility or see CI Pamphlet 65.

11.4 OTHER SAFETY EQUIPMENT

There should be emergency eyewash and deluge shower stations located throughout the facility. Each station should be close to any potential exposure zones, but not so close to the potential source as to be unusable in an emergency do to contamination. Please see OSHA 29 CFR and ANSI Z358.1 for detailed requirements.

12. KEY REGULATIONS AND CODES

Regulations change and current editions of the various *Code of Federal Regulations* (CFR) documents should be reviewed periodically. Both the text and section numbers tend to change.

The following are known federal regulations that impact chlorine packaging facilities, but should not be considered a complete listing. This document does not deal with the more general regulations with which any type of business must be concerned.

12.1 U.S. OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION: 29 CFR

Part 1904, Record Keeping Requirements

Part 1910.20, Access to Exposure and Medical Records

Part 1910.38, Emergency Action Plans

Part 1910.95, Occupation Noise Exposure

Part 1910.119, Process Safety Management of Highly Hazardous Chemicals

Part 1910.120, Hazardous Waste Operations and Emergency Response

Parts 1910.132 to 1910.139, Personal Protective Equipment

Part 1910.146, Confined Space

Part 1910.147, Control of Hazardous Energy (Lockout/Tag-out)

Part 1910.151, First Aid/Medical Service

Part 1910.154, Fire Extinguishers

Part 1910.178, Fork Trucks

Part 1910.1000, Air Contaminants

Part 1910.1200, Hazard Communication

12.2 U.S. ENVIRONMENTAL PROTECTION AGENCY: 40 CFR

Part 68, Clean Air Act/Accidental Releases

Part 150-159, Pesticide Registration and Classification Procedures

Parts 302 and 355, Release of Hazardous Substances, Emergency Planning, and Notification

Parts 307 and 372, Hazardous Chemicals Reporting: Community Right to Know

Parts 700 to 799, Toxic Substance Control Act (Record keeping and reporting for various chemical substances)

12.3 U.S. DEPARTMENT OF TRANSPORTATION: 49 CFR

Part 171, General Information, Regulations and Definitions

Part 172, Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training and Security Requirements (Shipping papers, marking, labeling, and placarding, as well as the training of hazmat employees and security program development)

Part 173, Shippers (General requirements for shipping and packaging; definitions of hazardous materials for transportation purposes; requirements for container inspections, testing, and retesting)

Part 174, Carriage by Rail (Transport, loading and unloading of railcars)

Part 177, Carriage by Public Highway (Handling, transportation, loading and unloading, and segregation of hazardous materials)

Part 178, Specifications for Packaging (Specifications for cylinders, portable tanks, and cargo tanks)

Part 180, Continuing Qualifications and Maintenance of Packaging (Qualifying existing cargo tanks for hazardous materials)

12.4 U.S. DEPARTMENT OF HOMELAND SECURITY: 6 CFR

Part 27, Chemical Facility Anti-Terrorism Standards

12.5 LOCAL REGULATIONS: FIRE CODES AND BUILDING CODES

Numerous fire and building codes affect chlorine production, storage, packaging, distribution, and use. Code requirements may include, but are not limited to, minimum separation distance between classes of chemicals, design of piping systems, secondary containment, need for treatment systems or gas detectors, emergency response requirements, and the need for sprinklers.

To properly address these codes, the local government (e.g., city or county) should be contacted. Determine what specific fire and building codes, including the code year, were passed by the governing jurisdiction.

Some local or state authorities develop their own codes. However, many jurisdictions adopt a model code or reference National Fire Protection Association (NFPA) Standards. Either of these may serve as the local code(s).

The model codes are modified annually and yearly supplements are issued. Completely new editions of the codes are published every third year. Therefore, the code year is important in determining which code is applicable. The specific requirements are contained in the applicable code.

The National Fire Protection Associations (NFPA) and the International Code Council (ICC) can provide all of the major model building and fire codes:

National Fire Protection Association
1 Battery March Park
P.O. Box 9101
Quincy, MA 02169-7471
Phone: (800) 344-3555
http://www.nfpa.org/

International Code Council
Phone: (888) 422-7233
http://www.iccsafe.org/

12.6 KEY CANADIAN REGULATIONS

Transport Canada, The Transportation of Dangerous Goods Act and Regulations (published by and obtainable from the Department of Supply and Services, Canadian Government Publication Center, Ottawa, Ontario, Canada. http://www.tc.gc.ca/

WHMIS, Hazardous Products Act, Controlled Products Regulations (published by and obtainable from the Department of Supply and Services, Canadian Government Publication Center, Ottawa, Ontario, Canada

13. REFERENCES

The following sections provide detailed bibliographic information on the Chlorine Institute publications and other documents.

13.1 CHLORINE INSTITUTE REFERENCES

The following publications are specifically referenced in CI Pamphlet 17. The latest editions of CI publications may be obtained at http://www.chlorineinstitute.org.

Pamphlet & DVD #	Title
6	*Piping Systems for Dry Chlorine*, ed. 15; Pamphlet 6; The Chlorine Institute: Arlington, VA, **2005**.
57	*Emergency Shut-Off Systems for Bulk Transfer of Chlorine*, ed. 5-R1; Pamphlet 57; The Chlorine Institute: Arlington, VA, **2009**.
63	*First Aid, Medical Management / Surveillance and Occupational Hygiene Monitoring Practices for Chlorine*, ed. 7; Pamphlet 63; The Chlorine Institute: Arlington, VA, **2003**.
64	*Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities*, ed. 6-R1; Pamphlet 64; The Chlorine Institute: Arlington, VA, **2008**.
65	*Personal Protective Equipment for Chlor-Alkali Chemicals*, ed. 5; Pamphlet 65; The Chlorine Institute: Arlington, VA, **2008**.
66	*Recommended Practices for Handling Chlorine Tank Cars*, ed. 4-R1; Pamphlet 66; The Chlorine Institute: Arlington, VA, **2009**.
73	*Atmospheric Monitoring Equipment for Chlorine*, ed. 7; Pamphlet 73; The Chlorine Institute: Arlington, VA, **2003**.
74	*Guidance on Complying with EPA Requirements Under the Clean Air Act by Estimating the Area Affected by a Chlorine Release*, ed. 4-R1; Pamphlet 74; The Chlorine Institute: Arlington, VA, **2006**.
76	*Guidelines for the Safe Motor Vehicular Transportation of Chlorine Cylinders and Ton Containers*, ed. 4; Pamphlet 76; The Chlorine Institute: Arlington, VA, **2007**.
89	*Chlorine Scrubbing Systems*, ed. 3-R1; Pamphlet 89; The Chlorine Institute: Arlington, VA, **2008**.
95	*Gaskets for Chlorine Service*, ed. 4; Pamphlet 95; The Chlorine Institute: Arlington, VA, **2008**.

Pamphlet & DVD #	Title
100	*Dry Chlorine: Definitions and Analytical Issues*, ed. 3; Pamphlet 100; The Chlorine Institute: Arlington, VA, **2002**.
H-DVD	*Health Effects from Short-Term Chlorine Exposure;* H-DVD; The Chlorine Institute: Arlington, VA, **2006**.
Security	*Security Management Plan for the Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks;* The Chlorine Institute: Arlington, VA, **2003**.

13.2 OTHER REFERENCES

The following documents are specifically referenced in Pamphlet 17.

Industrial Ventilation: A Manual of Recommended Practice
American Conference of Governmental Industrial Hygienists
1330 Kemper Meadow Drive
Cincinnati OH 45240
http://www.acgih.org/

CGA Pamphlet C-1, Methods for Hydrostatic Testing of Compressed Gas Cylinders
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

CGA Pamphlet C-6, Standards for Visual Inspection of Steel Compressed Gas Cylinders
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

CGA Pamphlet P-1, Safe Handling of Compressed Gases in Containers
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

CGA Pamphlet S-1.1, Pressure Relief Device Standards - Part 1 - Cylinders for Compressed Gases
(Different editions of this pamphlet are referenced by DOT and OSHA regulations)
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

CGA Pamphlet V-1, Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections
(This pamphlet is also designated as ANSI B57.1 and CSA B96.)
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

CGA Pamphlet V-9, Standard for Compressed Gas Cylinder Valves
Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151
http://www.cganet.com/

13.3 OTHER RECOMMENDED READING AND VIEWING

The following Chlorine Institute pamphlets and other documents, though not specifically referenced in Pamphlet 17, may be of additional help to the reader. These CI documents as well as the complete CI catalog may be obtained at http://www.chlorineinstitute.org/.

Pamphlet & DVD #	Title
1	*Chlorine Basics* (Formerly *The Chlorine Manual*), ed. 7; Pamphlet 1; The Chlorine Institute: Arlington, VA, **2008**.
5	*Bulk Storage of Liquid Chlorine*, ed. 7; Pamphlet 5; The Chlorine Institute: Arlington, VA, **2005**.
9	*Chlorine Vaporizing Systems*, ed. 6; Pamphlet 9; The Chlorine Institute: Arlington, VA, **2002**.
49	*Recommended Practices for Handling Chlorine Bulk Highway Transports*, ed. 9; Pamphlet 49; The Chlorine Institute: Arlington, VA, **2009**.
82	*Recommendations for Using 100 and 150 Pound Chlorine Cylinders at Swimming Pools*, ed. 2; Pamphlet 82; The Chlorine Institute: Arlington, VA, **2008**.
85	*Recommendations for Prevention of Personnel Injuries for Chlorine Producer and User Facilities*, ed. 4; Pamphlet 85; The Chlorine Institute: Arlington, VA, **2005**.
87	*Recommended Practices for Handling Sodium Hydroxide Solution and Potassium Hydroxide Solution (Caustic) Tank Cars*, ed. 3; Pamphlet 87; The Chlorine Institute: Arlington, VA, **2005**.

Pamphlet & DVD #	Title
88	*Recommended Practices for Handling Sodium Hydroxide Solution and Potassium Hydroxide Solution (Caustic) Cargo Tanks*, ed. 2; Pamphlet 88; The Chlorine Institute: Arlington, VA, **2001**.
91	*Checklist for Chlorine Packaging Plants, Chlorine Distributors, and Tank Car Users of Chlorine*, ed. 3; Pamphlet 91; The Chlorine Institute: Arlington, VA, **2006**.
94	*Sodium Hydroxide Solution and Potassium Hydroxide Solution (Caustic): Storage Equipment and Piping Systems*, ed. 3; Pamphlet 94; The Chlorine Institute: Arlington, VA, **2007**.
96	*Sodium Hypochlorite Manual*, ed. 3-R1; Pamphlet 96; The Chlorine Institute: Arlington, VA, **2008**.
98	*Recommended Practices for Handling Hydrochloric Acid in Tank Cars*, ed. 3-R2; Pamphlet 98; The Chlorine Institute: Arlington, VA, **2007**.
152	*Safe Handling of Chlorine Containing Nitrogen Trichloride*, ed. 2; Pamphlet 152; The Chlorine Institute: Arlington, VA, **2005**.
155	*Water and Wastewater Operators Chlorine Handbook*, ed. 2; Pamphlet 155; The Chlorine Institute: Arlington, VA, **2008**.
162	*Generic Risk Management Plan for Chlorine Pkg Plants & Sodium Hypochlorite Production Facilities*, ed. 2-R1; Pamphlet 162; The Chlorine Institute: Arlington, VA, **2004**.
163	*Hydrochloric Acid Storage and Piping Systems*, ed. 2; Pamphlet 163; The Chlorine Institute: Arlington, VA, **2006**.
164	*Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials*, ed. 2; Pamphlet 164; The Chlorine Institute: Arlington, VA, **2007**.
167	*Learning From Experience*, ed. 1; Pamphlet 167; The Chlorine Institute: Arlington, VA, **2002**.
IB/A	*Instruction Booklet: Chlorine Institute Emergency Kit A for 100-lb and 150-lb Chlorine Cylinders*, IB/A; The Chlorine Institute: Arlington, VA, **2009**.
IB/B	*Instruction Booklet: Chlorine Institute Emergency Kit B for Chlorine Ton Containers*, IB/B; The Chlorine Institute: Arlington, VA, **2009**.
IB/C	*Instruction Booklet: Chlorine Institute Emergency Kit C for Chlorine Tank Cars and Tank Trucks*, IB/C; The Chlorine Institute: Arlington, VA, **2009**.

Pamphlet & DVD #	Title
IB/RV	*Instruction Booklet: Chlorine Institute Recovery Vessel for 100-lb and 150-lb Chlorine Cylinders*, IB/RV; The Chlorine Institute: Arlington, VA, **2009**.
P-DVD	*Packager Training Program*, P-DVD; The Chlorine Institute: Arlington, VA, **2001**.
WC-1	*Wall Chart: Handling Chlorine Cylinders and Ton Containers*, WC-1; The Chlorine Institute: Arlington, VA, **2001**.
W-DVD	*Chlorine Safety for Water and Wastewater Operators*, W-DVD; The Chlorine Institute: Arlington, VA, **2009**.

APPENDIX A

PERFORMANCE CRITERIA FOR NEW CHLORINE CYLINDER AND TON CONTAINER VALVES May 22, 2008

Performance Criteria	Supplemental Information and Notes
A. PERFORMANCE	
1. Flow - Minimum C_v	
Cylinder 0.7 Ton Container 0.85 (at 360° open) 1.2 (at full open)	Cylinder charging and discharge rates and evacuation times are affected by the flow capacity of the cylinder valve. Determine C_v of valve by flow test and formula per CGA Pamphlet V-1. See CGA Pamphlet V-9 for qualifying test and qualifying test sample.
2. Operating Temperature	
No visual evidence of leakage, deformation or damage after two opening/closing cycles	See CGA Pamphlet V-9 for low/high temperature operation test.
3. Storage Temperature	
No visual evidence of leakage, deformation or damage after two opening/closing cycles.	See CGA Pamphlet V-9 for low/high temperature storage test.
4. Leakage	
Leak integrity should be demonstrated by using procedures and meeting the standards as specified in CGA Pamphlet V-9.	
5. Proof Pressure	
Proof pressure should be demonstrated by using procedures and meeting the standards as specified in CGA V-9.	

[1] CGA V-9: Compressed Gas Association Standard for Compressed Gas Cylinder Valves

Performance Criteria	Supplemental Information and Notes
6. Burst Pressure	
Burst pressure should be demonstrated by using procedures and meeting the standards as specified in CGA V-9.	
7. Endurance	
Endurance should be demonstrated by using procedures and meeting the standards as specified in CGA V-9.	
8. Maximum Opening/Closing Torque	
<u>Test</u> <u>Inch-lbs</u> Maximum Opening Torque 150 Maximum Closing Torque 150 Over Torque 300	Maximum opening and closing torque should be demonstrated by using procedures and meeting the standards as specified in CGA Pamphlet V-9.
B. DESIGN	
1. Valve Inlet Connection	
Cylinder valve inlet connection should be in conformance with one of the ¾-14NGT(CL) thread series in Federal Standard H28 and CGA Pamphlet V-1. Ton container valve inlet connection should be in conformance with one of the ¾-14NGT(CL) thread series in Federal Standard H28 and CGA Pamphlet V-1 or with one of the 1-11½NGT(CL) thread series in the following table:	To accommodate cylinder or ton container thread wear, oversize threads can be used (e.g. ¾-14NGT(CL)-2 through ¾-14NGT(CL)-5 threads). See CI Pamphlet 17, Sections 3 and 4, for more information related to valve inlet connections and thread sizes.

Performance Criteria	Supplemental Information and Notes

INLET THREAD DIMENSIONS, VALVE BODY	1-11 ½NGT(CL)-X (X=1,2,3,4, OR 5)				
	SIZE 1	SIZE 2	SIZE 3	SIZE 4	SIZE 5
SMALL END - MAJOR DIA.	1.2832	1.3049	1.3294	1.3592	1.4352
SMALL END - PITCH DIA.	1.2136	1.2353	1.2598	1.2896	1.3656
SMALL END 45° CHAMFER (MIN. DIA.)	1.1250	1.1467	1.1712	1.2010	1.2770
FULL EFFECTIVE THREADS PITCH DIA.	1.2712	1.2929	1.3174	1.3472	1.4232
LARGE END - MAJOR DIA. APPROX.	1.3457	1.3674	1.3919	1.4217	1.4977
HAND TIGHT ENGAGEMENT (NOMINAL)	0.4000				
FULL EFFECTIVE THD. LENGTH (ALL SIZES)	0.9217 (10.6 THREADS)				
OVERALL THREAD LENGTH (ALL SIZES)	1.0000				

2. Valve Outlet Connection

Performance Criteria	Supplemental Information and Notes
Valve outlet connection should be in conformance with CGA 820 or CGA 820C.	See CGA Pamphlet V-1 and CI Illustrations 131 and 189.

3. Operation

a. Minimum Torque to Failure

Performance Criteria	Supplemental Information and Notes
The valve and stem must withstand a minimum closing torque of 900 in-lbs without structural failure.	See CGA Pamphlet V-9 torque testing guidelines.

b. Valve Stem Wrench Connection

Performance Criteria	Supplemental Information and Notes
The valve stem must have a ⅜ inch wrench square.	This will allow the use of current wrenches for opening and closing the valve. Handles to be avoided so as not to interfere with attached hardware and safety closure operations.

c. Open Position of Valve Stem

Performance Criteria	Supplemental Information and Notes
Stem travel height should be limited to $^1/_8$ inch for the 360° rotation.	

224 of 593

Performance Criteria	Supplemental Information and Notes
d. Maximum Dimension of Outlet to Valve Stem End	
1. Maximum dimension from "centerline of valve outlet" to "end of valve stem" when at minimum C_v to be 2.835".	Additional distance from centerline to stem end will interfere with some dispensing equipment and prevent access with valve wrench.
2. Maximum width of valve at centerline of outlet to be 1.125".	Additional width will interfere with discharge hardware and controls.
4. Maintenance/Replacement of Parts	
Design to provide for ease of maintenance and replacement of parts.	Recommend that maintenance be done in accordance with CGA Pamphlet V-9. This refers to the component parts that form the pressure boundary between the wetted and non-wetted parts of the valve. Included are such components as bonnets, packing nuts, packing, washers, diaphragms, o-rings, packing rings and packing followers. The design of the valve closure systems should provide for easy maintenance and replacement of parts.
5. Pressure Relief Devices - Fusible Plug	
Melt temperature: Cylinders 150°F to 158°F Ton Containers 150°F to 165°F Where required, pressure relief devices for gases must be incorporated in the valve in accordance with CGA Pamphlet S-1.1.	See CGA Pamphlet S-1.1 for container fusible plug requirements.

Performance Criteria	Supplemental Information and Notes
6. Materials	
Valve must be chemically compatible with dry chlorine gas and liquid. Valve must be able to meet all engineering requirements.	The following materials have been used successfully in the chlorine industry; however, it is not inclusive of all materials that may be qualified for this application. • Aluminum Silicon Bronze, C64210 • Naval Brass, C48500, C46400, C48200 • Brass, C36000 - in non-wetted areas only • Monel, UNS N04400 • Teflon®, Virgin PTFE • Garlock 6130 Sample testing should be done to determine susceptibility to stress corrosion cracking. Examples of appropriate test standards for copper alloy parts are: • ASTM B858 Standard Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys • ASTM B154 Standard Test Method for Mercurous Nitrate Test for Copper Alloys • ISO 6957 Copper Alloys - Ammonia Test for Stress Corrosion Resistance For definition of dry chlorine reference CI Pamphlet 100 - *Dry Chlorine: Definitions and Analytical Issues.* Reference CGA Pamphlet V-9. Reference CI Pamphlet 164 – *Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Metals* – This pamphlet should be used only for an initial review. Designers should reference other sources for final design criteria.
7. Markings	
a. General	
Mark as per CGA Pamphlet V-9.	

Performance Criteria	Supplemental Information and Notes
b. Inlet Thread Size	
To indicate (CL)- size. Markings for oversize inlet threads should be as follows: 1. Standard size threads shall be marked (CL)-1. 2. Oversize Inlets that are 4 threads oversized should be marked (CL)-2. 3. Oversize Inlets that are 8-½ threads oversized should be marked (CL)-3. 4. Oversize Inlets that are 14 threads oversized should be marked (CL)-4. 5. Oversize Inlets that are 28 threads oversized should be marked (CL)-5. Other oversize inlets should be marked accordingly.	See Federal Standard H-28/9 or CGA Pamphlet V-1 for marking specifications.
c. Other Markings	
At manufacturer's discretion.	At the manufacturer's or user's discretion, additional markings may be used where in their judgment such markings have beneficial value. Marking to identify oversize threads is required.
8. Leak Testing of Valves	
Demonstration of no leaks with valve pressurized open (outlet capped) or closed at 500 psig for one minute.	See CGA Pamphlet V-9. Each lot of production valves should be tested for leak integrity. See table in CGA Pamphlet V-9 on minimum test pressures for valves with relief device on the valve.

Performance Criteria	Supplemental Information and Notes
C. ADDITIONAL CRITERIA FOR CHLORINE CYLINDER AND TON CONTAINER VALVES	
1. Valves must be compatible with Chlorine Institute open and closed yokes with adaptors (See CI Illustrations 130, 131, and 189).	See CGA Pamphlet V-9.
2. The valve outlet cap must provide a pressure seal.	
3. Cylinder valves must fit under current cylinder protective hoods.	
4. Cylinder valves must be compatible with Chlorine Institute Emergency Kit A hood devices.	Valve designs found to be not compatible with the current Emergency Kit A or B should be brought to the attention of the Institute.
5. Ton container valves must be compatible with Chlorine Institute Emergency Kit B hood devices.	
6. Valves must have interchangeable parts within a specific manufacturer's valve designs.	

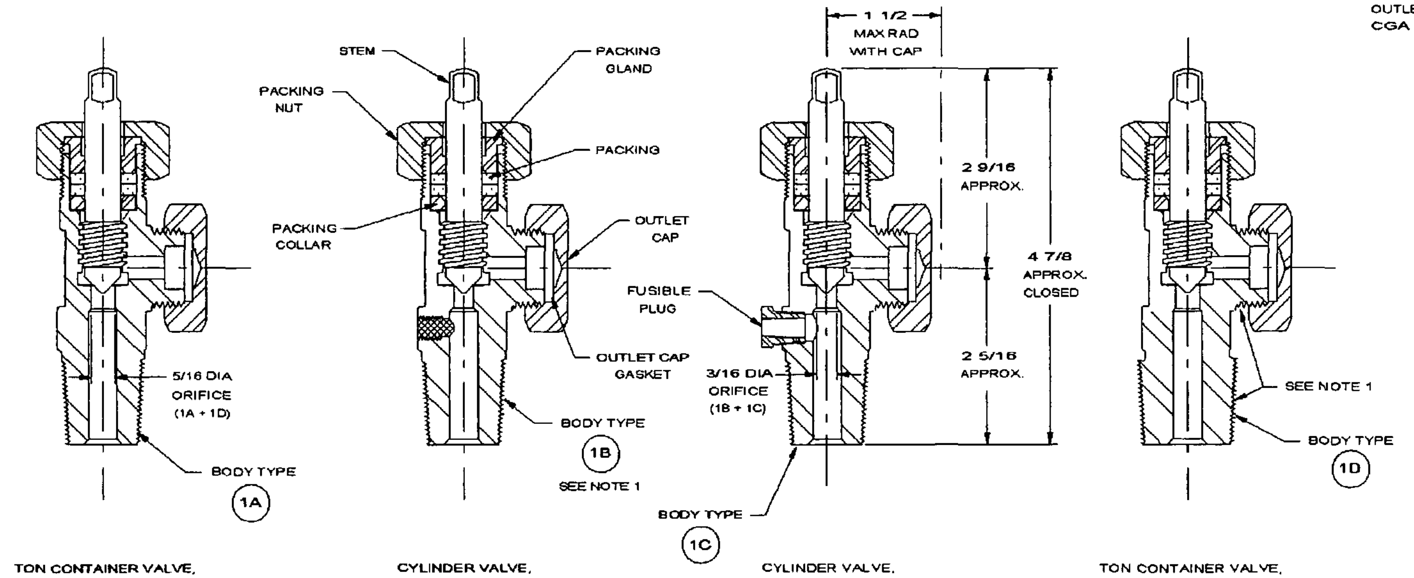
APPENDIX B

ILLUSTRATIONS

All dimensions are for example purposes only

NOTES:

1. INLET AND OUTLET DIMENSIONS CONFORM TO ANSI/CSA/CGA V-1. OUTLETS CONFORM TO CONNECTION CGA 820, 1.030-14 NGO-RH-EXT.



TON CONTAINER VALVE, NO FUSIBLE PLUG

INLET 3/4 NGT (CL)

CYLINDER VALVE, POURED FUSIBLE PLUG

INLET 3/4 NGT (CL)

CYLINDER VALVE, REMOVABLE FUSIBLE PLUG

INLET 3/4 NGT (CL)

TON CONTAINER VALVE, NO FUSIBLE PLUG

INLET 1-11 1/2 NGT (CL)

1A TON CONTAINER VALVE (NO TAP)

1B CYLINDER VALVE (POURED PLUG, TAP 5/16-18 NC-1)

1C CYLINDER VALVE (REMOVABLE PLUG, TAP 1/8-27 NGT)

1D TON CONTAINER (NO TAP)

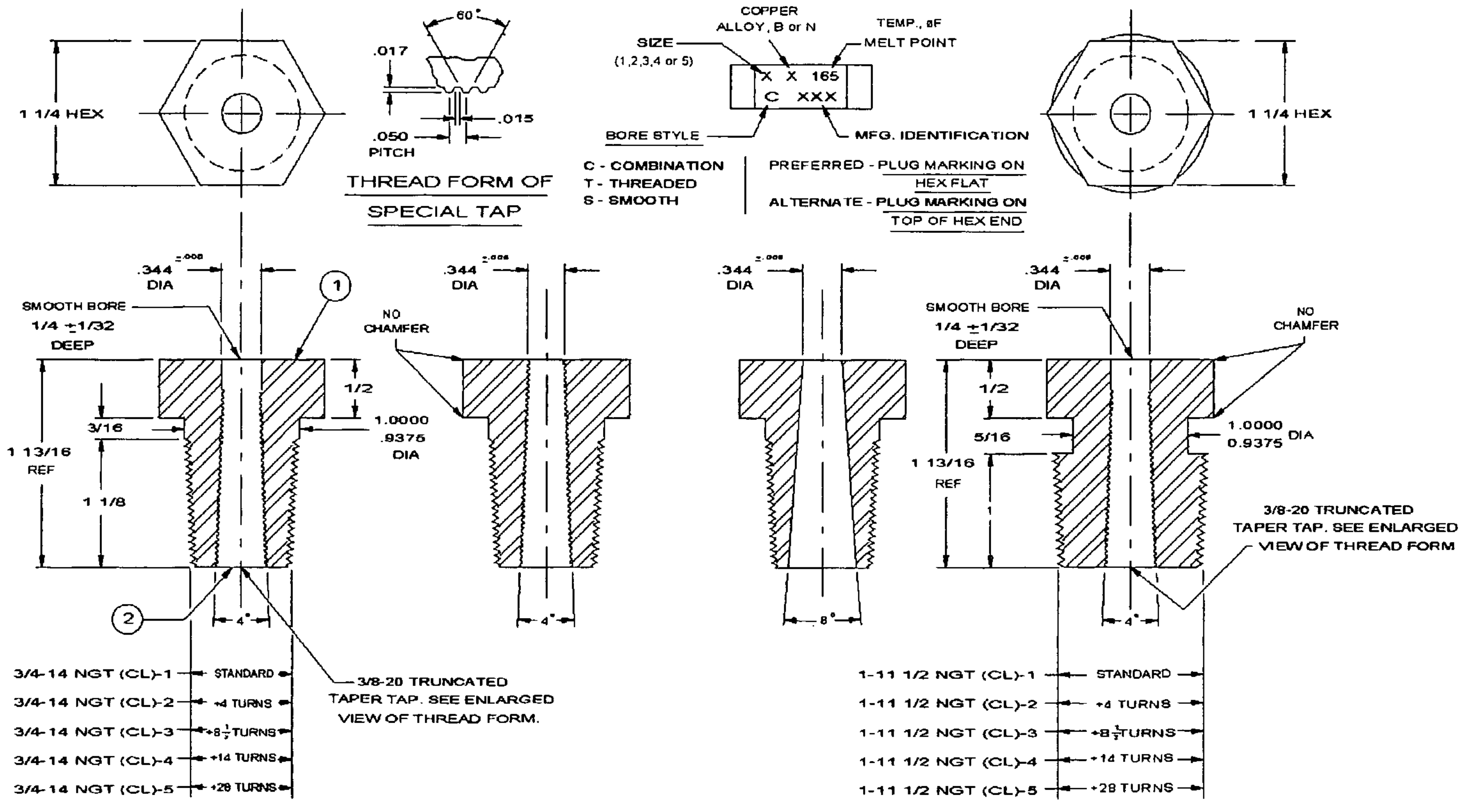
EXAMPLE OF:
VALVES FOR CHLORINE CYLINDERS AND TON CONTAINERS ASSEMBLIES

ILLUSTRATION 110 ISSUE 5

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

All dimensions are for example purposes only.

ITEM	NAME OF PART
1	FUSIBLE PLUG BODY
2	FUSIBLE ALLOY



STANDARD COMBINATION BORE (C)
3/4-14 NGT (CL)
(SEE NOTE 1)

ALTERNATE
THREADED BORE (T)

ALTERNATE
SMOOTH BORE (S)

STANDARD COMBINATION BORE (C)
1"-11 1/2 NGT;
THREADED (T) AND SMOOTH BORE (S) STYLES, STILL IN USE.

EXAMPLE OF:
3/4 AND 1 INCH FUSIBLE PLUGS FOR CHLORINE TON CONTAINERS

ILLUSTRATION 111 | ISSUE 8

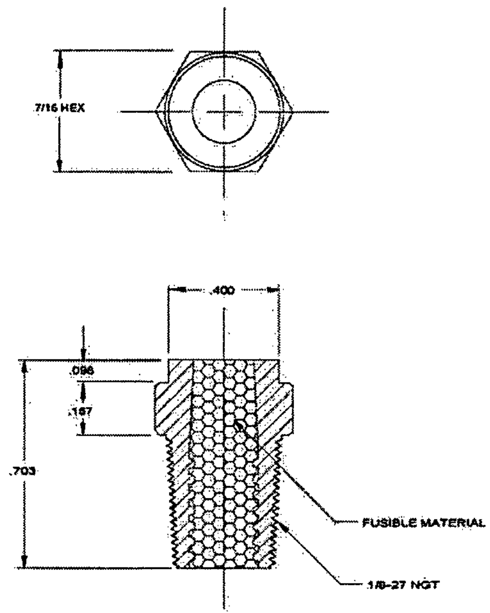
The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

NOTES:

1. This new style fusible plug may be visually identified by the presence of the 0.098" high cylindrical section which extends above the hex nut portion of the plug. Old style fusible plugs with a different melt range do not have the extended section.

2. New style fusible plugs also possess markings that identify the plug maximum melt temperature. This and other markings may be found on the side or the top of the cylindrical section which extends above the hex portion of the plug.

All dimensions are for example purposes only.



158°FUSE PLUG FOR CHLORINE CYLINDER VALVE

1/8-27 NGT-MOD

EXAMPLE OF:

1/8" FUSIBLE PLUG

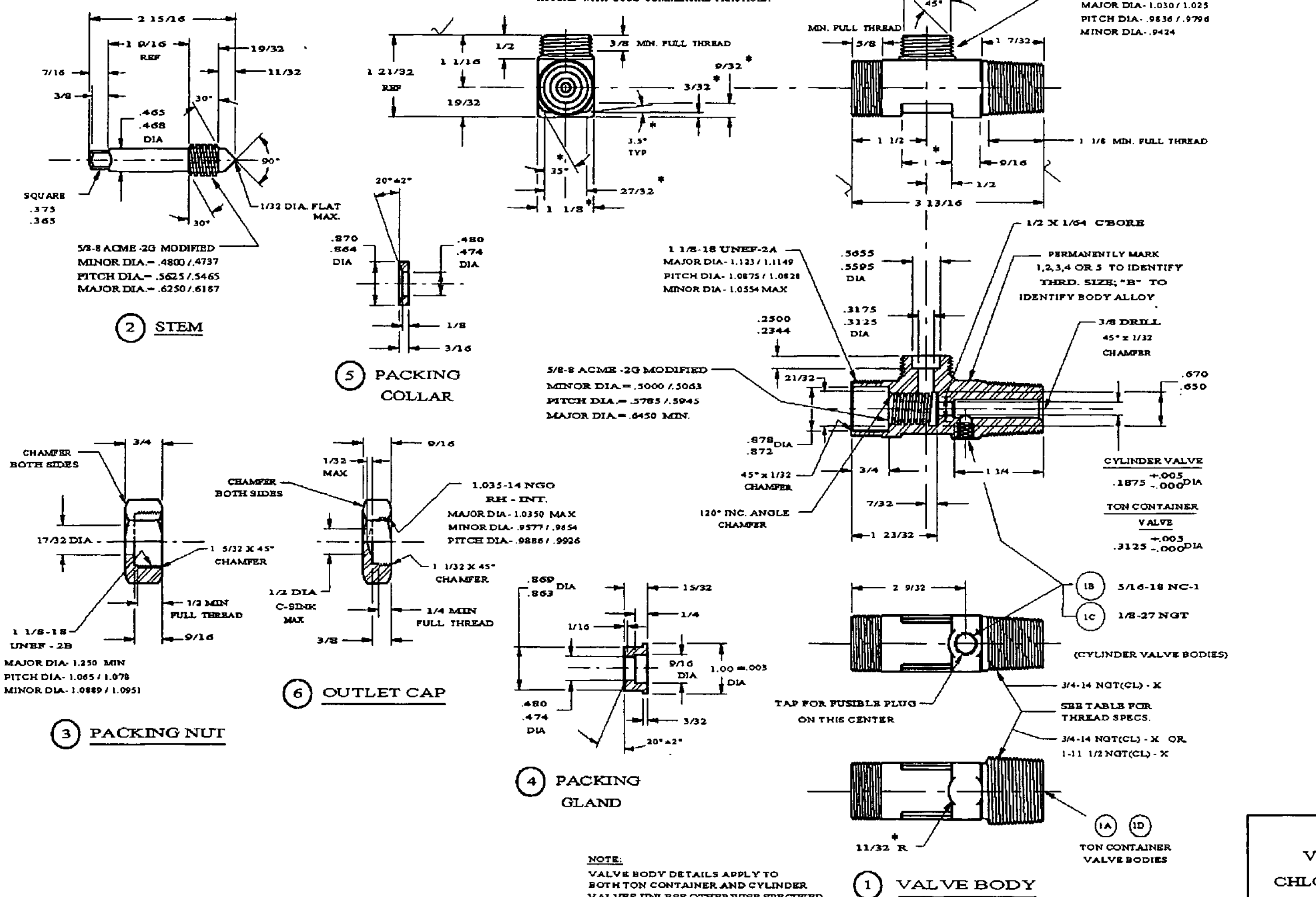
FOR CHLORINE CYLINDER VALVE

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

ILLUSTRATION: 112 ISSUE: 1

231 of 593

All dimensions are for example purposes only.



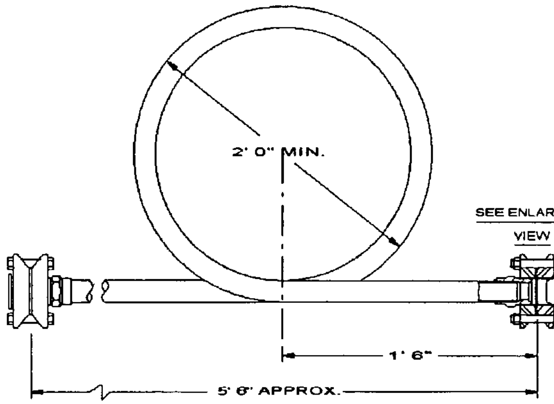
ITEM	NAME OF PART
1A	TON CONTAINER VALVE BODY 3/4-14 NGT
1B	CYLINDER VALVE BODY (POURED PLUG)
1C	CYLINDER VALVE BODY (REMOVABLE PLUG)
1D	TON CONTAINER VALVE BODY 1-11 1/2 NGT
2	STEM
3	PACKING NUT (1-1/4 HEX)
4	PACKING GLAND
5	PACKING COLLAR
	PACKING
6	OUTLET CAP (1-1/4 HEX)
	OUTLET CAP GASKET ALT. 1 ALT. 2
	FUSIBLE PLUG ASSY. (STANDARD)
	FUSIBLE PLUG ASSY. (ALTERNATE)

EXAMPLE OF:
VALVE DETAILS FOR CHLORINE CYLINDERS AND TON CONTAINERS

ILLUSTRATION 113 ISSUE 9

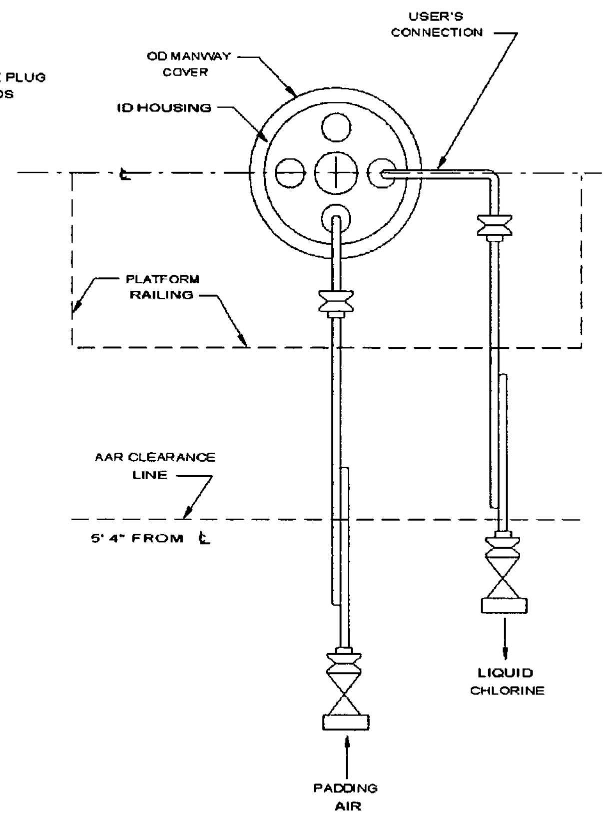
The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

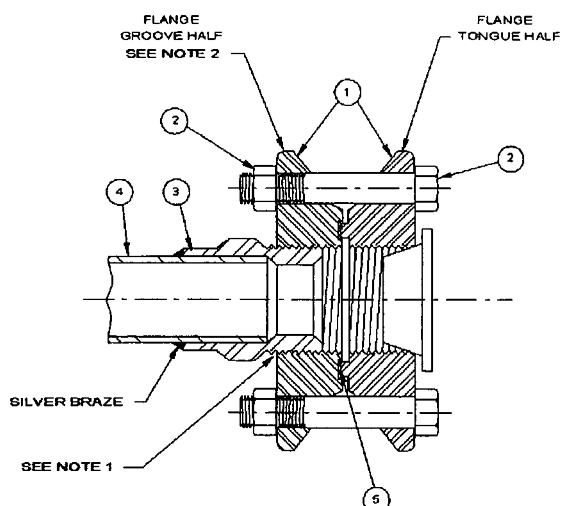
All dimensions are for example purposes only.



TESTING

HYDROSTATIC TEST AT 600 PSIG AND DRY THOROUGHLY.





ENLARGED VIEW

ITEM	NAME OF PART
1	TWO BOLT OVAL FLANGED UNION TYPE 1500# 1" NPT FEM THD (NOTE 4)
2	BOLTS & NUTS, HVY HEX, BOLTS PER ANSI B18.2.1 NUTS PER ANSI B18.2.2 THREADS PER ANSI B1.1 CLASS 2A & 2B FIT, BOLT DIA. & LENGTH TO SUIT FLANGES.
3	ADAPTER, SOLDER JOINT, PER ANSI B16.22; 1 1/8 OD TUBE TO 1" NPT MALE
4	TUBING,TYPE K, ANNEALED SIZE PER ANSI H 23.1 (1 1/8 OD x .065 WALL)
5	GASKET, ASBESTOS COMPOSITION OR 2% TO 4% ANTIMONY LEAD. DIMENSIONS TO SUIT FLANGES

NOTES:

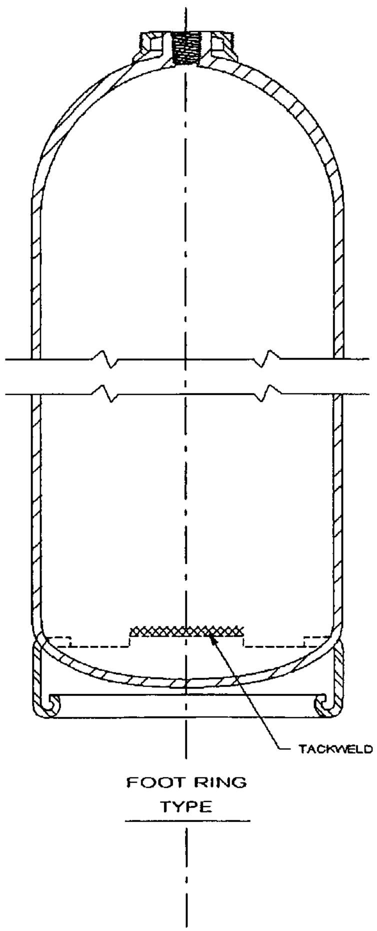
1. USE LITHARGE AND GLYCERINE OR WHITE LEAD PASTE ON PIPE THREADS.
2. ASSEMBLE THE GROOVE HALF OF THE FLANGE TO THE ADAPTER-BOTH ENDS.

EXAMPLE OF:
CHLORINE TANK CAR
UNLOADING
CONNECTION

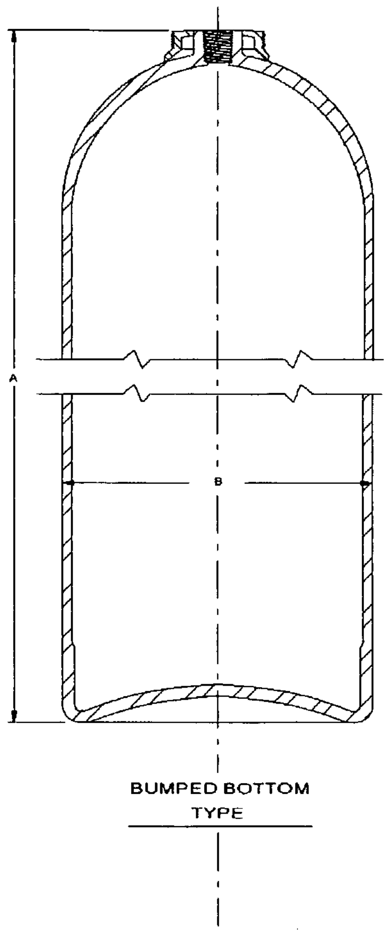
ILLUSTRATION 118 ISSUE 5

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

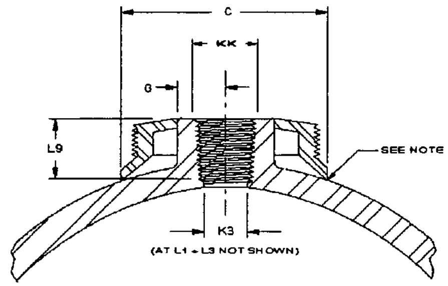
All dimensions are for example purposes only.



FOOT RING TYPE



BUMPED BOTTOM TYPE



ENLARGED VIEW OF NECK RING

NOTES:

1. NECK RINGS MUST BE SECURED BY PEENING OR WELDING.
2. THE 3/4"-NGT (CL)-1 THREAD SHALL CONFORM WITH ANSI B57.1 (CGA PAMPHLET V-1). LIMITS ON SIZE OF INTERNAL THREADS SHALL BE PLUS OR MINUS ONE TURN ALTHOUGH PREFERRED WORKING LIMITS ARE PLUS OR MINUS 1/2 TURN.
3. LIMITS ON TAPER OF 3/4"-NGT(CL)-1 THREAD SHALL BE PLUS ONE TURN MINUS ZERO TURNS.

	DIMENSIONS		MIN.	NOMINAL	MAX.
A	HEIGHT-	100# LONG	47	-	49 1/2
		100# SHORT	33	-	36
		150#	47	-	49 1/2
B	O.D.-	100# LONG	8 1/4	-	8 1/2
		100# SHORT	10 1/4	-	10 1/2
		150#	10 1/4	-	10 1/2
C	O.D.-	NECK RING	3 1/2	-	4 3/8
KK	COUNTERSINK DIA.		-	-	1 1/16
E1	PITCH DIA. AT FACE		-	0.8889	-
G	NECK RADIUS		11/16	-	-
K3	BORE AT FULL THD.		-	-	0.8972
L9	FULL ROOT LENGTH		0.9461	-	-
	INTERNAL THREAD		3/4"-NGT (CL)-1		
	EXTERNAL THREAD		3 1/8"-7NS-1A		

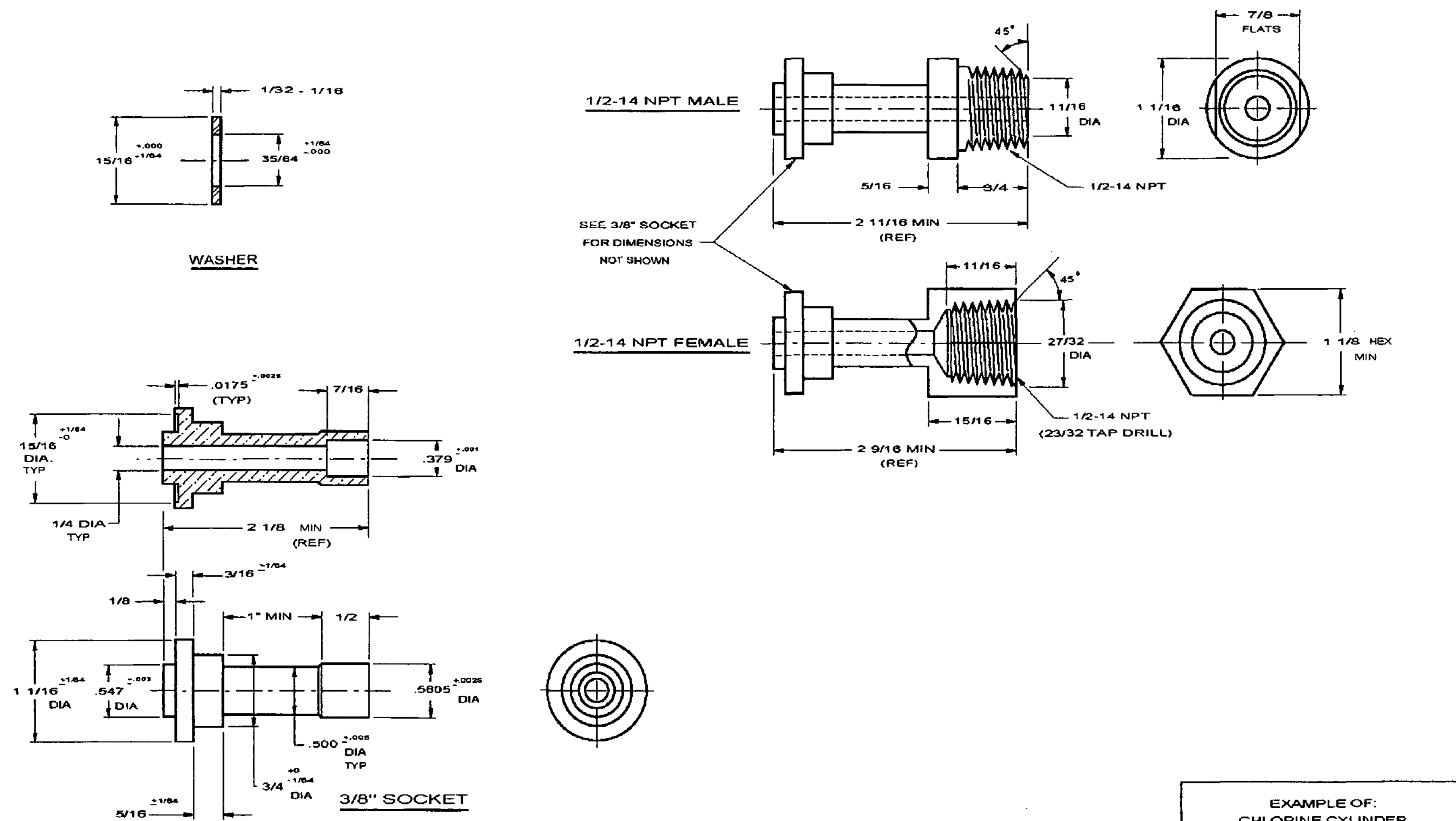
EXAMPLE OF:

LIMITING DIMENSIONS FOR CHLORINE CYLINDERS

ILLUSTRATION 121 | ISSUE 5

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

All dimensions are for example purposes only.

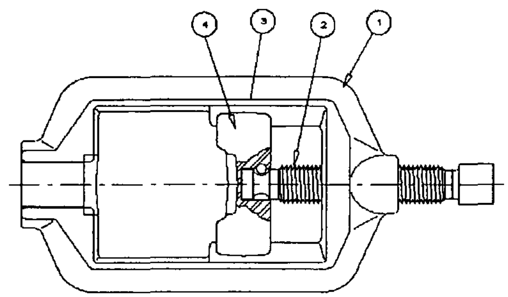


EXAMPLE OF:
CHLORINE CYLINDER
AND TON CONTAINER VALVE
YOKE ADAPTERS

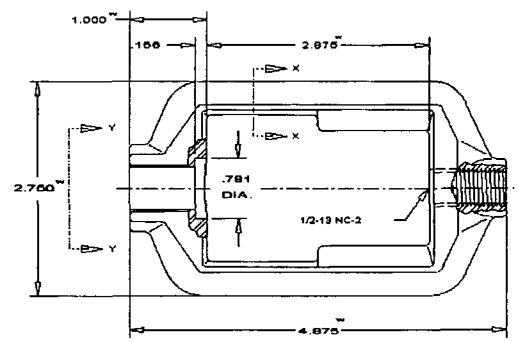
The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.	ILLUSTRATION 130	ISSUE 6

All dimensions are for example purposes only.

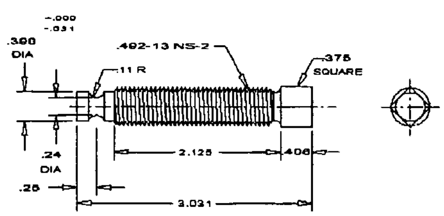
ITEM	NAME OF PART
1	BODY
2	SCREW
3	YOKE FOLLOWER
4	FOLLOWER PIN



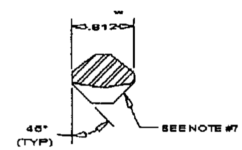
YOKE ASSEMBLY



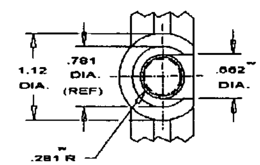
1 BODY



2 SCREW



SECTION X-X



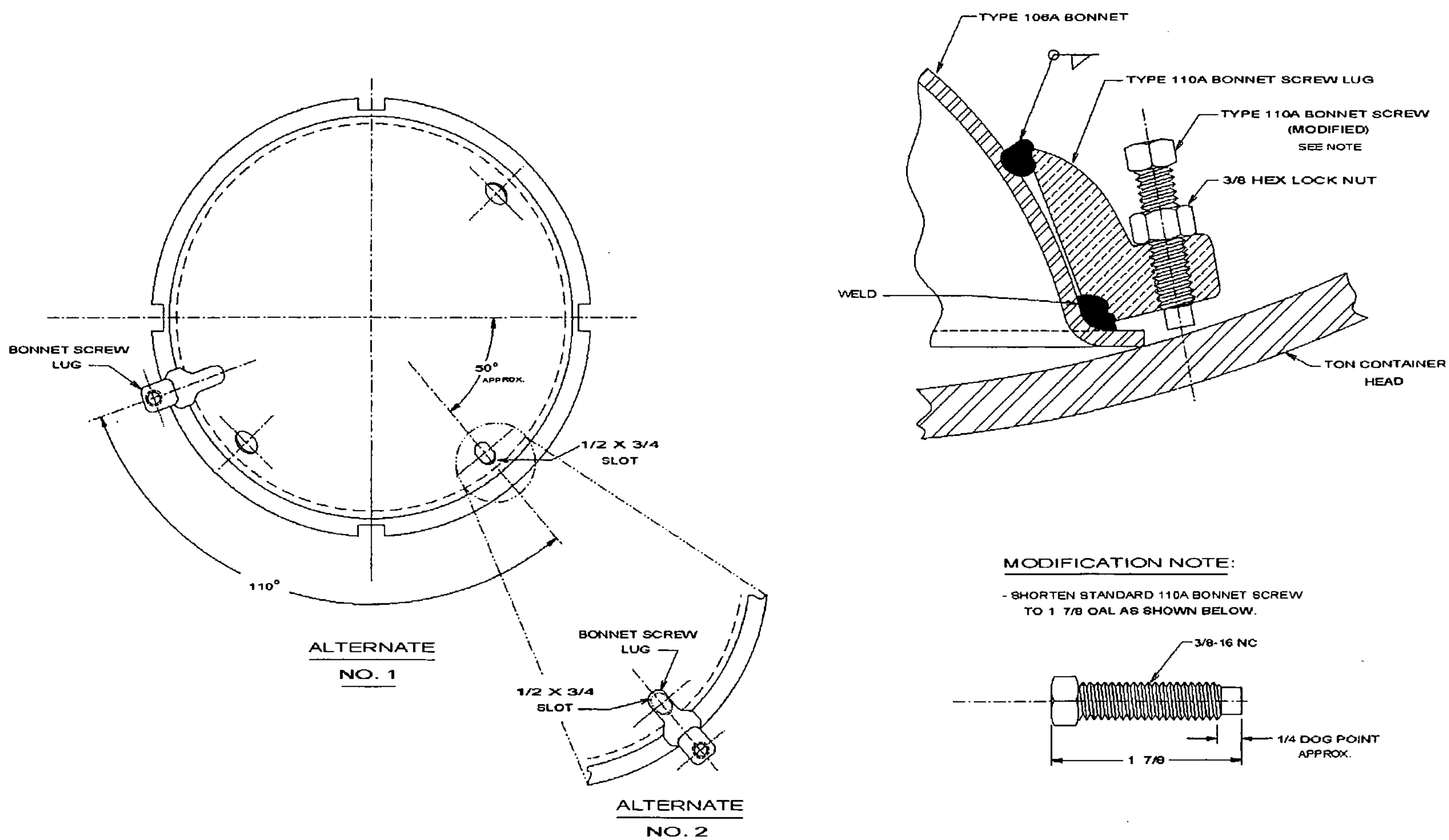
SECTION Y-Y

EXAMPLE OF:
CHLORINE CYLINDER
VALVE YOKE

ILLUSTRATION	ISSUE
131	5

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

All dimensions are for example purposes only.



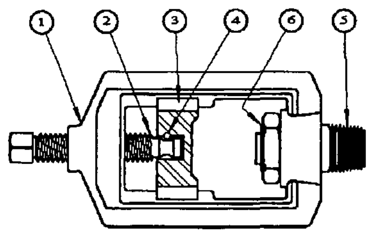
EXAMPLE OF:
A LOCKING LUG ARRANGEMENT
FOR VALVE PROTECTIVE HOUSING
ON TON CONTAINERS

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

ILLUSTRATION 182 ISSUE 4

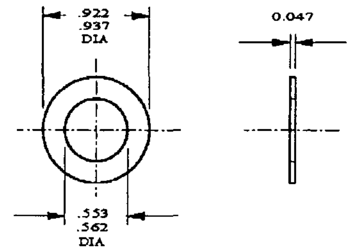
All dimensions are for example purposes only.

ITEM	NAME OF PART
1	BODY
2	SCREW
3	YOKE FOLLOWER
4	FOLLOWER PIN
5	NIPPLE
6	GASKET

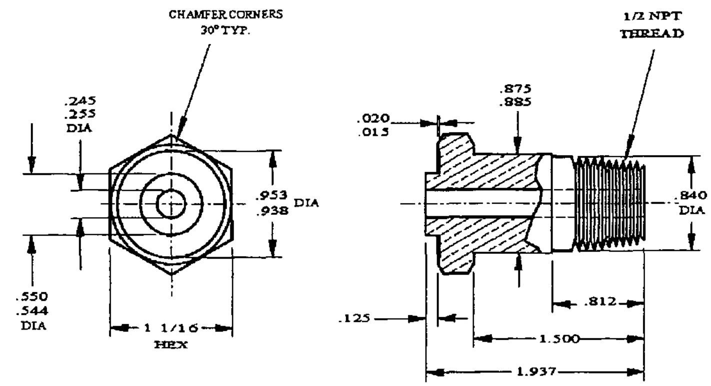


YOKE ASSEMBLY WITH NIPPLE

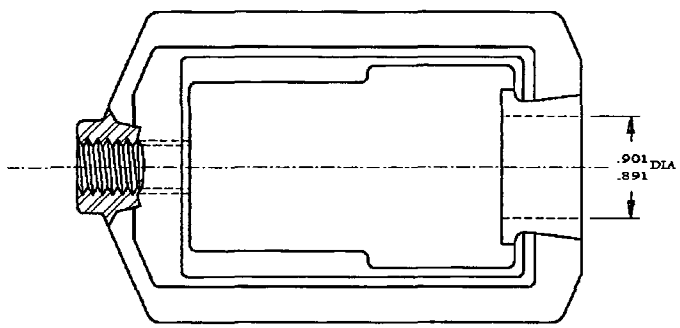
(1/2 SCALE)



6 GASKET



5 NIPPLE



SEE ILLUSTRATION 131 FOR ADDITIONAL INFORMATION

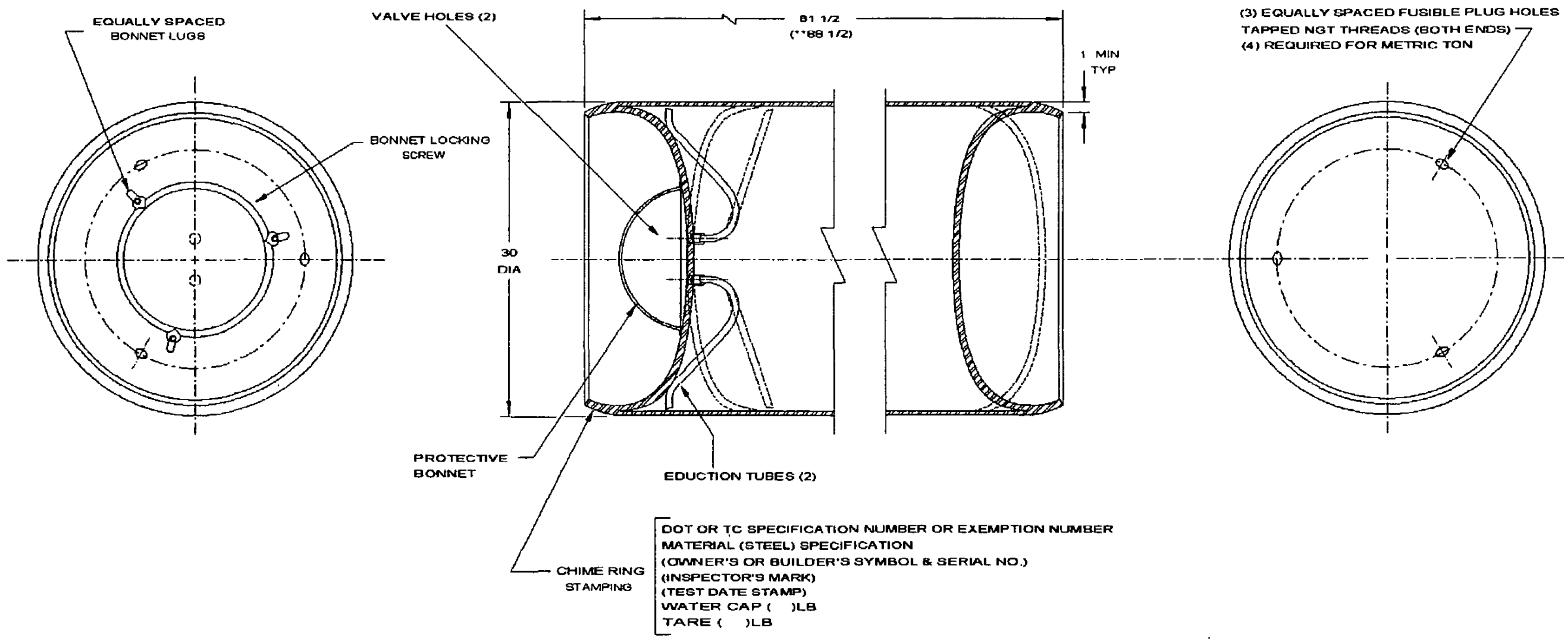
1 BODY

EXAMPLE OF:
CLOSED YOKE
CHLORINE CONTAINER
VALVE

ILLUSTRATION 189 | ISSUE 3

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

All dimensions are for example purposes only.



WATER CAPACITY AND WEIGHT

- WATER CAPACITY = 1600 LB. (**1764 LB) MINIMUM
- AVERAGE WEIGHT = 1375-1400 LB. (**1475 LB) INCLUDING WEIGHT OF VALVES & FUSIBLE PLUGS.

COMMODITY CAPACITY

- LIQUID CHLORINE CAPACITY = 2000 LB = 1 TON (**2204 LB) AT U.S. STANDARD FILLING DENSITY OF 125 PERCENT.
- FOR CAPACITY AND FILLING DENSITY OF OTHER U.S. AUTHORIZED LIQUIDS AND GASES SEE U.S. DEPARTMENT OF TRANSPORTATION HAZARDOUS MATERIALS REGULATIONS.

NOTE:

1. TARE WEIGHT INCLUDES WEIGHT OF EMPTY CONTAINER VALVES AND FUSIBLE PLUGS. DOES NOT INCLUDE WEIGHT OF VALVE PROTECTIVE BONNET.
2. CHLORINE TON CONTAINERS ARE BUILT TO U.S. DEPARTMENT OF TRANSPORTATION SPECIFICATIONS, DOT EXEMPTION OR THE EQUIVALENT TRANSPORT CANADA REGULATIONS.
3. **APPLIES TO METRIC TON CONTAINERES.
4. DOTTED LINE DENOTES ALTERNATE DESIGN.

EXAMPLE OF:
CHLORINE
TON CONTAINER

The purpose of this illustration is to show key features only. It is not intended to serve as a standard design nor should it be used for fabrication in any way.

ILLUSTRATION 197 | ISSUE 2

239 of 593

APPENDIX C

RECOMMENDED INSPECTION PROCEDURES CHLORINE CYLINDER AND TON CONTAINER VALVES

This document was prepared to add an extra level of safety for the users of chlorine cylinders and ton containers.

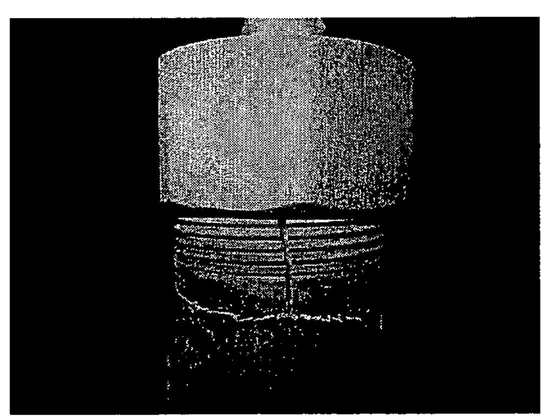
Although not common, there have been reports of cracks in both cylinder and ton container valves, most often in the area of the packing nut threads. Leaks, if any, will stop once the valve is closed. Normally, when the valve is open, leaks through the cracks are unlikely because they are sealed by the packing. On rare occasions, cracks have also been found elsewhere in the valve body and the packing nuts. Crack inspection should therefore cover the entire valve body.

Valves should be inspected each time before they are opened or reopened.

1. The cracks (See photos below) have been found running longitudinally through the threads by the packing nut (this is the nut that the valve stem passes through) as well as the valve body threads below and under the packing nut. The crack may vary from fractions of a millimeter up to 30 millimeters in length. In some instances, a second crack appears perpendicular to this crack about 10 to 30 millimeters below the bottom packing thread. One such crack covered a distance of about 120 degrees around the valve body. Longitudinal and transverse cracks may range from barely visible in length and depth to easily visible cracks over an inch long. If any cracks are found, separate and tag the cylinder or ton container. **Do not open the valve!**

2. If no cracks are found, you can connect to the container valve and by following CI recommended procedures, open the valve. A careful check using only the vapors from a 26° Baumé ammonia water (ammonium hydroxide solution) will produce a visible white gas if there is a leak. If a leak is found, close the valve and contact your chlorine supplier immediately.

3. If using ton container valves on manifolds or in chlorine headers, inspect the valve every time chlorine containers are changed. If a crack is found, close the valve and contact your equipment supplier immediately for instructions.



APPENDIX D

FUSIBLE PLUG DISCUSSION

At the Chlorine Institute's April 2008 Annual Meeting a concern was raised to the Transportation Issue Team regarding the recommended melt temperature (158°F - 165°F) of fusible plugs. The concern questioned if at these temperatures there was adequate expansion capacity within a ton container or cylinder to retain the expanded liquid volume of chlorine without rupture. A task group (Fusible Plug Task Group) was chartered to review the matter and make recommendations to the Issue Team.

Key Findings and Task Group Decision Points

- No cylinder or ton rupture could be definitely identified as having resulted from the melt temperature of a fusible plug.
- Calculations demonstrate that for both cylinders and tons (at nominal capacities), at temperatures above approximately 155° F, there is not adequate container capacity to retain the prescribed fill weight of chlorine.
- In working with the primary ton container manufacturer it was determined that the heads of ton containers are designed as expansion space through deformation.
- Utilizing the expansion capacity designed into the heads of ton containers there is adequate expansion capacity at 165°F.
- Norris Cylinder, the primary cylinder provider, reviewed recent cylinder builds and determined that there is significant capacity beyond nominal, which would provide for an additional expansion volume.
- The Task Group agreed that it was not reasonable to consider average capacity beyond nominal because there was no assurance that all cylinders in service are beyond nominal volume.
- Norris conducted normal hydrostatic testing on a cylinder to 3000 psi and reported on the expansion which occurs.
- The Task Group agreed that the use of this additional capacity over the nominal in determining the appropriate upper limit of the fusible plug melt temperature was safe and reasonable. By utilizing this additional volume it was determined that a cylinder at nominal capacity has adequate expansion capacity to 158° F.
- The Task Group considered alternatives and agreed that the most reasonable change is to the fusible plug melt recommendation for a cylinder.
- A concern was raised regarding the lower limit and after discussion the Task Group agreed that at 150° F unintended releases due to extreme environmental temperatures should not be a concern. This temperature was therefore selected as the lower limit.
- The Task Group further agreed that the lower limit of fusible plug material should be applicable to both the material for tons and cylinders.

- The Task Group agreed that by leaving the ton container fusible plug upper melt temperature limit as it is and opening the lower limit it was thought that this would provide maximum flexibility consistent with safety.

- Inquires were made to three manufacturers of plugs. At least one manufacturer identified material/alloys that would meet the new recommendation.

- Discussion on the time required to convert plug production were inconclusive but one manufacturer suggested that new plugs could be available by the end of the 2009 calendar year.

Task Group Recommendations

- Melt temperature for cylinder valve fusible plugs to be revised to 150° F - 158°F.

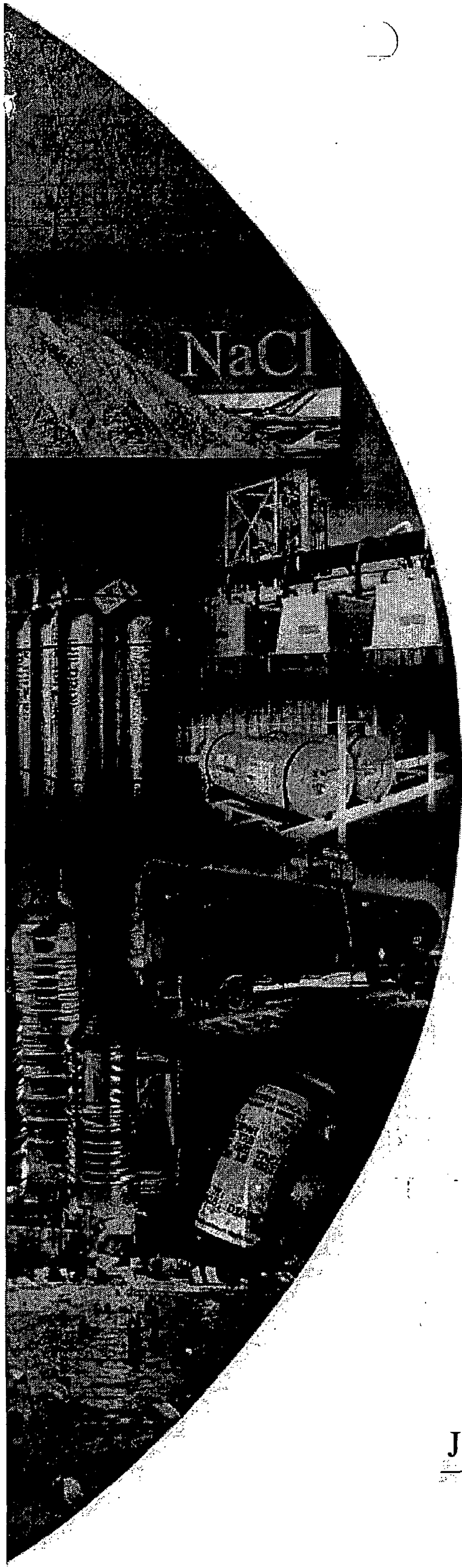
- Melt temperature for ton container fusible plugs to be revised to 150° F - 165°F.

- Forward Transportation Issue Team decisions to the Health Environment, Safety and Security Issue Team for insertion into Pamphlet 17.

- Notify the Compressed Gas Association of change to the Chlorine Institute fusible plug recommendations.

Status

The Transportation Issue Team approved all of the Fusible Plug Task Group recommendations at its August 2009 meeting. The Issue Team also agreed that the recommendations be implemented not later than the next cylinder/container hydro test (required every five years) starting when the fusible plugs are commercially available (believed to be early 2010).



THE CHLORINE INSTITUTE, INC.

Pamphlet 49

Recommended Practices for Handling Chlorine Bulk Highway Transports

Edition 9

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

A LEGACY OF SAFETY STEWARDSHIP since 1924

January 2009

Table of Contents

1. INTRODUCTION

1.1 SCOPE

This pamphlet provides guidelines, recommended practices and other useful information for the safe shipping, receiving, testing and handling of cargo tank motor vehicles and portable tanks used to transport chlorine by highway. It represents a compendium of Institute membership experience as of the date of publication.

1.2 CHORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. 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.

1.3 DEFINITIONS

In this pamphlet, the following meanings apply unless otherwise noted:

cargo tank	any tank permanently attached to or forming a part of any motor vehicle or any bulk liquid or compressed gas packaging not permanently attached to any motor vehicle which by reason of its size, construction or attachment to a motor vehicle, is loaded or unloaded without being removed from the motor vehicle. This does not include a portable tank.
cargo tank motor vehicle	a motor vehicle with one or more cargo tanks permanently attached to or forming an integral part of the motor vehicle (49 CFR 171.8)
carrier	a person engaged in the transportation of passengers or property as a common, contract or private carrier
CCPA	Canadian Chemical Producers Association
CFR	Code of Federal Regulations
chlorine	dry chlorine (either liquid or gas)

DCE	Design certifying engineer
dry air or nitrogen	air or nitrogen dried to a dew point of -40°F (-40°C) or below measured at the operating pressure
DOT	U.S. Department of Transportation
DHS	U.S. Department of Homeland Security
FMCSA	Federal Motor Carrier Safety Administration
filling density	the percent ratio of the weight of gas in the tank to the weight of water that the tank will hold (49 CFR 173.315)
Institute	The Chlorine Institute, Inc.
kPa	kilopascal(s)
motor vehicle	a vehicle, machine, tractor, trailer or semi-trailer, or any combination thereof, propelled or drawn by mechanical power and used upon the highways in the transportation of passengers or property (49 CFR 171.8)
NPSH	Net Positive Suction Head
NTTC	National Tank Truck Carriers, Inc.
PHMSA	Pipeline and Hazardous Materials Safety Administration
TC	Transport Canada
TSA	Transportation Security Administration
portable tank	a bulk packaging (except a cylinder having a water capacity of 1000 lbs or less) designed primarily to be loaded onto or on, or temporarily attached to a transport vehicle or ship and equipped with skids, mounting, or accessories to facilitate handling of the tank by mechanical means. It does not include a cargo tank, tank car, multi-unit tank car tank, or trailer carrying 3AX, 3AAX, or 3T cylinders (49 CFR 171.8)
psig	pounds per square inch gauge
tank	the chlorine containing vessel which conforms to MC 331, MC 330, or DOT 51

1.4 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require a change in the recommendations herein. Appropriate steps should be taken to ensure 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.

1.5 APPROVAL

The Institute's Transportation Issue Team approved Edition 9 of this pamphlet on January 15, 2009.

1.6 REVISIONS

Suggestions for revision should be directed to the Secretary of the Institute.

1.7 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. GENERAL INFORMATION

2.1 CHLORINE IN COMMERCE

Chlorine is classified for transportation by the DOT as a Class 2, Division 2.3 poison gas with a subsidiary corrosive hazard. In Canada, chlorine is classified by TC as a Class 2, Division 2.3 poison gas with a secondary classification of Class 5, Division 5.1 oxidizer. The classification in Mexico is the same as in Canada. The United Nations identification for chlorine is U.N. 1017. New chlorine cargo tanks must be constructed in accordance with specification MC 331. Existing MC 330 specification cargo tanks are also authorized for the carriage of chlorine provided the tank was marked or certified before May 15, 1967. Chlorine may also be carried in a Specification 51 portable tank.

2.2 RELATED PUBLICATIONS

For additional information on the physical properties of chlorine, cargo handling, personal protective equipment and cargo tank motor vehicle and portable tank related items, the reader should refer to Section 14.

A source of information for shippers and carriers with guidance on day-to-day operational concerns with tank truck transportation of chemicals is the Inter-Industry Bulk Chemical Highway Safety Task Force Recommendations published by the American Chemistry Council and NTTC.

Sources of security guidance include The Chlorine Institute Security Management Plan for Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks, and the American Trucking Association Sample Hazmat Transportation Security Plan (Reference 14.6.2).

3. EMERGENCY RESPONSE

3.1 EMERGENCY PLANNING

Facilities and Transfer Sites

All personnel responsible for transfer operations should be completely familiar with the facility's emergency plan for handling spills and leaks of product.

Transportation

The DOT has specific training requirements applicable to the handling of hazardous materials. Shippers must familiarize themselves with these requirements. In particular, DOT requires each operator of a cargo tank motor vehicle to have written procedures for all delivery operations. The procedures must describe the emergency discharge control features. For chlorine cargo tanks, this includes the parameters within which the excess flow valves will function to shut down cargo flow in the event there is a complete separation of the cargo transfer hose. Reference is made to 49 CFR 177.840(l) (Reference 14.2.1).

CHLOREP

The Chlorine Emergency Plan (CHLOREP) is an industry-wide program established by the Institute to improve the speed and effectiveness of response to chlorine emergencies in the United States and Canada. Under this plan the United States and Canada have been divided into regional sectors where chlorine emergency teams from producing, packager and consuming plants are on a 24-hour alert to handle potential or actual chlorine emergencies. During a chlorine emergency, any carrier, customer, or civil authority can obtain basic emergency information and be put in contact with the closest chlorine emergency group by phoning an emergency dispatch agency.

3.2 CHEMTREC AND CANUTEC

For transportation-related incidents in the U.S., one should utilize CHEMTREC, the Chemical Transportation Emergency Center in Arlington, VA, as the dispatch agency. CHEMTREC operates around-the-clock, 24 hours-a-day, seven days-a-week to receive direct-dial, toll-free calls from any point in the United States and Canada at 1-800-424-9300 (800-262-8200 for all other calls). CHEMTREC provides immediate advice for those at the scene of emergencies, then, if the emergency involves chlorine, promptly contacts the designated CHLOREP team, the shipper and others as required.

Registration with CHEMTREC is provided through the American Chemistry Council. In Canada, one should utilize CANUTEC, the Canadian Transport Emergency Centre in Ottawa as the dispatch agency. Their telephone number is 613-996-6666 (call collect). CANUTEC, administered by TC, operates in a similar manner to CHEMTREC.

3.3 EMERGENCY KITS AND RESPONSE TRAINING

Leaks that may occur in chlorine tanks usually involve the angle valves or pressure relief device and can be controlled with the Institute's Emergency Kit C. Over 2000 of these and earlier kits are in existence throughout the United States and Canada. These kits should be on site or readily available where tanks are in storage or in use. Each chlorine motor vehicle must carry an emergency kit.

The driver of the motor vehicle and shipper/receiver response personnel must be trained to properly apply this kit in emergency situations. A useful introduction to training for a chlorine emergency is found in The Chlorine Institute's DVD "Chlorine Emergencies: An Overview for First Responders".

3.4 PERSONAL PROTECTIVE EQUIPMENT

DOT regulations specify that chlorine tank motor vehicles be shipped with a gas mask approved for chlorine service. In the U.S. all respiratory equipment and maintenance thereof must comply with OSHA standards. Since it is unlikely the concentration of chlorine present in an emergency situation can be adequately monitored, it is recommended that a self contained breathing apparatus (SCBA) with a full face piece with at least 20 minutes of air operated in the positive pressure mode be carried on the motor vehicle. Institute recommendations on a suitable respiratory protection program are contained in CI Pamphlet 65. The driver of the vehicle must be trained in and familiar with all respiratory protection furnished. SCBA should also be available at loading and unloading sites.

3.5 REPORTING OF RELEASE

Chlorine is identified as hazardous substances in Table 302.4 - *List of Hazardous Substances and Reportable Quantities* of 40 CFR 302.4. CERCLA requires immediate notification of a release equal to or in excess of the reportable quantity while in transportation or at shipping or receiving facilities when not in transportation. The reportable quantity of chlorine is 10 pounds (4.54 Kg). Should a reportable release occur in the U.S., the law requires the National Response Center (1-800-424-8802) to be immediately notified. Incidents that occur in transportation also require reporting to DOT in a 5800 report. In Canada appropriate provincial response authorities must be immediately advised of a chlorine release of any quantity. State, provincial and local laws may require reporting to the appropriate state and/or local environmental agencies at lower thresholds or of any quantity.

4. REGULATORY REQUIREMENTS AND GUIDANCE FOR SAFETY AND SECURITY

4.1 DOT REGULATIONS

The DOT regulates the acceptance and transportation of hazardous materials including the specifications for shipping containers. As chlorine is a hazardous material, it is imperative that personnel involved in any aspect of handling, packaging and/or transportation of chlorine are knowledgeable of the regulatory requirements pertaining to chlorine. DOT regulations include requirements for plans to address security risks related to transportation of hazardous materials including chlorine. Publications should be readily available for reference. For ordering information, see Section 14.

Title 49 CFR details all of the requirements for hazardous material transportation in the United States. Pertinent sections in the DOT regulations in Title 49 CFR that cover many of the requirements relating to chlorine cargo tanks are identified below. Once a chlorine tank has been removed from the motor vehicle, it is no longer a cargo tank as defined by DOT and is not regulated under the DOT Hazardous Material Regulations 49 CFR Parts 171 – 180.

Part 107	General registration requirements
Part 171.8	Definitions and abbreviations
Part 171.15	Immediate notice of certain hazardous materials incidents
Part 171.16	Detailed hazardous materials incident reports
Part 172.101	Hazardous materials table
Part 172.102	Special provisions
Part 172.200	Applicability (shipping papers)
Part 172.201	General entries (shipping papers)
Part 172.202	Description of hazardous materials on shipping papers
Part 172.203	Additional description requirements (shipping papers)
Part 172.204	Shipper's certification
Part 172.302	General marking requirements for bulk packaging
Part 172.313	Poisonous hazardous materials
Part 172.326	Portable tanks
Part 172.328	Cargo tanks (marking)
Parts 172.500-519	Placarding
Part 172.540	POISON GAS placard

Part 172.555	Poison inhalation hazard placard
Parts 172.600-604	Subpart G emergency response information
Parts 172.700-704	Subpart H - Training
Parts 172.800-804	Subpart I – Security Plans
Part 173.32	Qualification, maintenance and use of portable tanks
Part 173.33	Qualification, maintenance and use of cargo tanks
Part 173.315	Compressed gases in cargo tanks and portable tanks
Part 177.800	Purpose and scope of this part and responsibility for compliance and training (carriage by public highway)
Part 177.816	Driver training
Part 177.817	Shipping papers
Part 177.834	General Requirements (Loading and Unloading)
Part 177.840	Class 2 (gases) materials (Loading and Unloading)
Part 178.245	Specification 51 (portable tank)
Part 178.320	General requirements applicable to all DOT specifications
Part 178.337	Cargo tank specification MC 331
Parts 180.401-417	Qualification and maintenance of cargo tanks
Part 180.415	Test and inspection markings
Part 397	Transportation of hazardous materials: driving and parking rules
Part 383	Commercial driver's license standard; requirements and penalties
Part 387	Minimum levels of financial responsibility of motor carriers
Part 389	Rule making procedures - Federal motor carrier safety regulations
Part 390	Federal Motor Carrier Safety Regulations: General
Part 391	Qualifications of drivers
Part 392	Driving of motor vehicles
Part 393	Parts and accessories necessary for safe operation
Part 394	Notification and reporting of accidents
Part 395	Hours of service of drivers

Part 396	Inspection, repair and maintenance
Part 397	Transportation of hazardous materials; driving and parking rule
Part 399	Employee safety and health standards

4.2 TSA VOLUNTARY MEASURES

TSA has developed voluntary Security Action Items which have been made available to those involved in the shipment of certain Security Sensitive Hazardous Materials. These measures should be considered in concert with industry guidance by those who load, transport, store incidental to transport or unload Security Sensitive Hazardous Materials including chlorine.

4.3 EPA REGULATIONS

In the United States, when chlorine is used for disinfection of drinking water, waste water and swimming pools it is considered to be a fungicide and is subject to EPA regulations issued under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The EPA regulations, found in 40 CFR Subchapter E and in particular 40 CFR 156, require shipper registration with EPA and appropriate labeling (Reference 14.4).

4.4 OSHA REGULATIONS

The OSHA occupational safety and health standards are found in Title 29 CFR Part 1910. Title 29 CFR 1910 regulates material handling and storage, 29CFR 1910 regulates process safety management, 29 CFR 1910 regulates the emergency response to hazardous substance releases and 29 CFR subpart I regulates personal protective equipment. (Reference 14.5)

4.5 CANADA REGULATIONS

The Canadian regulations for the Transportation of Dangerous Goods (TDG) parallel DOT requirements in most respects. The Canadian regulations can be found in the Canadian Transportation of Dangerous Goods Act and Regulations. These regulations include, by reference, various standards and specifications found in Canadian Standards Association (CSA) publications and in Canadian General Standards Board (CGSB) publications. There are also provincial regulations specific to each province (Reference 14.3).

4.6 MEXICO REGULATIONS

The Normas Officiales de Mexico (Official Mexican Standards), often referred to as Normas or NOMs, support the *Mexican Hazardous Materials Land Transportation Regulation*. The Mexican Secretariat for Communications and Transport is responsible for publishing and applying the NOMs. The Mexican NOMs are fairly consistent with those of the United Nations Recommendations on the Transport of Dangerous Goods (UN Recommendations) and TC and DOT regulations.

4.7 LOCAL REQUIREMENTS

In addition to federal requirements, state, provisional or local requirements might affect these operations. The reader is cautioned to check applicable codes.

5. TANK DESCRIPTION

5.1 SIZE AND TYPE

Chlorine cargo tanks and portable tanks in North America range in chlorine capacity from 9 to 22 tons. Tanks can be mounted in ISO frames, custom trailer mounts or be permanently mounted on or part of truck or trailer assemblies. There are many trailer assemblies that conform to DOT MC 331 specification. Figures 5.1 through 5.4 give outline drawings with approximate dimensions for several types of units.

5.2 INSULATION

Insulation for chlorine tanks is four inches minimum of cork board, or four inches of polyurethane foam or at least two inches of 4-pound per cubic foot (minimum) density ceramic fiber covered by two inches of glass fiber. The insulation is covered with a carbon steel or stainless steel jacket. A protective coating is applied to the exterior surface of the tank and to the inside surface of the steel jacket. The jacket is flashed around all openings so as to be weather tight.

5.3 TANK ARRANGEMENT AND EQUIPMENT

Manway Arrangements

All tanks are equipped with manway arrangements in accordance with CI Drawing 137. The manway cover, all standard valves, studs and gaskets are detailed in pertinent Institute drawings. This arrangement facilitates the use of the Institute's Emergency Kit C. Maintenance pamphlets are available for all standard valves.

Angle Valves

Most cargo tanks are equipped with four 1 inch manual angle valves. Reference is made to 49 CFR 178.337-9 (b)(8) (Reference 14.2.1). Effective October 1, 2008 in addition to valves designed per CI Drawing 104, valves meeting CI Pamphlet 166, Section 3 performance standards may be utilized without a special permit. The two angle valves on the longitudinal center line of the tank are for liquid discharge.

The two valves on the transverse center line are connected to the vapor space. The liquid valves are each equipped with 1.25-inch (31.75 mm) diameter eduction pipes extending to the bottom of the tank for unloading of the contents. (**NOTE**: angle valves should be capped when not in use)

Excess Flow Valve

Each eduction pipe is equipped with an excess flow valve having a maximum operating flow rate of 7,000 lbs (3175.2 kg) of liquid chlorine per hour (See CI Drawing 101). Vapor valves must be equipped with excess flow valves per CI Drawing 106. Reference is made to 49 CFR 178.337-8(b) (Reference 14.2.1). Other excess flow valve arrangements may be used with a DOT special permit.

Cargo Tank
Trailer Mount (DOT MC-331)

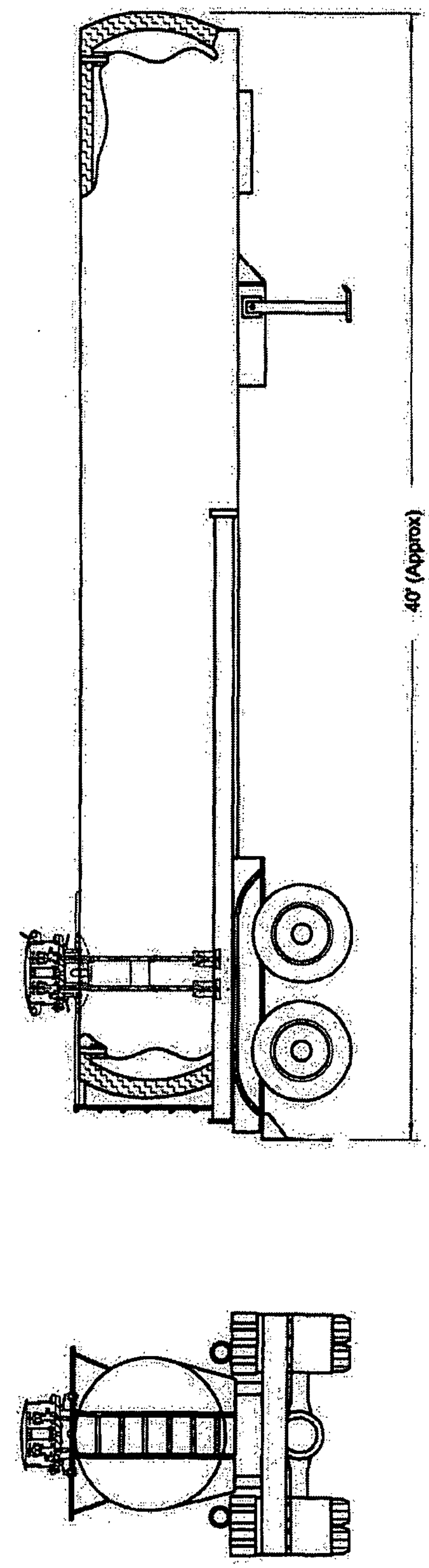


Fig. 5-1

258 of 593

Cargo Tank
Chassis Mount (DOT MC-331)

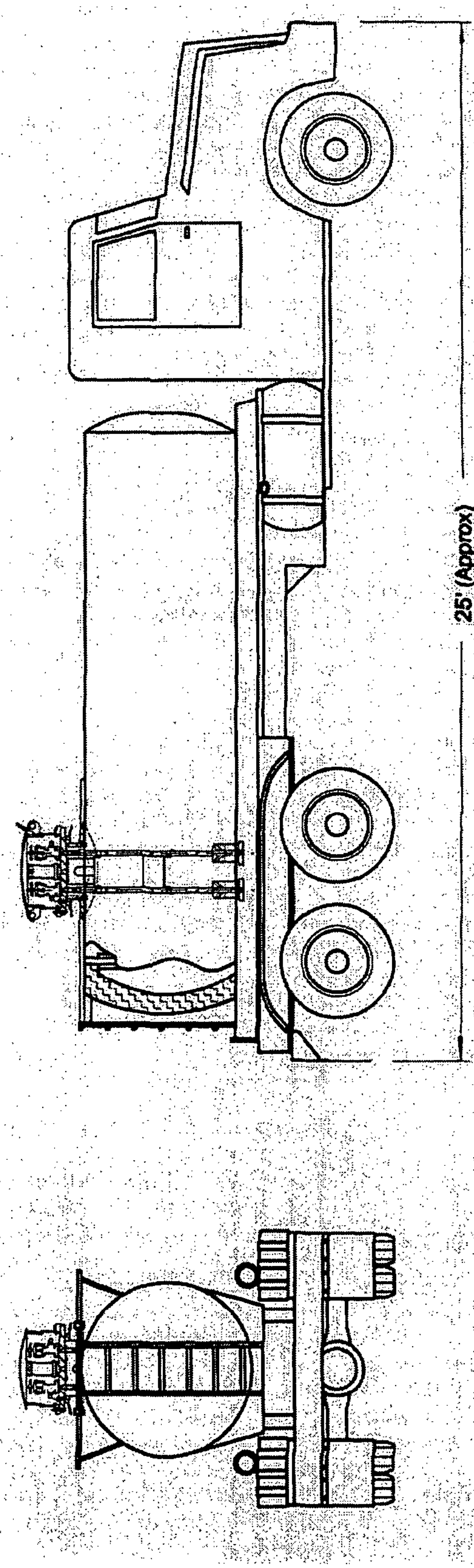


Fig. 5-2

Cargo Tank
Demountable (DOT MC-331)

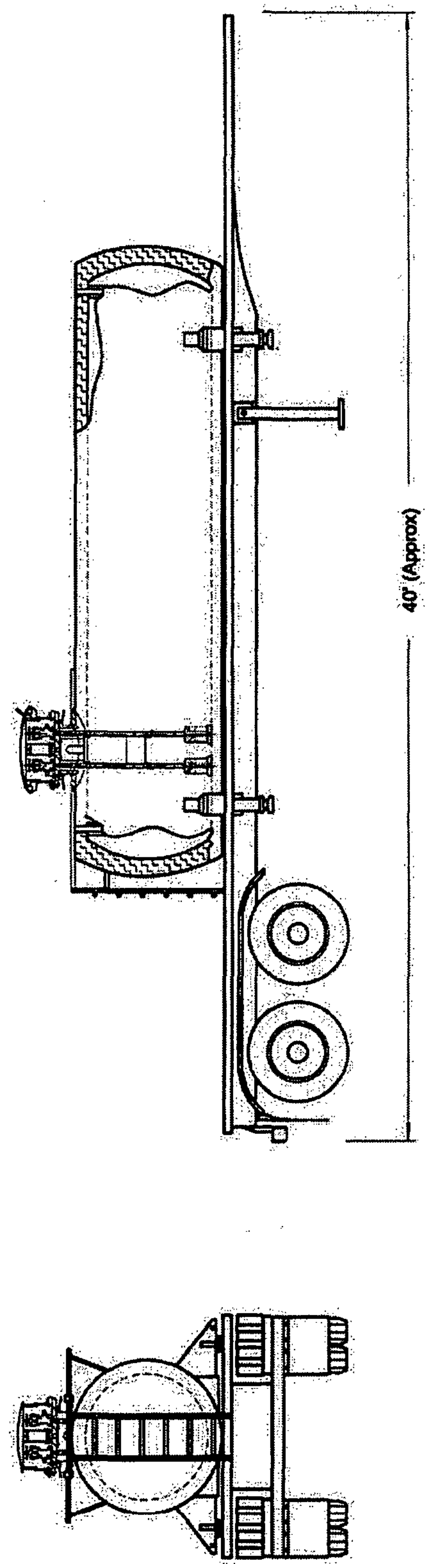
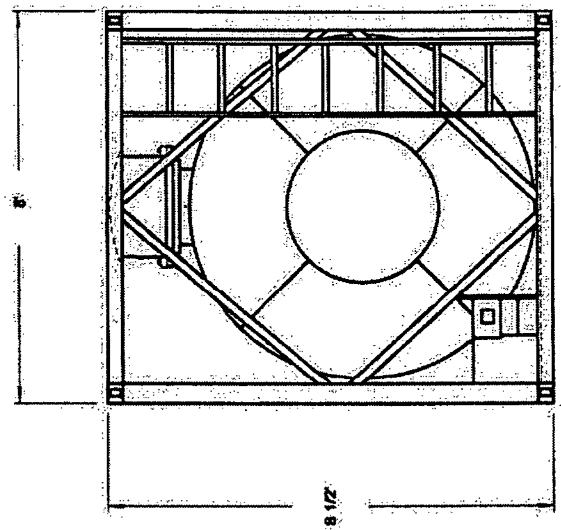


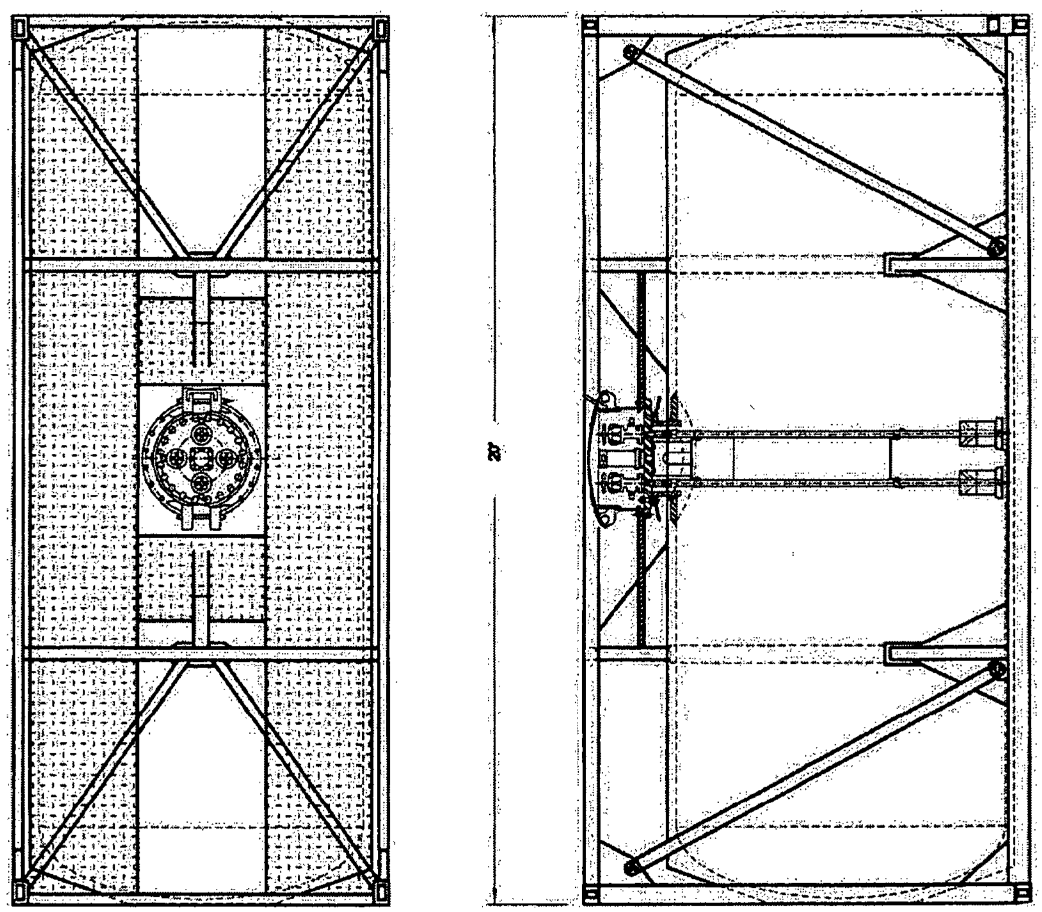
Fig. 5-3

260 of 593

Portable Tank (DOT 51)

Fig. 5-4





Pressure Relief Device

Each tank is equipped with a pressure relief device located in the center of the manway cover. Other authorized pressure relief devices can be used. The device is set to discharge at 225 psig (1551 kPa). See CI Drawings H-50155 (elastomeric seat design) and H-51970 (metallic seat design).

Accessories

Trucks and trailers may carry transfer hoses in specially designed racks that ensure hose integrity and dry chlorine transfer (note: transfer hoses should be plugged at both ends when not in use). All chlorine tank haulers carry the Chlorine Institute's Emergency Kit C or a similar kit to facilitate emergency response. Personal protection equipment is also carried (See Section 3.4). Some trucks and trailers are fitted with compressors and air dryers for use during loading or unloading.

6. OPERATORS OF TANK MOTOR VEHICLES

6.1 DRIVER QUALIFICATIONS

In order for a driver to be considered qualified for transporting chlorine the driver must:

- Successfully complete a DOT required medical evaluation. Evaluation to be per DOT established criteria
- Have considerable and varied driving experience
- Be properly licensed for the size and class of the vehicle to be driven including all appropriate endorsements for the cargo carried
- Have basic familiarity with the construction of the chlorine tank and fittings on the manway assembly
- Be able to inspect the tank and manway fittings and identify any discrepancies
- Be properly trained to respond to an emergency in transit, and be provided with proper notification procedures

262 of 593

- Pass a DOT-required initial employment drug test and be enrolled in a proper DOT - required random drug and alcohol testing program
- Have training in the company's security plan which includes all applicable components of the of the Chlorine Institute Security Management Plan for the Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks and meets the requirements of 49CFR 172.800

6.2 DRIVER TRAINING

On a periodic basis, the vehicle owner or authorized agent should schedule a formalized chlorine driver training program for all involved drivers with at least one annual refresher. Training must be administered by qualified personnel in the following specific areas:

- Physical and chemical characteristics of chlorine
- General construction and features of the tank including inspection techniques and proper completion of a daily vehicle inspection report
- Tank manway details (e.g. locking devices, bolts, side access ports and access means to the manway)
- Making and breaking connections and chlorine transferring operation
- Detection and location of leaks
- Use of a positive pressure, self-contained breathing apparatus with full face piece
- Emergency procedures, contacts and reporting
- General precautions (i.e. weight shifting and stopping distance)
- Personal protective equipment
- DOT-required hazmat employee training (every 3 years)
- Security Training in the company transportation security plan.

The following is a listing of the mandatory training requirements contained in Title 49 CFR:

Part 172.700	Purpose and scope
Part 172.704	Training requirements
Part 177.800	Purpose and scope and responsibility for compliance and training

Part 177.816	Driver training
Part 383.23	Commercial driver's license
Part 387.9	Financial responsibility, minimum levels (Motor Carriers)
Part 390	Federal Motor Carrier Safety Regulations: General
Part 391.11	Qualifications of drivers
Part 392	Driving of motor vehicles
Part 393	Parts and accessories necessary for safe operation
Part 395	Hours of service of drivers
Part 396	Inspection repair and maintenance
Part 379	Transportation of hazardous materials: driving and parking rules
Part 399	Employee safety and health standards

6.3 CARRIER QUALIFICATIONS

As an alternative to utilizing the shipper's own drivers, "for hire"/contract carriers may be selected to haul liquid chlorine. It is recommended that such carriers be pre-approved to meet a shipper's qualification standard and only those carriers should be utilized thereafter. Examples of carrier qualification requirements are:

- Proof of the minimum insurance required
- Copies of operating authority
- Pass a facility equipment/questionnaire or a driver training inspection/ questionnaire
- Copy of DOT safety rating
- Transportation Security Plan per 49 CFR 172.800
- Hazardous Material Safety Permit
- Latest motor carrier safety survey
- In Canada, a CCPA carrier evaluation criteria system is in effect

6.4 U.S. DOT HAZARDOUS MATERIALS REGISTRATION PROGRAM

Under DOT regulations found in 49 CFR 107.601 - 107.620, a person who offers or transports certain quantities or types of hazardous materials must register annually with DOT. This includes chlorine carried in MC 330, MC 331 and Specification 51 tanks. To register, the DOT Form F 5800.2 must be completed and sent to the U.S. Department of Transportation Hazardous Materials Registration, P.O. Box 70985, Charlotte, NC 28272-0985. The registration requires an annual fee. The DOT will issue a registration number each year after payment.

7. LOADING\UNLOADING\FACILITY ISSUES

7.1 TANK PRESSURE

Conditions of loading and padding must be such that when the temperature of the chlorine increases, pressure in the tank will not approach the pressure relief device setting.

Temperature/Pressure Relationships

Chlorine in a tank is a liquefied gas under pressure. The tank always contains some non-condensable gases in addition to the chlorine vapor. These gases may or may not be in equilibrium with the chlorine. The total pressure in the tank is the sum of the partial pressure of the chlorine and the partial pressure of the non-condensables. Because of a lack of equilibrium, it is not possible to calculate the exact pressure by means of gas laws.

The partial pressure of the chlorine is a function of its temperature. The partial pressure of the non-condensables is a function of the molecular weight of such gases, the volume of the vapor space and the gas temperature.

The following pressure limits apply:

Specifications	**Pressure Relief Device (*Start-to-Discharge)***	**Limiting Pressure**
MC-330/331 and DOT 51	225 psig (1551 kPa)	225 psig (1551 kPa) at 105°F (40.5°C)

Chlorine vapor pressure at various temperatures is shown below in Table 7-1.

Table 7-1. Vapor Pressure of Chlorine

Temperature		Vapor Pressure		Temperature		Vapor Pressure	
°F	°C	psig	kPa	°F	°C	psig	kPa
0	-18	13.8	95	60	16	70.9	489
10	-12	20.3	140	70	21	85.5	589
20	-7	27.8	192	80	27	101.8	701
30	-1	36.6	252	90	32	119.9	826
40	4	46.6	321	100	38	140.1	965
50	10	58.0	400	105	41	151.3	1042

Loading Pad Limit

The final tank pressure after padding should not exceed the maximum values shown on CI Drawing 201. This curve can be used for padding prior to shipment or padding to make a transfer.

Unloading Pad Air Pressure

Unloading pad air pressure should be the minimum consistent with the process needs. The limits contained in CI Drawing 201 and the cargo tank certification (See Section 7.9) should be observed. For additional information see section 7.5.

Pressure Developed During Transloading

If padding is used to transfer chlorine between two tanks or between a tank and a tank car, care must be taken to ensure excess inert gas does not result in an over pressure situation.

7.2 CHLORINE TRANSFER METHODS

Inert Gas Padding

The vapor pressure of chlorine at various temperatures is given in Table 7-1. If more pressure is needed to unload the tank, padding of the tank may be necessary. See Section 7.5 for more information. Dry air is commonly used; however, other suitable inert gases, such as nitrogen can be used. To minimize need for padding, consideration should be given to the following:

- reducing the pressure at the point of consumption
- reducing the pressure drop in the piping system
- housing the tank in a warm shed (This is helpful where extremely cold weather is encountered.)

Pumping

Pumps are typically used to load tanks in large producing locations. Unloading using pumps is generally impractical due to NPSH requirements of commercially available pumps.

Chlorine Padding (Recompression)

Some carriers and some owners of stationary storage systems use chorine compressors to compress vapor in the fixed storage for use as pad gases to remove liquid from the transport tank. This is acceptable if the system is designed to exclude moisture entry from ambient air leakage and adequate inert gas is always available in the system. If there is inadequate inert vapor in the fixed storage tank, the transfer compressor will compress a gas that is mostly chlorine. If temperatures are low in the transport tank, the chlorine gas from the compressor will liquefy, possibly overfilling the transport tank rather than increasing the pressure to pad the liquid out.

7.3 CHLORINE DELIVERY

It is quite common for the chlorine tank to be directly connected to the consuming process. When utilizing this method the unloading of a chlorine tank may take place over an extended period of time. Chlorine can also be unloaded into fixed storage containers for future transfer to the process.

Choice is generally based on relative risk of multiple transfers and additional equipment versus reliability of unloading connections. For additional information see CI Pamphlet 5.

7.4 EVACUATION AND ABSORPTION SYSTEM

At a minimum, an evacuation or absorption system should be provided to remove chlorine contained in transfer lines prior to disconnect. Additional safeguards may be justified based on local risk analysis.

7.5 UNLOADING AND PADDING PRECAUTIONS

Even small amounts of moisture can cause corrosion to tank equipment and to the user's piping and handling system. Chlorine and oil will react to produce contaminants and, under certain conditions, the reaction might occur with violent force. For these reasons, it is essential that air used for padding be free from oil and foreign matter and dried to a dew point of -40°F (-40°C) or below measured at the operating pressure.

Moisture Content

To make sure that no moisture is entering the chlorine system, the moisture content of padding air should be tested each time a tank is connected for padding. This is easily done with a commercial dew point tester. Draining of the water trap and filter in the air line should not be overlooked and should be on a scheduled periodic maintenance program.

Separate System

Padding air should not be taken from the plant air system, but, ideally, should come from an independent air compressor used solely for this purpose. Unless safeguards are taken, in a common system a heavy demand for air elsewhere could lower the overall system pressure below the tank pressure. Chlorine could then feed back into the air system with probable damage to equipment and danger to personnel.

Air Padding

A suitable air compressor and an ASME Code receiver equipped with a pressure gauge, a safety valve, a drain valve and automatic pressure controls should be used. An after-cooler and a trap or filter should be provided to remove condensed moisture and entrained oil to reduce the load on the dryer. A filter should also be installed which is designed specifically for oil removal. See CI Drawing 119 for a typical installation. Table 7.2 shows the air flow required at tank pressures for various unloading rates.

Air Dryers

Commercial regenerative type dryers using activated alumina or silica gel as the desiccant are recommended and can be obtained with any degree of refinement from manual to fully-automatic control. If continuous operation is desired, dual units are necessary. For required capacity, see Tables 7-2 and 7-3.

Shipper or Receiver Air Padding

When the required unloading pressure is lower than the vapor pressure of chlorine at ambient temperatures and the pressure due to air is required only during the initial unloading period while the chlorine is relatively cold, the shipper may add air pressure prior to shipment. If the pressure in the tank is not sufficient when received or throughout unloading, the receiver should notify the shipper.

Table 7-2. Continuous Air Flow Requirements for Padding[1]				
Unloading Rate	Std. Cubic Feet per Minute (SCFM) of Air Required			
	ft^3/minute		m^3/second	
lbs/hour of chlorine	P=125 psig	P=100 psig	P=862 kPa	P=684 kPa
7,500	10.00	7.5	.00472	.00354
6,000	8.00	6.0	.00378	.00283
4,000	5.33	4.0	.00252	.00189
1,000	1.33	1.0	.00063	.00047

- **SCFM Air = $\frac{\text{lbs/hr of chlorine} \times (P - 25)}{75{,}000}$**
- **P = total pressure in tank (psig)**

Table 7-3. Air Quantity Requirements for Padding[1]				
Nominal Chlorine Capacity	Total Air Required (SCFM)			
	ft^3/minute		m^3/second	
	P=125 psig	P=100 psig	P=862 kPa	P=684 kPa
16 short tons (14.5 metric tons)	3,070	2,300	1.449	1.086
22 short tons (20 metric tons)	4,224	3,168	1.994	1.495

- **ft^3 of air = tons of chlorine x 1.92 x (P - 25)**
- **P = total pressure in tank (psig)**

7.6 OVER PRESSURE PREVENTION

To minimize the increased hazards accompanying air padding, pressures should be kept as low as possible. In any case, the total pressure (the vapor pressure of the chlorine plus the pressure of the air pad) should not exceed the pressures indicated on the appropriate curves on Cl Drawing 201.

Atmospheric heat entering the tank will raise the temperature of the liquid chlorine and increase its vapor pressure. The heat will also cause the liquid to expand thus reducing the vapor space with resulting increase in the air pressure.

[1] Requirements are based on the assumption that no air dissolves in the chlorine and an average chlorine temperature in the tank of 18°F (-7.8°C). Corresponding vapor pressure is 24.7 psig (170 kPa). Higher temperatures will require less air. The standard cubic foot is measured at 68°F (20°C) and 1 atm.

The combined effects of expansion of the liquid and increase in its vapor pressure may increase the total pressure enough to open the pressure relief device.

For example, if a full tank at 33°F is padded from the vapor pressure of 40 psig (276 kPa) to a total pressure of 125 psig (862 kPa) and is then allowed to warm up to 88°F, the combined effects of the expansion of the liquid chlorine and increase in its vapor pressure will raise the total pressure above 225 psig (1551 kPa) and a pressure relief device set at that pressure will open.

It is especially important to prevent buildup of excessive pressure over periods when chlorine is not being withdrawn such as nights, weekends, plant vacation periods or shutdowns. Such tanks should be inspected routinely for leaks and excessive pressure. If necessary, excessive pressure should be vented to a recovery system.

7.7 Other Equipment

For loading operations either a direct reading scale or the ability to load from a weighed feed tank followed by a check scale is required. The filling density must not exceed 125%.

7.8 Emergency Shut-Off

49 CFR 173.315(n) (2) specifies requirements for emergency shutdown to shut off the flow of product within 20 seconds of an unintentional release caused by separation of a liquid delivery hose. Excess flow valves should not be relied upon as the only means of mitigating a hose or piping failure during chlorine transfer. CI Pamphlet 57, *Emergency Shut-Off Systems for Bulk Transfer of Chlorine* outlines CI recommended practices for emergency protection against major chlorine spills during chlorine transfers involving chlorine tank handling systems. The pamphlet illustrates one emergency shut-off system that will quickly bring a release situation under control. The system described in CI Pamphlet 57 provides the means to shut down the flow of chlorine from the cargo tank by isolating both sides of the cargo transfer hose. Use of an emergency shut-off system that meets the standards in CI Pamphlet 57 is recommended during the loading or unloading of a chlorine cargo tank. Use of a proper hose suitable for the transfer of chlorine as recommended in CI Pamphlet 6 should be part of the transfer system.

270 of 593

7.9 CARGO TANK CERTIFICATION

DOT regulations (49 CFR 173.315(n)(2)) (Reference 14.2.1) require a cargo tank motor vehicle carrying liquefied compressed gases including chlorine to be certified by a Design Certifying Engineer (DCE) that there is a means to automatically shut off the flow of product during unloading without human intervention (a passive system) within 20 seconds of an unintentional release caused by the complete separation of a liquid delivery hose.

The Chlorine Institute has obtained certification, based on the cargo tank's excess flow valves (see 5.3.3), for the chlorine cargo tank unloading system. Copies of the certifications are included in Appendix B. The certified cargo tank unloading systems consist of the following:

- Six foot length of 1¼ inch schedule 80 eduction pipe inside the cargo tank
- Up to an 18 inch length of one inch schedule 80 pipe nipple
- An automatic isolation valve, which may not be on all systems, consisting of a ball or plug valve of nominal one inch diameter, in the fully opened position with a Cv of at least 44
- A chlorine transfer hose meeting the standards of CI Pamphlet 6 with a nominal one inch diameter and a maximum length of 25 feet, and
- One of the following excess flow valve and angle valve combinations:
    - An excess flow valve as per CI Drawing 101 (7,000 lb/hr) and an angle valve as per CI Drawing 104; or
    - An excess flow valve as per CI Drawing 101 (7,000 lb/hr) and an angle valve as per Midland Manufacturing Corp Drawing A-713-ML; or
    - An excess flow valve as per Midland Manufacturing Corp Drawing A-120-ML (32,000 lb/hr of water) and an angle valve as per Midland Manufacturing Corp Drawing A-713-ML

Unloading operations must be conducted within the limitations set by the DCE certification as follows:

- The pressure in the cargo tank during unloading must be at least 20 psig for systems with CI Drawing 101 (7,000 lb/hr) excess flow valves. For systems with Midland Manufacturing Corp Drawing A-120-ML (32,000 lb/hr of water) excess flow valves, the pressure in the cargo tank during unloading must be as specified in the DCE certification (see Appendix B) which bases the required pressure on the length of the cargo hose and varies between 50 psig and 103 psig

- The angle valve and the other valves in the system must be in the fully opened position during unloading

- The cargo transfer hose can be no more than 42 inches above the angle valve opening; and

- The excess flow valves must be properly maintained and meet all manufacturer's design specifications

7.10 NITROGEN TRICHLORIDE - HAZARD AWARENESS

The presence of nitrogen trichloride in liquid chlorine is the suspected cause of explosions that have occurred, although infrequently, in chlorine systems including chlorine transportation containers. Nitrogen trichloride is formed from nitrogen that enters the system during the chlorine production process. CI Pamphlet 152 provides methods for the detection, prevention and destruction of nitrogen trichloride. Bulk shipping containers (barge tanks, tank cars and cargo tanks) should not be unloaded in the gas phase. If present, nitrogen trichloride will concentrate in the liquid phase because of nitrogen trichloride's higher boiling point. Due to the relatively large amount of chlorine in the bulk container, the nitrogen trichloride in the liquid phase could concentrate to dangerous levels if only gases are removed.

8. RESPONSIBILITIES

8.1 LOADING FACILITY RESPONSIBILITIES

It is recommended that the loading facility ensure to the extent practicable the tank complies with all current tank regulations and applicable recommendations contained in this pamphlet, and that a satisfactory pre-loading inspection is made prior to loading. The loading facility should ensure that:

- The tank and vehicle meet the applicable DOT and TC specifications, including chlorine requirements

- The pressure relief device is within required test dates

- No piping or hoses have been left attached to the angle valves

- The tank is checked for a current specification plate and for test and inspection markings

- The angle valves comply with regulations pertaining to testing

- The transfer hoses are compatible with chlorine and no moisture is present (See CI Pamphlet 6 for recommendations on transfer hoses)

- The filling density requirements are not exceeded

- The tank's manway arrangement is correct
- Responsibility is taken if the tank is left on the premises
- The tank is loaded in a safe area properly equipped to handle any emergency
- Safe access to the manway area by safe steps, platforms, drop bridges or guard rails has been provided
- Flexible connections, valves, emergency shutoff devices have been provided. Reference is made to CI Pamphlets 6 and 57
- An evacuation or absorption system or other means of purging connecting lines to prevent releases of chlorine into the atmosphere after shutoff and during disconnection is provided
- The padding system meets the appropriate standards
- Good lighting for night and inclement weather operations has been provided
- Emergency equipment has been provided
- Access is restricted to authorized persons
- Shipping documents and placarding are prepared for the shipment of the tank

8.2 CARRIER RESPONSIBILITIES

The carrier should ensure that:

- The tank and pressure relief device meet appropriate DOT and TC specifications, including chlorine transportation requirements
- The motor vehicle is equipped with an Emergency Kit C and an SCBA
- The gross vehicle weight is not exceeded
- Shipping papers, placards and other required documentation are furnished
- The tank's manway arrangement is correct
- There is a safe delivery and placement of the chlorine tank

- Markings are consistent with maintaining the gross vehicle weight below the local maximum
- The driver is fully qualified
- There is proper support for tanks that remain at the unloading facility

8.3 UNLOADING FACILITY RESPONSIBILITIES

The unloading facility should ensure that:

- Responsibility is taken if the tank is left on the premises
- The tank is unloaded in a safe area properly equipped to handle any emergency
- Safe access to the manway area by safe steps, platforms, drop bridges or guard rails is provided
- Flexible connections, valves, emergency shut-off devices are provided. Reference is made to CI Pamphlets 6 and 57
- An evacuation or absorption system or other means of purging connecting lines to prevent releases of chlorine into the atmosphere after shutoff and during disconnection is provided
- The padding system meets the appropriate standards. See Section 7
- Good lighting for night and inclement weather operations is provided
- Access is restricted to authorized persons
- Shipping documents and placarding are prepared for the return of tank to the supplier

9. RECEIVING AND SPOTTING CHLORINE TANKS

When a cargo tank motor vehicle arrives at a facility, and before it is at the transfer site, it should be ascertained that it is the proper carrier with a carrier's bill of lading authorized for the shipment of the tank to be loaded or unloaded.

The carrier furnishing the tank and/or motor unit is responsible for safe delivery to and positioning of the tank at the transfer destination. Proper positioning of the tank for transfer must be done for safety considerations. The unit should be on firm ground or supports, and out of the path of other vehicles. When the tank is spotted at the transfer rack, the driver should shut off the engine, set hand brakes and chock the wheels.

A recommended practice is obtaining keys from the driver or placing a "transfer in progress" sign on the tractor windshield. It is recommended the driver not be permitted to remain in the cab during the transfer operations (See Section 10.5 regarding monitoring of monitoring of loading/unloading).

If the tractor is to be withdrawn, the trailer support should be placed on a firm surface capable of supporting the unit. An extra nose support under the fifth wheel plate should be used.

Drivers should be instructed on emergency evacuation procedures. Precautions should be taken to prevent unauthorized movement of the tank.

10. TANK LOADING PROCEDURES

10.1 GENERAL

When loading a chlorine tank, the safety aspects of the operation should be uppermost in the minds of loading personnel. The loader must verify that proper spotting and receiving procedures have been completed before beginning transfer operations.

Proper personal protective equipment should be worn during the transfer operation (See CI Pamphlet 65). Safety showers and eye wash facilities should be immediately available.

The reader's attention is drawn to 49 CFR 177.834(i) covering the attendance requirements during the loading operation. Development of attendance procedures should take these rules into account.

10.2 TANK INSPECTION CHECKLIST

An inspection checklist should be used for all aspects of the loading operation. It should include all recommendations contained in this pamphlet plus any company procedures or special requirements specific to each facility. The checklist documents that the proper loading and securement procedures have been completed. The checklist should be retained for an appropriate period of time.

The pre-load portion of the checklist should at a minimum include:

- Determination that the proper tank has been supplied
- Check of the tank for DOT/TC specification plate. A tank that does not have one should not be loaded

- Inspection of the running gear, safety appliances, marking and other pertinent items. The purpose of this portion of the inspection is to identify all defects in the tank motor vehicle before loading any chlorine. All tank fittings should be checked to verify they are properly secured to the manway cover
- Inspection of angle valves to ensure they are closed
- An inspection for proper securement of all components and fittings. This could be verified by a pressure test
- Confirmation the tank is properly stenciled and placarded
- Verify location of C-Kit and SCBAs
- Verify Kingpin support in place if needed, brakes are set and wheels chocked

10.3 LOADING CONSIDERATIONS

Connections

The manway cover of chlorine tanks recently hydrostatically tested should receive particular attention to ensure that the gasket joint is leak proof.

Chlorine tank angle valves are equipped with a one inch pipe plug closure secured to the valve body. This plug should be tightly in place when the tank is received and located for loading. Before any connection is made all piping should be clean, dry, and free of oil. Refer to CI Pamphlet 6.

A nipple made from one inch schedule 80 carbon steel, about 15 inches long, threaded at both ends should be tightly screwed into the tank valve outlet.

The threads on the nipple should be standard NPT, sharp, clean and prepared with an appropriate sealant that is non reactive with chlorine. Care should be taken when tightening the nipple to prevent undue strain on the valve. A flexible transfer hose, per recommendations contained in Appendix A of CI Pamphlet 6 or a flexible copper loop, per CI Drawing 118, should be provided between the nipple and the permanent piping to compensate for the change in elevation of the tank during loading. A valve arrangement incorporating fail safe features, mounted as close as possible to the tank angle valve, is recommended. A chlorine pressure gauge, protected with a suitable diaphragm, with a range of twice the operating pressure, should be mounted at the beginning of the permanent piping. A second valve arrangement incorporating fail safe features should be mounted on the permanent piping feeding the chlorine to process. Use of an emergency shut-off system that meets the standards in CI Pamphlet 57 is recommended during the loading of a chlorine cargo tank.

Teflon tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly. If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed. To properly apply Teflon tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug.

Weight of Chlorine Tank

The weight of the chlorine tank with all chocks and loading connections in place should be determined and recorded. This weight should be used as the initial tare weight for filling. This procedure prevents overloading.

If it is necessary to interrupt the loading operation before the tank is completely filled, the connected weight of the partly loaded tank should be determined and recorded before disconnecting and the weight of chlorine already loaded should be calculated. When the tank is reconnected, the new connected weight of the tank should be recorded and the loading completed so that the total weight of chlorine loaded meets the required level of accuracy.

The weight of chlorine in a tank must not exceed 125% of the weight of water the tank will hold. This is defined as the filling density. It is absolutely vital to always comply with this limit. Exceeding this limit will result in an unsafe container and possible discharge of chlorine from the unit. In addition, state or provincial axle and gross load limits must not be exceeded.

Cargo tanks must be weighed either during or before and promptly after each loading to be certain that the maximum load limit was not exceeded. If loading is done on a scale, flexible filling lines must be used to ensure accurate weighing. Weights must be noted on shipping documents.

Tank Pressure

The final tank pressure should not exceed the maximum values shown on CI Drawing 201. If the tank pressure is excessive when loading is complete, the tank should be vented to a recovery system until the proper pressure is obtained.

The minimum pressure in a loaded tank when offered for shipment must be at least 20 psig for cargo tanks with the CI Drawing 101 (7,000 lb/hr) excess flow valve and 50 psig for cargo tanks with the Midland Manufacturing Corp Drawing A-120-ML (32,000 lb/hr of water). This will ensure there will be sufficient flow to close the excess flow valves if an angle valve is broken off.

Conditions of loading and padding must be such that when the temperature of the chlorine increases, pressure in the tank will not approach the pressure relief device setting. Reference is made to Section 7.

10.4 LEAK TEST

DOT requirements state in 49 CFR 173.315(o) that "prior to each loading, the cargo tank must be inspected and the angle valves and gasket joints must be examined and tested at a pressure of not less than 50 psig to determine that they are not leaking and are in proper condition for transportation." Ways to meet this requirement include documenting a leak test of at least 50 psig on a return tank prior to depressurization, and adding a small amount of chlorine at the loading rack and padding with dry air to 50 psig followed by a leak test.

A squeeze bottle containing 26° Baumé aqua ammonia (ammonium hydroxide) solution can be used to detect a minor release or leak. A white cloud will form if a leak is present. To avoid corrosion, ammonia solution should not be directly sprayed onto connections. Any efforts to detect the source of a leak should be carried out with full consideration for potential hazards.

10.5 MONITORING THE LOADING

DOT (49 CFR 177.834(i)) and TC (CSA Std B622) regulations require a cargo tank to be attended by a qualified person at all times during loading. The person attending the loading must be alert and be within 25 feet of the tank. A qualified person is one that has been made aware of the hazards of chlorine and the procedures to be followed in an emergency, is authorized to move the cargo tank and has the means to do so.

10.6 LEAKS DURING LOADING

Leaks in Connections and Piping

Chlorine piping systems should be pressure tested at regular intervals according to Institute recommendations (See CI Pamphlet 6). All chlorine piping systems should be inspected at regular intervals for signs of leakage, internal or external corrosion, insulation failure or support problems. If a chlorine leak should occur in equipment or piping, the chlorine transfer should be stopped immediately, the pressure relieved and the necessary repairs made. When the leak has been located and the faulty equipment repaired, loading may be resumed.

Leaks at Fittings

Leaks around the angle valve stems can usually be stopped by tightening the packing gland nuts. If this does not stop the leak, the angle valve should be closed. Only if a valve leak cannot be stopped by corrective measures should the Emergency Kit C be used. If the pressure relief device must be capped, regular monitoring must be established. A DOT special permit is required to move a trailer outside a facility with a C-Kit installed.

10.7 DISCONNECTING

As soon as it is determined that the tank is loaded, the liquid valves should be closed first and the loading line emptied before any other valves in the discharge system are closed. The loading line should then be purged, evacuated and disconnected. This should be done with care being sure the line has been cleared. **CAUTION:** It is imperative that no chlorine be released upon disconnection. Appropriate personal protective equipment should be worn when disconnecting lines that have contained chlorine. Reference is made to CI Pamphlet 65. Never trap liquid chlorine in the discharge line between valves, since extremely high pressure can develop from an increase in the temperature of the chlorine. This pressure may lead to hydrostatic rupture of the line.

Adequate back flow protection should be utilized to prevent chlorine contamination of the padding system. The ends of loading lines and angle valves should be capped/plugged to prevent moisture contamination.

10.8 PRERELEASE CHECK

- Inspect angle valves to ensure they are closed
- Check for leaks using aqua ammonia as soon as all connections have been secured, valves closed and outlet plugs installed wrench-tight
- Close and secure the protective housing cover
- Remove chocks
- Prepare shipping papers
- Ensure the tank pressure is recorded

11. TANK UNLOADING PROCEDURES

11.1 GENERAL

When unloading a chlorine tank the safety aspects of the operation should be uppermost in the minds of unloading personnel. Before beginning transfer operations, the unloader must verify proper spotting and unloading procedures have been followed and a cargo tank safety check, which includes the discharge system and the cargo transfer hose, has been completed. The pressure in the cargo tank must be at or above that needed to ensure operation of the excess flow valves if there were a complete separation of the cargo transfer hose.

Reference is made to Section 7.9. Proper personal protective equipment should be worn during the transfer operation, see CI Pamphlet 65. Safety showers and eyewash facilities should be readily available. In addition all suppliers' recommendations should be followed during product transfer. The reader's attention is drawn to 49 CFR 177.834(i) covering the attendance requirements during the unloading operation. Development of attendance requirements should take these rules into account.

11.2 TANK INSPECTION CHECKLIST

An inspection checklist should be used for all aspects of the unloading operation. It should include all recommendations contained in this pamphlet plus any company procedures or special requirements specific to each facility. The checklist documents that the proper unloading and securement procedures have been completed. The checklist should be retained for an appropriate period of time.

The checklist for procedures to be followed after spotting the unit should at a minimum include:

- Verification that the tank is loaded with chlorine by careful inspection of the bill of lading, the vehicle number, commodity marking and placards

- Inspection of the running gear, safety appliances, marking (including stenciling), placarding and other pertinent items. The purpose of this portion of the inspection is to identify all defects in the tank motor vehicle before unloading any chlorine

- Verification that the tank security has been maintained. (Protective housing cover seal or driver assurance)

- Opening the housing cover and inspecting the manway fittings for evidence of a leak

- Verification that the receiving tank has sufficient capacity to receive the chlorine to be transferred
- Verification that the angle valve is fully closed before removing the angle valve plug
- A FIFRA label approved by the EPA if the tank is to be unloaded at water or sewage treatment facilities in the U.S.
- A check of the discharge system and the cargo transfer hose
- Verify location of C-Kit and SCBAs
- Verify Kingpin support in place if needed, brakes are set and wheels chocked

11.3 UNLOADING CONSIDERATIONS

Connections

Chlorine tank angle valves are equipped with a one inch pipe plug closure secured to the valve body. This plug should be tightly in place when the tank is received and located for unloading. Before any connection is made all piping should be clean, dry, and free of oil. Refer to CI Pamphlet 6.

A nipple made from one inch schedule 80 carbon steel, about 15 inches long, threaded at both ends should be tightly screwed into the tank valve outlet. The threads on the nipple should be standard NPT, sharp and clean and prepared with an appropriate sealant that is non reactive with chlorine. Care should be taken when tightening the nipple to prevent undue strain on the valve. A flexible transfer hose, per recommendations contained in Appendix A of CI Pamphlet 6 or a flexible copper loop, per CI Drawing 118, should be provided between the nipple and the permanent piping to compensate for the rise of the tank during unloading.

Teflon tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly. If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed. To properly apply Teflon tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug.

A valve arrangement incorporating fail safe features, mounted as close as possible to the tank angle valve, is recommended. A chlorine pressure gauge, protected with a suitable diaphragm, with a range of twice the operating pressure, should be mounted at the beginning of the permanent piping. A second valve arrangement incorporating fail safe features should be mounted on the permanent piping feeding the chlorine to process.

Use of a proper transfer hose suitable for the transfer of chlorine as recommended in CI Pamphlet 6 should be part of the transfer system. Use of an emergency shut-off system that meets the standards in CI Pamphlet 57 is recommended during the unloading of a chlorine cargo tank. An emergency shut-off arrangement as described in CI Pamphlet 57 is required for the unloading of all chlorine cargo tanks.

It is advisable, after all connections are made, to allow a small amount of chlorine gas into the system. Each connection, valve packing and flange should then be checked for leaks. If a leak is found, it must be corrected before allowing more chlorine into the line.

A squeeze bottle containing 26° Baumé aqua ammonia (ammonium hydroxide) solution can be used to detect a minor release or leak. A white cloud will form if a leak is present. To avoid corrosion, ammonia solution should not be directly sprayed onto connections. Any efforts to detect the source of a leak should be carried out with full consideration for potential hazards.

Opening Angle Valves

Each angle valve opening on the chlorine tank is equipped with an excess flow valve. The tank liquid angle valve must be opened slowly until it is completely opened and left fully open. If opened rapidly, the excess flow valve may close and flow will not occur. The angle valves should not be opened remotely without a qualified person in attendance.

Line Pressurization

While slowly opening the tank liquid angle valve, the pressure gauge located at the beginning of the permanent piping should be observed. A rise in pressure indicates there is liquid flow. The line valve should be in a closed position at this point. As soon as the gauge indicates a steady pressure, the tank liquid angle valve should be opened fully. As soon as the valve is completely open, the same procedure should be followed at the line valve, that is, it should be opened slowly until the liquid chlorine completely fills the line to process.

CAUTION: If liquid chlorine is trapped between two valves, extremely high pressure can develop upon increase in the temperature of the chlorine. Refer to CI Pamphlet 6.

Excess Flow Valve Unseating

Chlorine tanks are equipped with excess flow valves under all angle valves. The excess flow valve consists of a rising ball or plug which blocks the flow when the rate of flow exceeds a predetermined value. It does not respond to tank pressure alone.

It is designed to close automatically against the flow of chlorine if the angle valve is broken off or if there is a complete separation of the cargo transfer hose. If there is a leak of lesser magnitude, the emergency shut down system described in CI Pamphlet 57 can be used to stop the flow of chlorine. There may be times, due to opening the angle valve too rapidly or due to unusually high flow rates, the excess flow valve will close.

If this occurs, close the angle valve on the tank and leave it closed until the metal ball or plug in the excess flow valve drops back into place. A noticeable click will be heard when the ball or plug drops. If the ball or plug does not drop a connection can be made to the other liquid valve on the tank. The supplier should be consulted if neither of these two methods is successful.

11.4 <u>Monitoring the Unloading</u>

DOT (49 CFR 177.834(i)) and TC (CSA Std. B622) regulations require a cargo tank to be attended by a qualified person at all times during unloading. The person attending the unloading must be alert, have an unobstructed view of the tank and cargo transfer hose and be within 25 feet of the tank. A qualified person is one that has been made aware of the hazards of chlorine and the procedures to be followed in an emergency, is authorized to move the cargo tank and has the means to do so.

11.5 <u>Leaks During Unloading</u>

Leaks in Connections and Piping

Chlorine piping systems should be pressure tested at regular intervals according to Institute recommendations (See CI Pamphlet 6). All chlorine piping systems should be inspected at regular intervals for signs of leakage, internal or external corrosion, insulation failure or support problems. If a chlorine leak should occur in equipment or piping, the chlorine transfer should be stopped immediately by closing the tank angle valve, the pressure relieved and the necessary repairs made. When the leak has been located and the faulty equipment repaired, unloading may be resumed.

Leaks at Fittings

Leaks around the angle valve stems can usually be stopped by tightening the packing gland nuts. If this does not stop the leak, the angle valve should be closed. Only if a valve leak cannot be stopped by corrective measures should the Emergency Kit C be used. If the pressure relief device must be capped, regular monitoring must be established. The shipper should be advised of the problem as soon as possible.

11.6 <u>Determining Amount of Chlorine Unloaded</u>

Where chlorine tanks cannot be unloaded on scales, and reliable direct gauging devices are not readily available, the most common practice for estimating the quantity of chlorine remaining in the tank is from the consumption records on the quantity removed. When a sharp drop in tank pressure occurs, unloading is normally complete. The contents must be unloaded to the maximum extent practicable.

11.7 DISCONNECTING

As soon as it is determined that the tank is as empty as possible, the liquid angle valves should be closed first and the discharge line emptied before any other valves in the discharge system are closed. The unloading lines should then be purged, evacuated and disconnected. This should be done with care being sure the line or lines have been cleared. **CAUTION:** It is imperative that no chlorine be released upon disconnection. Appropriate personal protective equipment should be worn when disconnecting lines that have contained chlorine. Reference is made to CI Pamphlet 65. Never trap liquid chlorine in the discharge line between valves, since extremely high pressure can develop from an increase in the temperature of the chlorine. This pressure may lead to hydrostatic rupture of the line.

11.8 PRERELEASE CHECK

1. Inspect angle valves to ensure they are closed
2. Check for leaks using aqua ammonia as soon as all connections have been secured, valves closed and outlet plugs installed wrench-tight
3. Close and secure the protective housing cover
4. Remove chocks
5. Prepare shipping papers

12. MAINTENANCE REQUIREMENTS

12.1 GENERAL REQUIREMENTS

As with all hazardous material transport containers, chlorine tanks must be maintained in a safe working condition. Therefore, it is essential all scheduled tests and inspections be carried out with great diligence and care.

12.2 DAILY INSPECTION AND MAINTENANCE

Pre-trip vehicle condition reports are required to be completed by the driver at the beginning of the daily run. This inspection should disclose any obvious deficiencies.

Post trip vehicle condition reports should disclose any problems or deficiencies uncovered during the day's operation.

Inspections must be conducted on the vehicle at the completion of the day's work and any necessary deficiencies corrected before the unit resumes service on the public highways. Records must be kept and be available for reference during future scheduled maintenance events to assure that a uniform and cohesive flow of information is available to future inspectors. Specific DOT requirements for inspection, repair and maintenance can be found in 49 CFR Part 396.

12.3 Periodic Maintenance

Careful and thorough vehicle maintenance should be performed on a fixed schedule as dictated by operating conditions and environment. For example, colder climates may cause maintenance problems such as corrosion due to road salting, spring and tire failure due to potholes caused by frozen roadways, etc. Each vehicle should be subjected to a thorough visual inspection on at least a quarterly basis.

Angle valves should be reconditioned at regular intervals. Before installation, each angle valve must be tested for leakage at not less than 225 psig using dry air or inert gas (49 CFR 178.337-9(b)(8)).

12.4 Hose and Fitting Maintenance

Procedures for maintenance, testing and inspection of hoses should be set by each facility based on experience, equipment use and regulatory requirements in 49 CFR 180.407 and 416. Cargo transfer hoses carried on the tank must be properly purged and capped, to prevent the ingress of moisture, and secured in a safe, proper manner.

All hoses should be of the appropriate construction and comply with recommendations found in CI Pamphlet 6, Appendix A.

Hoses shall be carefully inspected prior to and after each use to assure none of the following conditions exist: damage to the hose cover that exposes the reinforcement; damaged, slipping or excessively worn hose couplings; or loose coupling assemblies.

Each hose must be marked with a unique identification number and maximum working pressure.

12.5 Tests and Inspections

Title 49 CFR Part 180 contains the requirements for maintenance, use, inspection, repair, retest and qualification of cargo tanks. Report and record retention requirements can be found in 49 CFR 180.417.

Any required weld repairs, as described in 49 CFR 180.413, may only be accomplished by a repair shop awarded a National Board "R" Stamp.

The following is a summary of chlorine cargo tank tests and inspections. Reference is made to 49 CFR 180.407 and 416 for the specific requirements for these tests and inspections.

Test/Inspection Type	Required
• Cargo Tank External Visual Inspection	Every year (V)
• Cargo Tank Internal Visual Inspection (The visual inspection is part of the required pressure test.)	Every two years
• Cargo Tank Leakage Test	Every two years (K)
• Cargo Tank Pressure Test (The hydrostatic test method should be used to conduct the pressure test.)	Every two years (P)
• Cargo Tank Thickness Test (recommended)	Every two years
• Removal of Upper Coupler (At each pressure test)	Every two years
• Pressure Relief Device	At each Pressure Test
• Transfer Hose Inspection	Monthly
• Transfer Hose Leakage Test (Hose assembly must be marked with month and year of most recent leakage test.)	Annually
• Transfer Hose Pressure Test (Test to a minimum of 120 percent of the hose maximum working pressure and permanently mark with the month and year of test.)	New or repaired hoses
• Cargo Piping Inspection	Monthly

Thickness testing is required every two years for cargo tanks carrying materials corrosive to the tank. Specifically, liquid chlorine is not corrosive to steel. However, certain conditions can cause chlorine to become corrosive to steel, such as the introduction of moisture. Furthermore, as the exterior surface of tank envelope is masked by the insulation and jacketing, there exists the potential for corrosion on this surface which will not be revealed without the jacket removal. It is for these reasons the practice of performing a thickness test every two years is recommended.

Upon satisfactory completion of test/inspection events, the tester must place a legend denoting the month/year of the test followed with the letter signifying the type of test performed (e.g. **6/00 P** for a pressure test performed during June 2000). This legend must be permanently affixed near the specification plate in characters or anywhere on the front head, not less than $1^1/_4$ inches high. Legends are not required to be displayed noting the removal, testing, inspection and reinstallation of pressure relief devices or upper coupler assemblies, but records of these events must be available for review (49 CFR 180.415).

Every chlorine tank must have a legible DOT specification plate securely attached to the frame or shell at the front of the unit. Adjacent to this plate the legend **NQT** (for tanks of non-quenched and tempered steel) must be displayed in characters not less than two inches high.

Records demonstrating completion of tests and inspections must be maintained at the tank's terminal, or at a permitted regional, central, or terminal office according to DOT rules in Part 180.417. Records must be immediately available for review and must be completed and signed by the authorized inspector or tester. Only facilities expressly registered with the DOT and possessing a registration number may grant inspector or tester authorization using criteria established by the DOT. For minimum qualifications for inspectors or testers, see 49 CFR 180.409.

12.6 Records and Control

It is important to keep complete records of different operations related to the safe handling transfer of chlorine tanks. Logs should be kept relative to tank and valve testing. Outgoing and incoming inspection reports of full and empty tanks should be maintained for at least one year.

Records documenting the test and inspection of cargo transfer hoses must be kept. (49 CFR 180.416(f)(3)).

13. TRANSPORTATION

13.1 Route Plan

Managements of the parties operating the chlorine tank and the consignee should approve the proposed route. It is advisable to include experienced transportation personnel in this decision.

A high level of communication and confidence-building should be attained with affected authorities for emergency preparedness, familiarity with equipment and, possibly, for joint emergency response drills. **Routing of chlorine tank motor vehicles must fully comply with all federal, state local and/or provincial laws, standards or guidelines.** Actions for various alert levels as outlined in the Cl Cylinder, Ton and Cargo Plan should be reviewed.

13.2 Marking and Placarding of Tanks

DOT regulations require very specific marking and placarding on the chlorine tanks (CI Drawing 168).

Marking requirements

- **CHLORINE** must be printed in 2-inch (50 mm) letters on each side and end (49 CFR172.328(b)
- **INHALATION HAZARD** must be printed in 2-inch (50 mm) letters on two opposing sides if these words do not appear on the placard (49 CFR 172.313(a) and 172.302(b))
- **NQT** must be printed in 2-inch (50 mm) letters on MC 330 or MC 331 near the specification plate (172.328(c))
- The pressure relief device must be permanently marked with the following:
  a) The start-to-discharge pressure
  b) The actual rate of discharge of the device in cubic feet per minute of air at 60°F (15.6°C) and at atmospheric pressure
  c) The manufacturer's name and catalog number (49 CFR 173.315(i))
- All tank inlets and outlets, except pressure relief devices, must be marked to designate whether they communicate with vapor or liquid (49 CFR 178.337-9(c))
- Each tank must be durably and legibly marked, in English, with the date (month and year) and the type of test or inspection performed. The date must be readily identifiable with the applicable test or inspection. The marking must be in letters and numbers at least 1.25-inches (32-mm) high, on the tank shell near the specification plate or anywhere on the front head

The type of test or inspection may be abbreviated as follows:

V = External Visual Inspection and Test

I = Internal Visual Inspection

P = Pressure Retest

K = Leakage Test

T = Thickness Test

For example, the marking **10-00 P, V** would indicate that in October 2000 the tank received and passed the prescribed pressure retest and the external visual inspection and test (49 CFR 180.415(a)(b)).

Placarding requirements

DOT placarding is required on each side and each end of the tank, for any quantity of hazardous material (49 CFR 172.504, 506, 514 and 540). Placards alert persons to the potential dangers associated with hazardous materials contained within tanks.

Placards also guide emergency personnel who respond to incidents involving hazardous materials. At the time of pamphlet issue DOT allowed several methods of placarding. The reader is cautioned to ensure placarding meets DOT and TC regulations.

13.3 TRANSPORTATION INCIDENTS/ACCIDENTS

Chlorine Leak

At first indication of a leak in transit, the driver should quickly determine the nature of the leak. If at all possible, the vehicle should be driven to an isolated area for a complete inspection. The emergency plan should be activated. Where possible, the driver should stay on the scene to assist emergency response personnel. All other persons should be kept away from the affected area. The location of a leak can usually be detected by the reaction of aqua ammonia vapor with the escaping chlorine. See 10.4 for information on testing for leaks.

The Institute's Emergency Kit C contains devices to stop leaks from the angle valves and the pressure relief device, as well as leaks between the valves and the manway cover. Respiratory equipment is not included in the kit. DOT regulations require respiratory equipment to be on board the motor vehicle during transportation.

Never use water on a chlorine leak. Chlorine is only slightly soluble in water, and the corrosive action of chlorine and water will make a leak worse.

Fire

In the event of fire, the vehicle should be removed from the fire zone immediately. If it cannot be moved, the driver should advise the emergency response personnel that the container should be kept cool by applying water. Although non-flammable, chlorine will react vigorously with most metals (including steel) at high temperatures.

Collision

In the event of a minor collision not affecting the safety of the chlorine tank, normal procedures for reporting any traffic accident should be followed. In the event of a collision that damages the chlorine tank, or the running gear of the chlorine tank, even if no leak has developed, the driver should contact the shipper. If a chlorine leak develops or the potential for a leak is present, the emergency plan should be activated.

Reports

When transporting chlorine in tanks, all carriers in local, intrastate or international commerce must comply with DOT Part 394 "Notification, Reporting and Recording of Accidents", and DOT 171.15 "Immediate notice of certain hazardous material incidents".

14. REFERENCES

14.1 Institute Publications

Pamphlet & Drawing #	**Title**
1	*Chlorine Basics,* ed. 7; Pamphlet 1; The Chlorine Institute: Arlington, VA, **2008**.
5	*Bulk Storage of Liquid Chlorine*, ed. 7; Pamphlet 5; The Chlorine Institute: Arlington, VA, **2005**.
6	*Piping Systems for Dry Chlorine*, ed. 15; Pamphlet 6; The Chlorine Institute: Arlington, VA, **2005**.
57	*Emergency Shut-Off Systems for Bulk Transfer of Chlorine*, ed. 5; Pamphlet 57; The Chlorine Institute: Arlington, VA, **2009**.
65	*Personal Protective Equipment for Chlor-Alkali Chemicals*, ed. 5; Pamphlet 65; The Chlorine Institute: Arlington, VA, **2008**.
73	*Atmospheric Monitoring Equipment for Chlorine*, ed. 7; Pamphlet 73; The Chlorine Institute: Arlington, VA, **2003**.
95	*Gaskets for Chlorine Service*, ed. 4; Pamphlet 95; The Chlorine Institute: Arlington, VA, **2008**.
152	*Safe Handling of Chlorine Containing Nitrogen Trichloride*, ed. 2; Pamphlet 152; The Chlorine Institute, Arlington, VA, **2005**.

290 of 593

Pamphlet & Drawing #	Title
IB/C	IB/C Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks, ed. 8-R1; Pamphlet IB/C; The Chlorine Institute: Arlington, VA, **2006**.
DWG-101	*Excess Flow Valve with Removable Seat - 7000 lbs/hr*, Drawing; DWG 101-7; The Chlorine Institute: Arlington, VA, **1993**.
DWG-102	*Studs, Nuts and Gaskets for Chlorine Tank Manway Covers and Valves*, Drawing; DWG 102-11; The Chlorine Institute: Arlington, VA, **2006**.
DWG-103	*Manway Cover for Chlorine Tank Cars and Cargo Tanks*, Drawing; DWG 103-8; The Chlorine Institute: Arlington, VA, **2001**.
DWG-104	*Standard Chlorine Angle Valve Assembly*, Drawing; DWG 104-9; The Chlorine Institute: Arlington, VA, **2002**.
DWG-105	*Standard Chlorine Angle Valve Parts*, Drawing; DWG 105-10 (two sheets); The Chlorine Institute: Arlington, VA, **2002**.
DWG-106	*Excess Flow Valve with Removable Gasket*, Drawing; DWG 106-6; The Chlorine Institute: Arlington, VA, **1993**.
DWG-118	*Chlorine Tank Car Unloading Connection*, Drawing; DWG 118-4; The Chlorine Institute: Arlington, VA, **1991**.
DWG-119	*Chlorine Tank Car Air Padding, Drawing*; DWG 119-3; The Chlorine Institute: Arlington, VA, **1993**.
DWG-137	*Typical Manway Arrangement - Chlorine Cargo Tank*, Drawing; DWG 137-5; The Chlorine Institute: Arlington, VA, **1996**.
DWG-168	*Chlorine Cargo Tank Marking and Placarding*, Drawing; DWG 168-5; The Chlorine Institute: Arlington, VA, **1998**.
DWG-201	*Maximum Internal Tank Pressure for Padding Chlorine Bulk Transports*, Drawing; DWG 201-3; The Chlorine Institute: Arlington, VA, **2001**.
DWG-H-51970	*Pressure Relief Device for Chlorine Service - Metallic Seat Design*, Styles 1 ½ JQ 225 and 1 ½ JQ 375, Drawing; H-51970-F; Anderson Greenwood Crosby: Wrentham, MA, **1996**.
DWG-H-50155	*Pressure Relief Device for Chlorine Service - Elastomeric Seat Seal Design*, Styles 1 ½ JQ 375, Drawing; H-50155-H; Anderson Greenwood Crosby: Wrentham, MA, **1996**.
Security	Security Management Plan for Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks

14.2 DOT REGULATIONS

14.2.1 *Hazardous Materials Regulations.* Department of Transportation. 49 CFR Parts 170-178. U.S. Government Printing Office: Washington, DC, (revised annually).

14.2.2 *Federal Motor Carrier Safety Regulations.* Department of Transportation. 49 CFR Parts 386-399. U.S. Government Printing Office: Washington, DC, (revised annually).

14.3 CANADIAN REGULATIONS

14.3.1 *Canadian Transportation of Dangerous Goods in Clear Language*; ICC International Compliance Center Ltd: Mississauga, Ontario, **2008**.

14.3.2 *Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods*; CSA B620; Canadian Standards Association: Mississauga, Ontario, **2009**.

14.3.3 *Selection and Use of Highway Tanks, Multiunit Tank Car Tanks, and Portable Tanks for the Transportation of Dangerous Goods Class 2, by Road*; CSA B622; Canadian Standards Association: Mississauga, Ontario, **2009**.

14.4 EPA REGULATIONS

Code of Federal Regulations. Title 40. Part 150. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

14.5 OSHA REGULATIONS

Code of Federal Regulations. Title 29. Part 1910. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

"OSHA Standard Method for Determination of Respiratory Protection Program Acceptability"

14.6 OTHER PUBLICATIONS

14.6.1 *Inter-Industry Bulk Chemical Highway Safety Task Force Manual of Recommendations*; The American Chemistry Council: Arlington, VA, and National Tank Truck Carriers: Alexandria, VA **1996**.

14.6.2 American Trucking Association Sample Hazmat Transportation Security Plan (5/31/03)

For further assistance and information on items referenced, contact:

American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5000
703-741-6000 (Fax)
www.americanchemistry.com

Canadian Chemical Producers Association
350 Sparks Street
Suite 805
Ottawa, Ontario K1R 7S8 (Canada)
613-237-6215
613-237-4061 (Fax)
www.ccpa.ca

Government of Canada Publications
Ottawa, Ontario K1A 0S5 (Canada)
1-800-635-7943
www.publications.gc.ca

Canadian Standards Association
5060 Spectrum Way
Mississauga, Ontario L4W 5N6 (Canada)
416-747-4000
416-747-4044 (standard purchases)
416-747-4149 (Fax)
www.csa.ca

International Compliance Center Ltd.
205 Matheson Boulevard, East, Unit 7
Mississauga, Ontario L4Z 1X8 (Canada)
416-890-7227
416-890-7070 (Fax)
www.thecompliancecenter.com

National Tank Truck Carriers, Inc.
950 North Glebe Road, Suite 520
Arlington, VA 22203
703-838-1960
703-684-5753 (Fax)
www.tanktruck.org

Superintendent of Documents
Government Printing Office
732 North Capitol Street, NW
Washington, DC 20401
202-512-0000
www.access.gpo.gov

The Chlorine Institute, Inc.
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5760
703-741-6068 (Fax)
www.chlorineinstitute.org

APPENDIX A

PAMPHLET 49 CHECKLIST

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

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

Yes	No	N/A			
❐	❐	❐	1.	Are personnel familiar with facility and transfer site emergency plans?	{3.1.1}
❐	❐	❐	2.	Are Emergency Kit C and SCBA carried on chlorine motor vehicles?	{3.3, 3.4}
❐	❐	❐	3.	Are personnel trained in regulatory requirements for chlorine?	{4.1}
❐	❐	❐	4.	Has shipper registered with EPA and are tanks properly labeled when chlorine is to be used in FIFRA regulated application?	{4.2}
❐	❐	❐	5.	Do chlorine tanks meet all governmental specifications and Chlorine Institute recommendations?	{5.1.-5.3.5}
❐	❐	❐	6.	Are drivers properly qualified and preapproved prior to transporting chlorine?	{6.3}
❐	❐	❐	7.	Are carriers properly qualified and preapproved prior to transporting chlorine?	{6.3}
❐	❐	❐	8.	Are the shipper and carrier registered under the US DOT Hazardous Materials Registration Program?	{6.4}
❐	❐	❐	9.	Are conditions during loading and padding such that tank pressure will not approach the relief device setting?	{7.1}
❐	❐	❐	10.	Is air, used for unloading and padding, free from oil and foreign matter, dried at or below specified dew point and tested using a commercial dew point tester?	{7.5}
❐	❐	❐	11.	Does the loading facility comply with the responsibilities outlined in CI Pamphlet 49?	{8.1}
❐	❐	❐	12.	Does the carrier comply with the responsibilities outlined in CI Pamphlet 49?	{8.2}

Yes	No	N/A		
❐	❐	❐	13. Does the unloading facility comply with the responsibilities outlined in CI Pamphlet 49?	{8.3}
❐	❐	❐	14. Is an inspection checklist used for all aspects of the loading operation?	{10.2}
❐	❐	❐	15. Is an inspection checklist used for all aspects of the unloading operation?	{11.2}
❐	❐	❐	16. Is a qualified person in attendance at all times during cargo tank unloading to meet governmental requirements?	{11.4}
❐	❐	❐	17. Are chlorine tanks maintained and tested per governmental requirements?	{12.5}
❐	❐	❐	18. Are records maintained consistent with governmental regulations?	{12.6}
❐	❐	❐	19. Are chlorine tanks marked and placarded per governmental requirements?	{13.2}
❐	❐	❐	20. Is a transportation security plan as specified by 49 CFR 172.800 in place?	{14.2.1}
❐	❐	❐	21. Are training records in place to document that employees are trained to the security plan?	{14.3.2}

REMINDER:

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

APPENDIX B

Cargo Tank Certifications

CARSON
ENGINEERING

P.O. Box 2969 ● Renton, WA 98056 ● (425) 235-7551 ● Fax (425) 277-5780 ● E-MAIL - carengr@nwrain.com

CHLORINE CARGO TANK UNLOADING SYSTEM CERTIFICATION

(A) Summary

This document is the Design Certifying Engineer certification of the design for the means to provide for a passive shut-down of the chlorine cargo tank unloading system within twenty seconds of an unintentional release caused by a complete separation of a liquid delivery hose as required by U.S. Department of Transportation regulations in Title 49 CFR 173.315 (n)(2), published on May 24, 1999 (64 FR 28029).

(B) Description of the Chlorine Cargo Tank Unloading System

A chlorine cargo tank unloading system consists of a closed loop process involving liquid and gaseous chlorine consisting of liquid chlorine flow through -

a) Six foot length of 1¼-inch schedule 80 eduction pipe inside the cargo tank.
b) An excess flow valve as per The Chlorine Institute, Inc. Drawing 101 (7,000 lb/hr)
c) An angle valve assembly as per The Chlorine Institute, Inc. Drawing 104.
d) Up to 18-inches length of one inch schedule 80 pipe nipple.
e) An automatic isolation valve. This valve, which may not be on all systems, consists of a ball or plug valve of nominal one-inch diameter. This valve, in the fully opened position, has a Cv of at least 44.
f) A chlorine transfer hose with a nominal one-inch diameter with a maximum length of 25 feet.

(C) Certification

I have reviewed technical information and performed volumetric flow calculations pertaining to the chlorine cargo tank unloading system as described above and found the chlorine cargo tank transfer system, as described above, meets the design requirements of Title 49 CFR 173.315 (n)(2), that is, the system's excess flow valves will shut-down the flow of chlorine cargo within twenty seconds of an unintentional release caused by a complete separation of a liquid delivery hose, under the following conditions:

a) The pressure in the cargo tank is at least 20 psig;
b) The angle valve and the other valves in the system are in the fully opened position;
c) The cargo transfer hose is no more than 42 inches above the angle valve opening; and
d) The excess flow valves are properly maintained and meet the manufacturer's design specifications.

As a Design Certifying Engineer registered with the U.S. Department of Transportation, I certify the above to be true and correct.

12-23-99

Signed:

William D. Carson, DOT Certification ID #CT8063

WILLIAM D. CARSON
STATE OF WASHINGTON
REGISTERED PROFESSIONAL ENGINEER

EXPIRES 9/15/2000

CARSON
ENGINEERING

P.O. Box 2969 ● Renton, WA 98056 ● (425) 235-7551 ● Fax (425) 277-5780 ● E-MAIL - carengr@nwrain.com

CHLORINE CARGO TANK UNLOADING SYSTEM CERTIFICATION

(A) **Summary**

This document is the Design Certifying Engineer certification of the design for the means to provide for a passive shut-down of the chlorine cargo tank unloading system within twenty seconds of an unintentional release caused by a complete separation of a liquid delivery hose as required by U.S. Department of Transportation regulations in Title 49 CFR 173.315 (n)(2), published on May 24, 1999 (64 FR 28029).

(B) **Description of the Chlorine Cargo Tank Unloading System**

A chlorine cargo tank unloading system consists of a closed loop process involving liquid and gaseous chlorine consisting of liquid chlorine flow through

a) Six foot length of 1¼-inch schedule 80 eduction pipe inside the cargo tank.
b) An excess flow valve as per Midland Manufacturing Corp. A-120-ML
c) An angle valve assembly as per Midland Manufacturing Corp. Model A-713-ML.
d) Up to 18-inches length of one inch schedule 80 pipe nipple.
e) An automatic isolation valve. This valve, which may not be on all systems, consists of a ball or plug valve of nominal one-inch diameter. This valve, in the fully opened position, has a Cv of at least 44.
f) A chlorine transfer hose with a nominal one-inch diameter with variable length (see below).

(C) **Certification**

I have reviewed technical information and performed volumetric flow calculations pertaining to the chlorine cargo tank unloading system as described above and found the chlorine cargo tank transfer system, as described above, meets the design requirements of Title 49 CFR 173.315 (n)(2), that is, the system's excess flow valves will shut-down the flow of chlorine cargo within twenty seconds of an unintentional release caused by a complete separation of a liquid delivery hose, under the following conditions:

a) The pressure in the cargo tank is variable dependent on hose length:

Hose Length	Minimum Tank Pressure
10 ft	50 psig
15 ft	68 psig
20 ft	85 psig
25 ft	103 psig

b) The angle valve and the other valves in the system are in the fully opened position;
c) The cargo transfer hose is no more than 42 inches above the angle valve opening; and
d) The excess flow valves are properly maintained and meet the manufacturer's design specifications.

As a Design Certifying Engineer registered with the U.S. Department of Transportation, I certify the above to be true and correct.

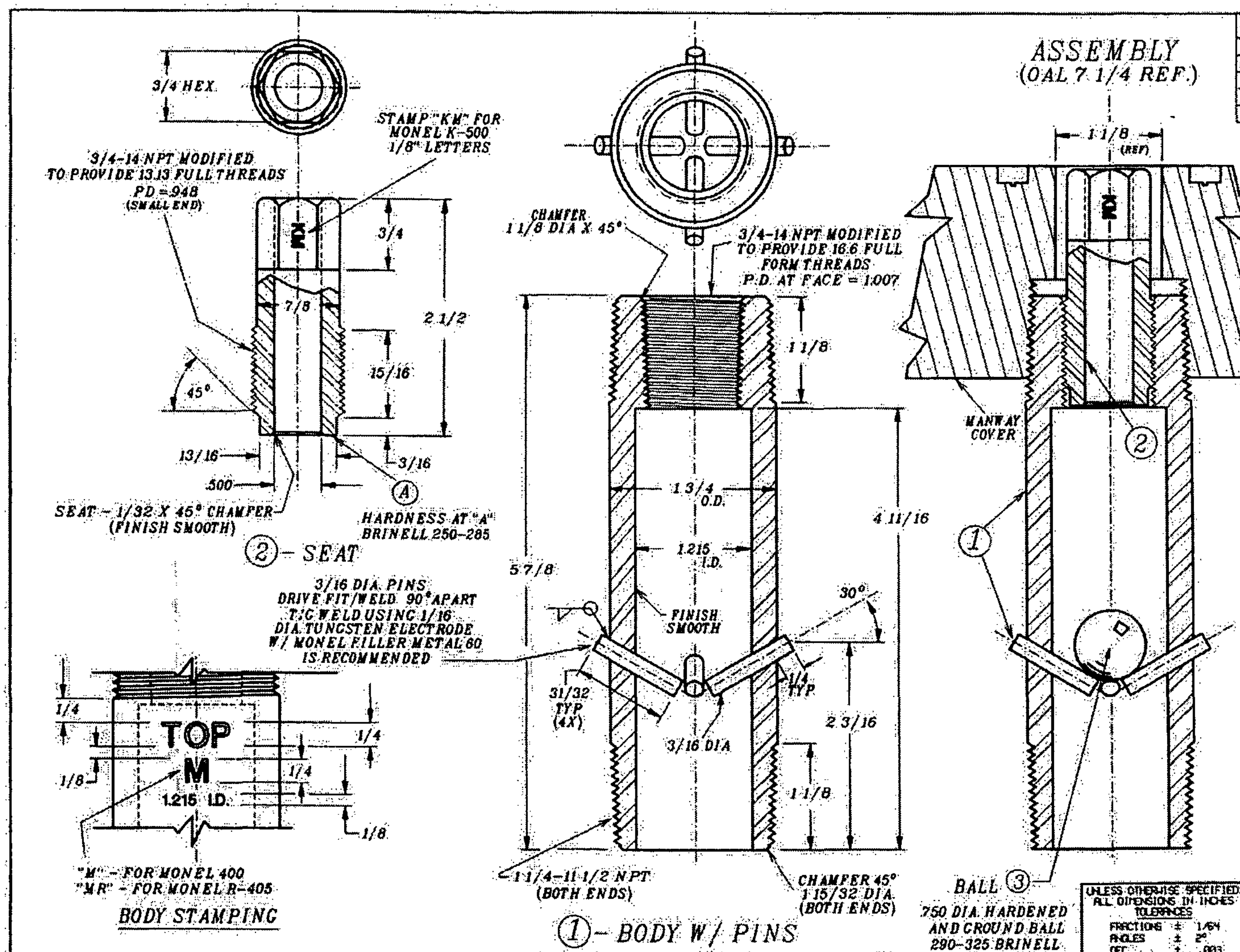
4/28/00

Signed:

William D. Carson DOT Certification ID #CT8063

WILLIAM D. CARSON
STATE OF WASHINGTON
00182?7
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES 9/15/00

DRAWINGS



ITEM	PART NAME	MATERIAL
1	BODY ASSY	
1A	BODY	MONEL 400 or R 405
1B	PINS	MONEL K-500
2	SEAT	MONEL K-500
3	BALL	MONEL K-500

NOTES:

1. ALL THREAD TOLERANCES AND GAUGING SHALL CONFORM TO ANSI B2.1(NPT) AND ANSI B1.1 (SCREW THREADS)
2. BREAK ALL SHARP EDGES
3. BODY ASSEMBLY MUST BE PRESSURE TIGHT AT 90 PSIG
4. THIS VALVE IS DESIGNED FOR USE UNDER THE LIQUID ANGLE VALVES ON CHLORINE TANK CARS AND MOTOR VEHICLE TANKS.

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

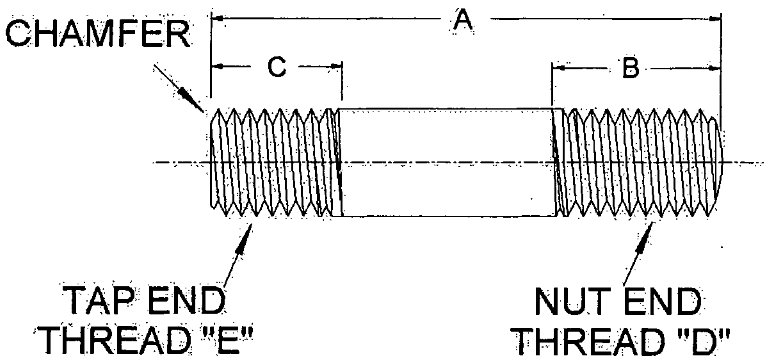
ISS	DATE	REVISION	APPR
7	7/93	REDRAWN	
6	9/73	ADD 1/4" TO PINS, WELD NOTE	CCSS
6	9/73	ADD R-405 AUTH.	CCSS
5	4/71	NOTE 1 & MAT. SPEC ADD	CCSS
4	5/69	NOTES AND TITLE REVISED	CCSS
3	1/59	THDS REV. NOTES ADDED	CCSS
2	8/57	GENERAL REVISION	CCSS
1	10/56	INITIAL ISSUE	RLM

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

EXCESS FLOW VALVE WITH REMOVABLE SEAT

MAXIMUM OPERATING FLOW RATE 7000 LBS LIQUID CHLORINE PER HOUR

DRAWN	A. KASS	7-93	
TRACED		SCALE 1" = 1"	
CHECKED	REP		
APPROVED			
DWG. NO.	101	ISSUE	7



ITEM	PART	USE
1	STUD	Tank car and cargo tank pressure relief device (1 1/2 JQ)
2	STUD	Standard angle valve and tank car protective housing. (see NOTE 7)
2A	STUD	Alternate angle valve. (see NOTE 7)
3	STUD	Tank car and cargo tank manway cover.
4	GASKET	Angle valve, pressure relief device (1 1/2 JQ)
5	GASKET	Tank car and cargo tank manway cover.
6	NUT	Angle valve, pressure relief device (1 1/2 and 4JQ) tank car and cargo tank protective housing.
7	NUT	Tank car and cargo tank manway cover.
8	GASKET	Tank barge pressure relief device (4JQ)
9	STUD	Tank barge pressure relief device (4JQ)

STUDS

DIM.	ITEM 1	ITEM 2	ITEM 2A	ITEM 3	ITEM 9	CLASS OR TOL.
A	3 3/4	3	2 5/8	4 1/2	4 1/8	+1/16,-0
B	2 3/8	1 5/8	1 1/4	2 3/4	1 3/8	+0,-1/16
C	7/8	7/8	7/8	1 1/4	1	+0,-1/16
D	3/4-10 UNC	3/4-10 UNC	3/4-10 UNC	1 1/8-7 UNC	3/4-10 UNC	2A
E	3/4-10 UNC	3/4-10 UNC	3/4-10 UNC	1 1/8-7 UNC	3/4-10 UNC	3A

ITEM 6 - 3/4-10 UNC-2B (1 1/4 ACROSS FLATS)
ITEM 7 - 1 1/8-7 UNC-2B (1 13/16 ACROSS FLATS)

Material shall conform to ASTM A320 Grade L7 specifications including impact testing.

GASKETS

DIM	ITEM 4	ITEM 5	ITEM 8
OD	2 1/4	20 1/4	6 3/16
ID	1 1/2	19 1/4	5 3/16
THICK	1/8	1/8	1/8

MATERIAL: Per gasket material section in pamphlet 95

NUTS

Nuts shall be heavy series, semifinished hexagon type in conformance with ANSI B18.22 & ASTM A194

NOTES:

1. Dimensions in inches unless noted.
2. Screw thread tolerance and gaging shall conform to ANSI B1.1.
3. Dimensions "B" and "C" include 1 to 1-1/4 imperfect threads.
4. Lock washers not permitted.
5. Cargo tank parts are identical to tank car parts.
6. Place grade mark "L7" on nut end of stud.
7. The valve supplier should be consulted for the proper stud dimensions.

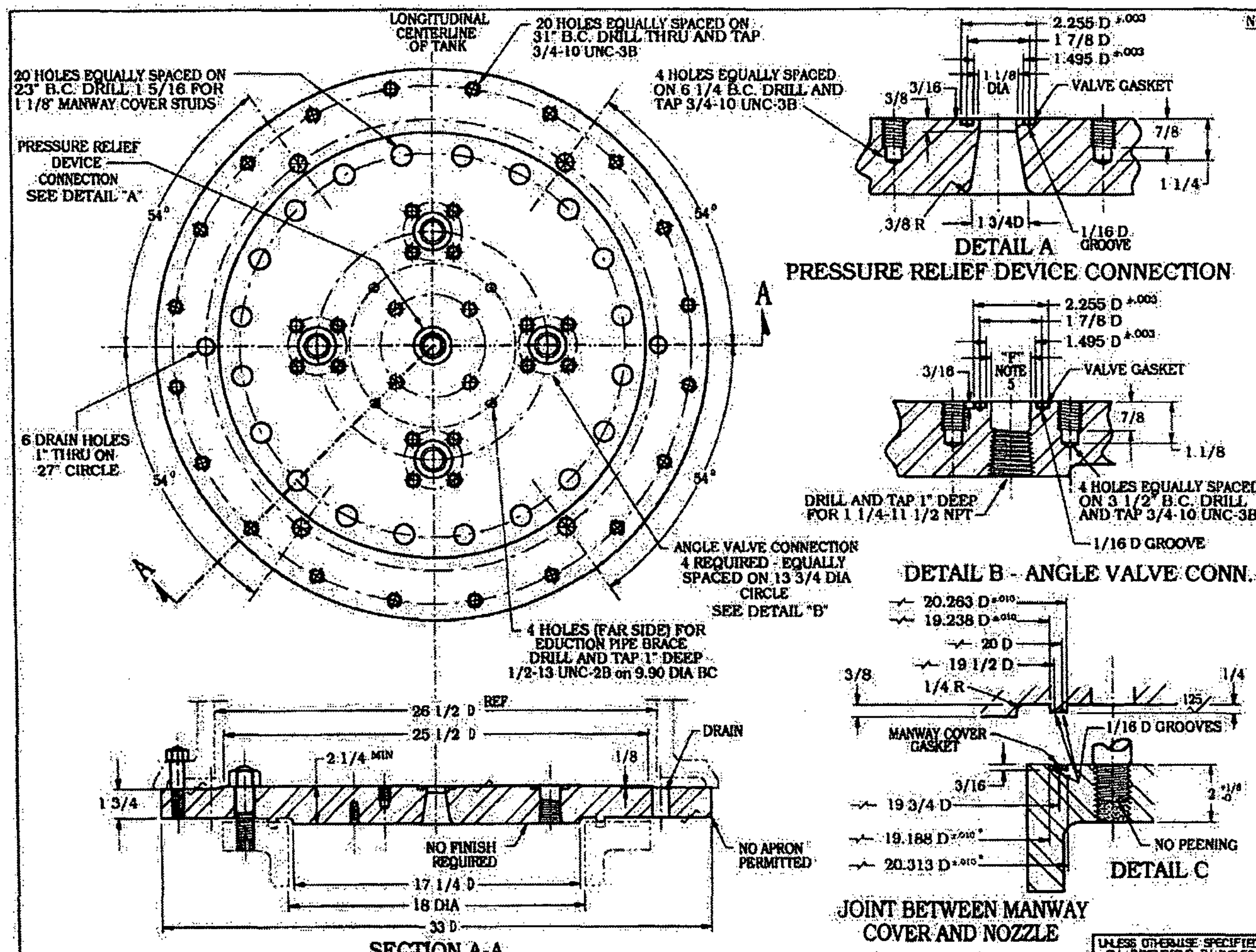
THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

ISS	DATE	REVISION	APPR
11	10/06	ADDED "2A", REVISED NOTES	
10	1/01	CLARIFIED USE & MAT. NOTES	STC
9	7/93	REDRAWN	
8	8/83	CORRECT DIM "C", ITEM 2 & 9	
7	9/82	ADD NOTE 6	STC
6		GASKET SPEC UPDATED	CCSS
5	9/76	ITEMS 1-3, DIM. A, B & C REV.	
4	11/62	4JQ STUDS, 8C GASKET ADDED	CCSS
3	5/58	GENERAL REVISIONS	CCSS
2	1/58	THREADS REVISED TO UNC	CCSS
1	2/57	ISSUED	RLM

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

STUDS, NUTS & GASKETS FOR CHLORINE TANK MANWAY COVERS & VALVES

DRAWN	A. KASS	7-93
TRACED		
CHECKED	REP	
APPROVED		
DWG. NO. 102		ISSUE 11



NOTE: * NEW CONSTRUCTION OR REPAIR INCLUDING FULL FILL OF GROOVE WITH WELDING:
±.010 - AS MACHINED
±.035 - AS CAR COMPLETED

NOTES:

1. BREAK ALL SHARP CORNERS IN ACCORD WITH GOOD COMMERCIAL PRACTICE.
2. THREAD TOLERANCE AND GAGING SHALL CONFORM TO ANSI B1.1 FOR SCREW THREADS AND ANSI B2.1 FOR NPT THREAD.
3. MATERIAL - ASTM A516-70 NORM.
4. SEE DRAWING 107 FOR TANK CAR MANWAY ARRANGEMENT; SEE DRAWING 137 FOR CARGO TANK MANWAY ARRANGEMENT.
5. FOR TANK CAR MANWAY COVERS, DIA. F=1 1/8. FOR CARGO TANK MANWAY COVERS, DIA. F=1 1/4.
6. MACHINED SURFACE TO BE 250 UNLESS OTHERWISE SPECIFIED.
7. BOLT CIRCLES AND GROOVES TO BE CONCENTRIC WITH EACH OTHER WITHIN ±.015
8. BOLT HOLE SPACING ON BOLT CIRCLES TO BE EQUALLY SPACED WITHIN ±.015

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

ISS	DATE	REVISION	APPR
8	1/01	ADDED TOLERANCING NOTE	STC
7	11/96	ADDED TOLERANCING	
6	11/93	REDRAW	
5	9/77	"MIN" ADDED TO THICKNESS DIM.	CCSS
4	9/71	DET. B & NOTES REVISED	CCSS
3	1/58	REMOVE NOTE 5-EDITORIAL REV	CCSS
2	6/57	HOUSING STUD DRILLING	CCSS
1	3/57	INITIAL RELEASE	CCSS

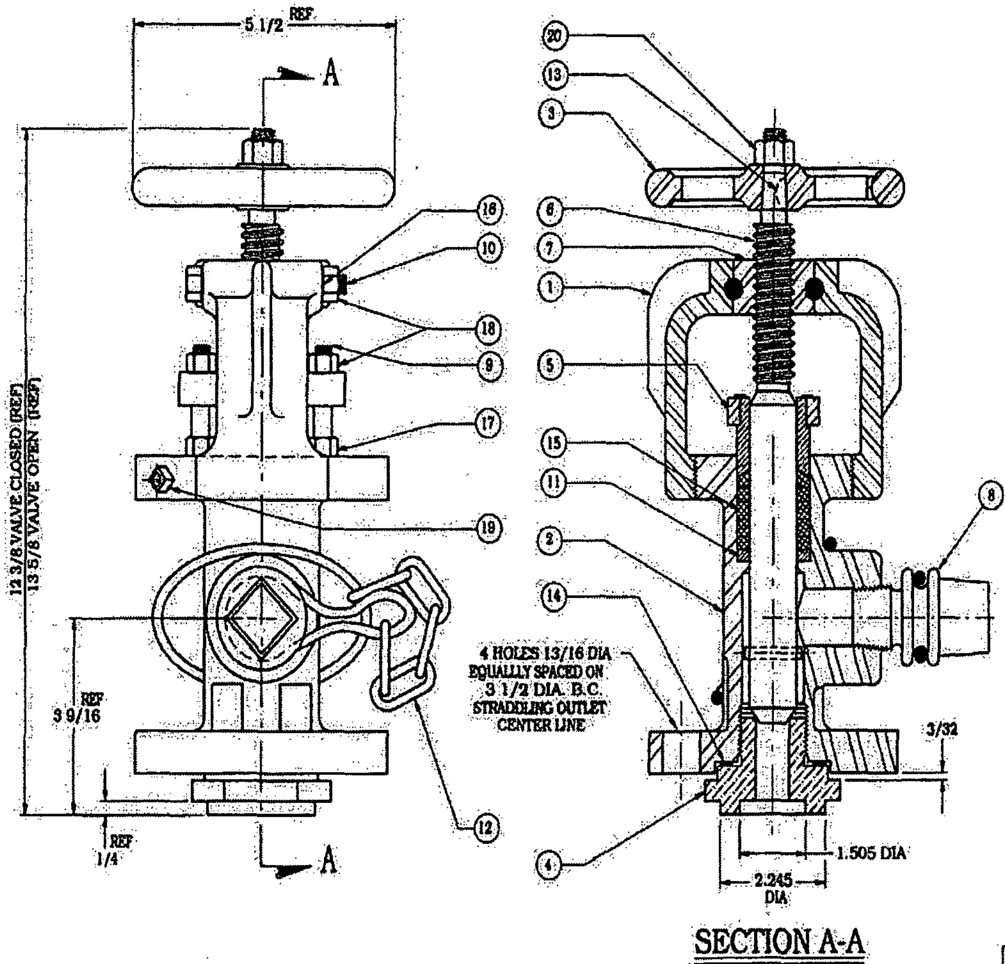
THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

MANWAY COVER FOR CHLORINE TANK CARS AND CARGO TANKS 18" MANWAY

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES

FRACTIONS	±	1/64
ANGLES	±	2°
DEC.	±	.005

DRAWN	A. KASS	11-93	
TRACED		SCALE = 1" = 6"	
CHECKED	REP		
APPROVED			
DWG. NO.	103	ISSUE	8



ITEM	NAME OF PART	QTY	MAT
1	YOKE	1	STL
2	BODY	1	STL
3	HANDWHEEL	1	IRON
4	SEAT	1	MONEL
5	PACKING GLAND ASSY.	1	MONEL
6	STEM ASSY.	1	MONEL
7	YOKE BUSHING	1	STL
8	PLUG	1	STL
9	PACKING GLAND STUD	2	STL
10	BUSHING BOLT	2	STL
11	PACKING RETAINER	1	MONEL
12	PLUG CHAIN/CABLE ASSY.	1	STL
13	WOODRUFF KEY #606	1	STL
14	SEAT GASKET	1	NOTE 2
15	PACKING RING SET	6/7	DWG.105
16	BUSHING LOCKWASHER	2	STL
17	GLAND STUD JAM NUT	2	STL
18	NUT	4	STL
19	SET SCREW	2	STL
20	HANDWHEEL NUT	1	STL

NOTES:

1. Nuts shall be steel American Std. Heavy series semi-finished, hex type.
2. Gasket material may be 2-3% antimony lead, compressed asbestos sheet to Fed spec HH-P-46S or Garlock 3510.
3. See Dwg. 102 for mounting studs, gasket details and specifications.
4. See Dwg. 105 for details of design and material including alternatives.
5. See Dwg. 190 for condemning limits.

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

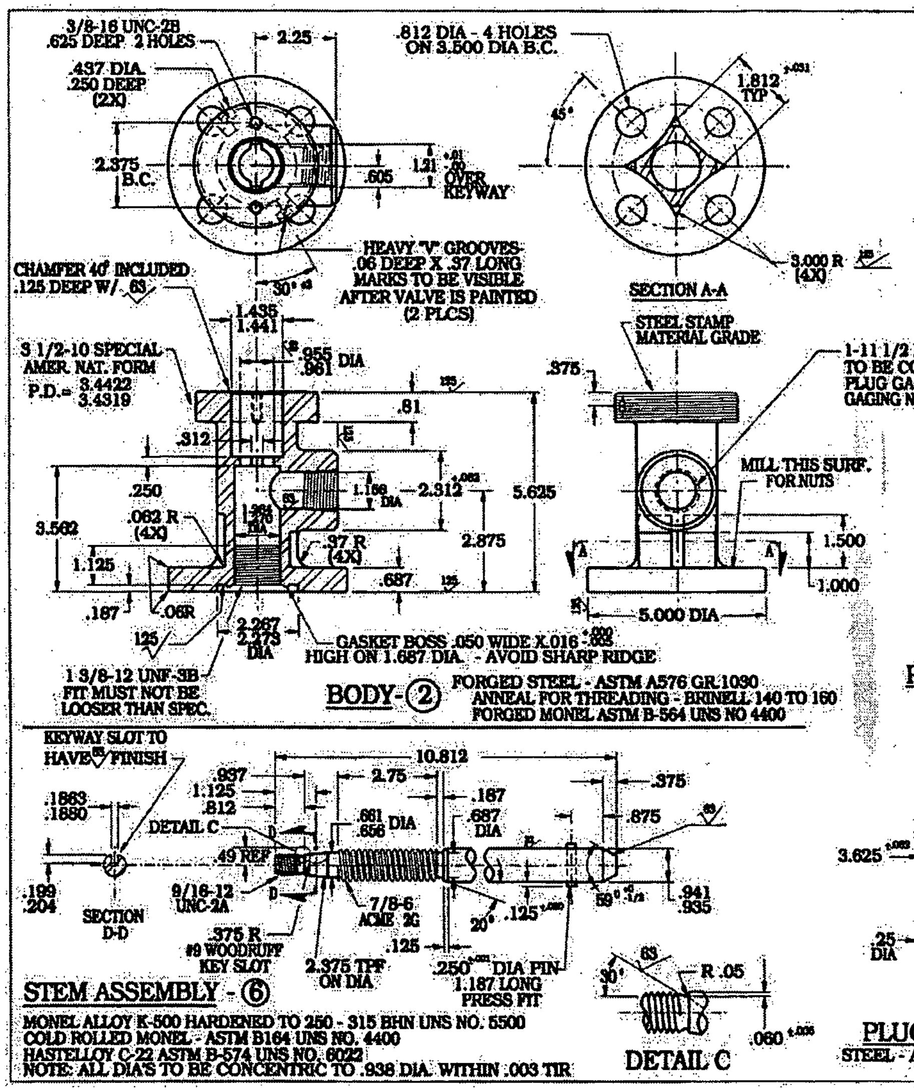
ISS	DATE	REVISION	APPR
9	4/02	EDITED NOTE 2	STC
8	12/97	MODIFY ITEMS: 7, 12, & 17	STC
7	7/93	REDRAW	STC
6	12/83	13 5/8 WAS 12 5/8	STC
5	9/78	REDRAWN - VALVE ASSY.	DCSS
4	5/58	STUD & STEM REVISED	DCSS
3	1/58	GENERAL REVISIONS	DCSS
2	6/57	PLUG CHAIN REVISED	DCSS
1	3/57	INITIAL RELEASE	DCSS

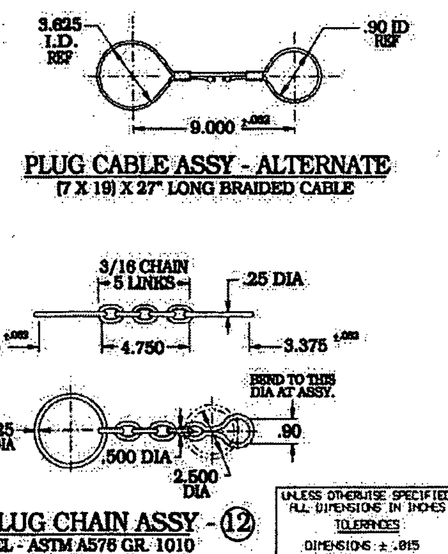
THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

STANDARD CHLORINE ANGLE VALVE ASSEMBLY

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/64
ANGLES ± 2°
DEC. ± .003

DRAWN	A. KASS	7-93
TRACED		SCALE = NONE
CHECKED	MEL	
APPROVED		
DWG. NO.	104	ISSUE 9





ITEM	NAME OF PART	MATERIAL DESCRIPTION	DIMENSIONS
13	WOODRUFF KEY #606	STEEL	PER ANSI B17.2
14	SEAT GASKET	2-3% ANTIMONY LEAD GARLOCK GYLON 3510 COMPRESSED ASBESTOS SHEET TO FEDERAL SPEC HH-P 46E	2 1/4 OD x 1 13/32 ID x 1/16 or 1/8 THICK
15	PACKING RINGS	GASKET & STEEL FABRICATORS, 3-12-1 VIRGIN PTFE (7 RINGS INCL. 1 OUTER & 1 INNER BEVELED). SEE NOTE 7 GARLOCK 6130 (5 RINGS) CHICAGO GASKET B-4004 OR EQUIV (7 RINGS INCL. 1 OUTER & 1 INNER BEVELED). SEE NOTE 7	(AREA TO BE FILLED) 1 7/16 OD X 15/16 ID
16	BUSHING LOCK WASHER	STEEL	3/8 REG ANSI B27.1
17	GLAND STUD JAM NUT	STEEL - ASTM A194 GR. 2H	3/8-16 UNC 2B-NOTE 3
18	NUT	STEEL - ASTM A194 GR. 2H	3/8-16 UNC 2B-NOTE 3
19	SET SCREW	STEEL - ASTM A194 GR. 2H SQ. HD. DOG POINT ANSI B18.6.2	3/8-16 UNC 2A 7/8 LONG
20	HANDWHEEL NUT	STEEL - ASTM A194 GR. 2H	9/16-12 UNC 2B-NOTE 3

ITEM	REQD	NAME OF PART
1	1	YOKE
2	1	BODY
3	1	HANDWHEEL
4	1	SEAT
5	1	PACKING GLAND ASSY
6	1	STEM ASSY
7	1	YOKE BUSHING
8	1	PLUG
9	2	PACKING GLAND STUD
10	2	BUSHING BOLT
11	1	PACKING RETAINER
12	1	PLUG CHAIN ASSY
13	1	WOODRUFF KEY
14	1	SEAT GASKET
15	1	PACKING RING SET
16	2	BUSHING LOCKWASHER
17	2	GLAND STUD JAM NUT
18	4	NUT
19	1	SET SCREW
20	1	HANDWHEEL NUT

NOTES:
1. BREAK ALL SHARP EDGES IN ACCORD WITH GOOD COMMERCIAL PRACTICE.
2. THREAD TOL. AND GAGING SHALL CONFORM TO ANSI B1.1 FOR SCREW THREADS & ANSI B1.1 FOR NPT THREADS
3. NUTS SHALL BE HEX SERIES SEMI-FINISHED PER ANSI B18.2.2
4. TO DISTINGUISH THE MONEL PARTS OF THE VALVE, THE FOLLOWING PREFERRED STAMPING 1/32 HIGH LETTERS IS RECOMMENDED:
KM - FOR MONEL ALLOY K500
M - FOR MONEL UNS NO 4400
MR - FOR MONEL UNS NO 4405
H - FOR HASTELLOY NO 6022
5. SEE DWG 102 FOR MOUNTING STUDS, GASKET DETAILS AND SPECS.
6. SEE DWG 104 FOR VALVE ASSEMBLY
7. WHEN USING PTFE PACKING RINGS THE MIN SUGGESTED PACKING GLAND TORQUE IS 100 IN-LB. AND THIS SHOULD BE RECHECKED AFTER 24 HRS.

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ISS	DATE	REVISION	APPR
10	4/02	UPDATE PACKING RING INFO	STC
9	1/01	UPDATE PACKING GLAND 5	STC
8	12/97	MAT. FOR ITEMS 17-20, STEM FINISH	STC
7	7/93	REDRAW	STC
6	12/82	MAT'L ITEMS 8,15 & NOTE 9	STC
5	9/77	MAT'L ITEMS 2,4 & 15	CCSS
4	9/72	REDRAW, INC. ALL VALVE PARTS	CCSS
3	6/64	BUSHING ALTERNATE ADDED	CCSS
2	1/60	BODY ALTERNATES ADDED	CCSS
1	5/57	INITIAL RELEASE	CCSS

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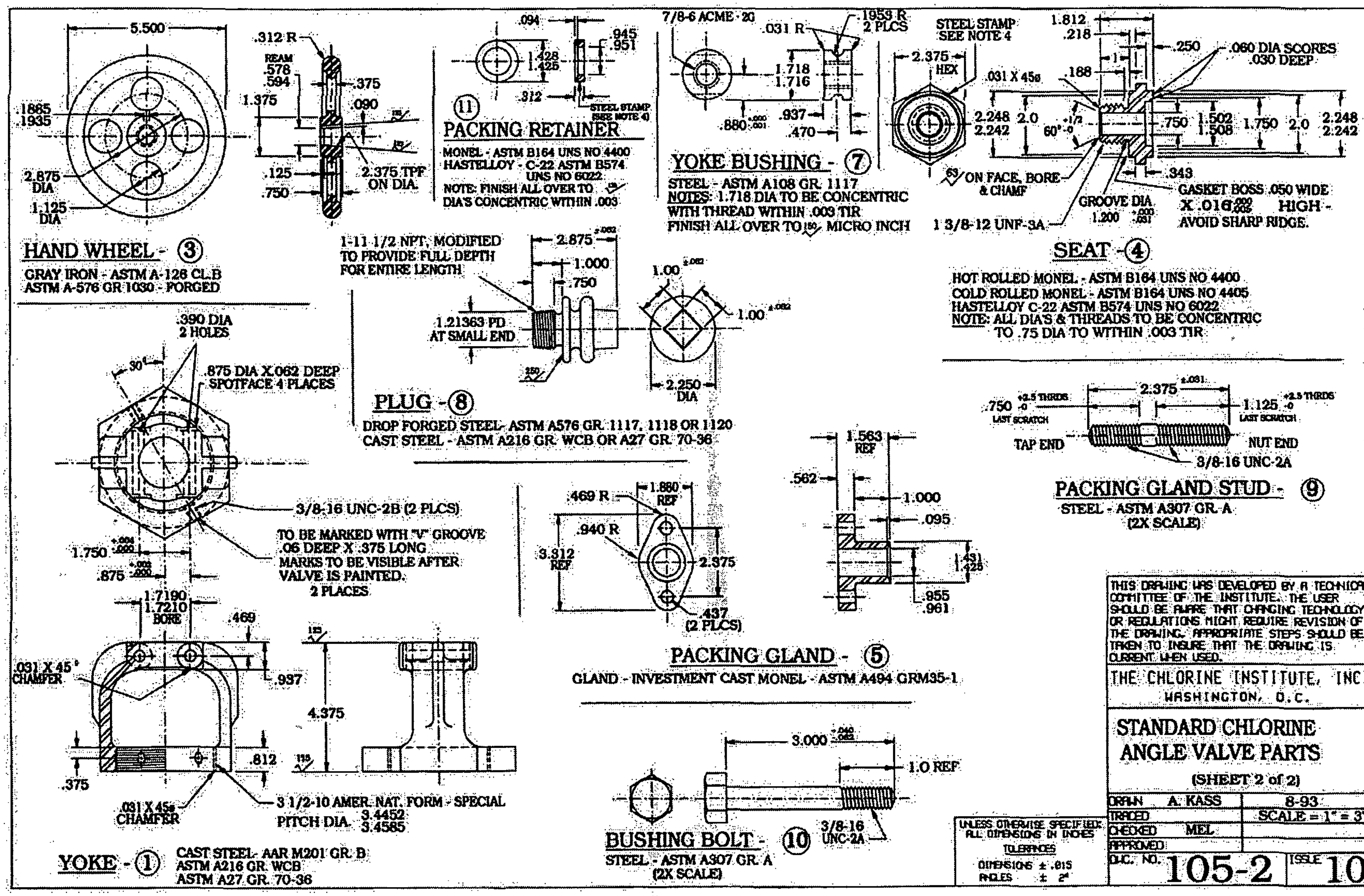
STANDARD CHLORINE ANGLE VALVE PARTS

(SHEET 1 of 2)

DRAWN	A. KASS	7-93	
TRACED		SCALE = 1" = 3"	
CHECKED	MEL		
APPROVED			
DWG. NO.	105-1	ISSUE	10

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
DIMENSIONS ± .015
ANGLES ± 2°

302 of 593


HAND WHEEL - 3
GRAY IRON - ASTM A-126 CL.B
ASTM A-576 GR 1030 - FORGED
PACKING RETAINER 11
MONEL - ASTM B164 UNS NO 4400
HASTELLOY - C-22 ASTM B574 UNS NO 6022
NOTE: FINISH ALL OVER TO 125; DIA'S CONCENTRIC WITHIN .003
YOKE BUSHING - 7
STEEL - ASTM A108 GR. 1117
NOTES: 1.718 DIA TO BE CONCENTRIC WITH THREAD WITHIN .003 TIR
FINISH ALL OVER TO 125 MICRO INCH
SEAT - 4
HOT ROLLED MONEL - ASTM B164 UNS NO 4400
COLD ROLLED MONEL - ASTM B164 UNS NO 4405
HASTELLOY C-22 ASTM B574 UNS NO 6022
NOTE: ALL DIA'S & THREADS TO BE CONCENTRIC TO .75 DIA TO WITHIN .003 TIR
STEEL STAMP SEE NOTE 4
GASKET BOSS .050 WIDE X .016 HIGH - AVOID SHARP RIDGE.
1 3/8-12 UNF-3A
1-11 1/2 NPT, MODIFIED TO PROVIDE FULL DEPTH FOR ENTIRE LENGTH
PLUG - 8
DROP FORGED STEEL- ASTM A576 GR. 1117, 1118 OR 1120
CAST STEEL - ASTM A216 GR. WCB OR A27 GR. 70-36
PACKING GLAND STUD - 9
STEEL - ASTM A307 GR. A
(2X SCALE)
TAP END
NUT END
3/8-16 UNC-2A
3/8-16 UNC-2B (2 PLCS)
TO BE MARKED WITH "V" GROOVE .06 DEEP X .375 LONG MARKS TO BE VISIBLE AFTER VALVE IS PAINTED. 2 PLACES
.875 DIA X.062 DEEP SPOTFACE 4 PLACES
PACKING GLAND - 5
GLAND - INVESTMENT CAST MONEL - ASTM A494 GRM35-1
3 1/2-10 AMER. NAT. FORM - SPECIAL
PITCH DIA. 3.4452 3.4585
YOKE - 1
CAST STEEL- AAR M201 GR. B
ASTM A216 GR. WCB
ASTM A27 GR. 70-36
BUSHING BOLT - 10
STEEL - ASTM A307 GR. A
(2X SCALE)
THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.
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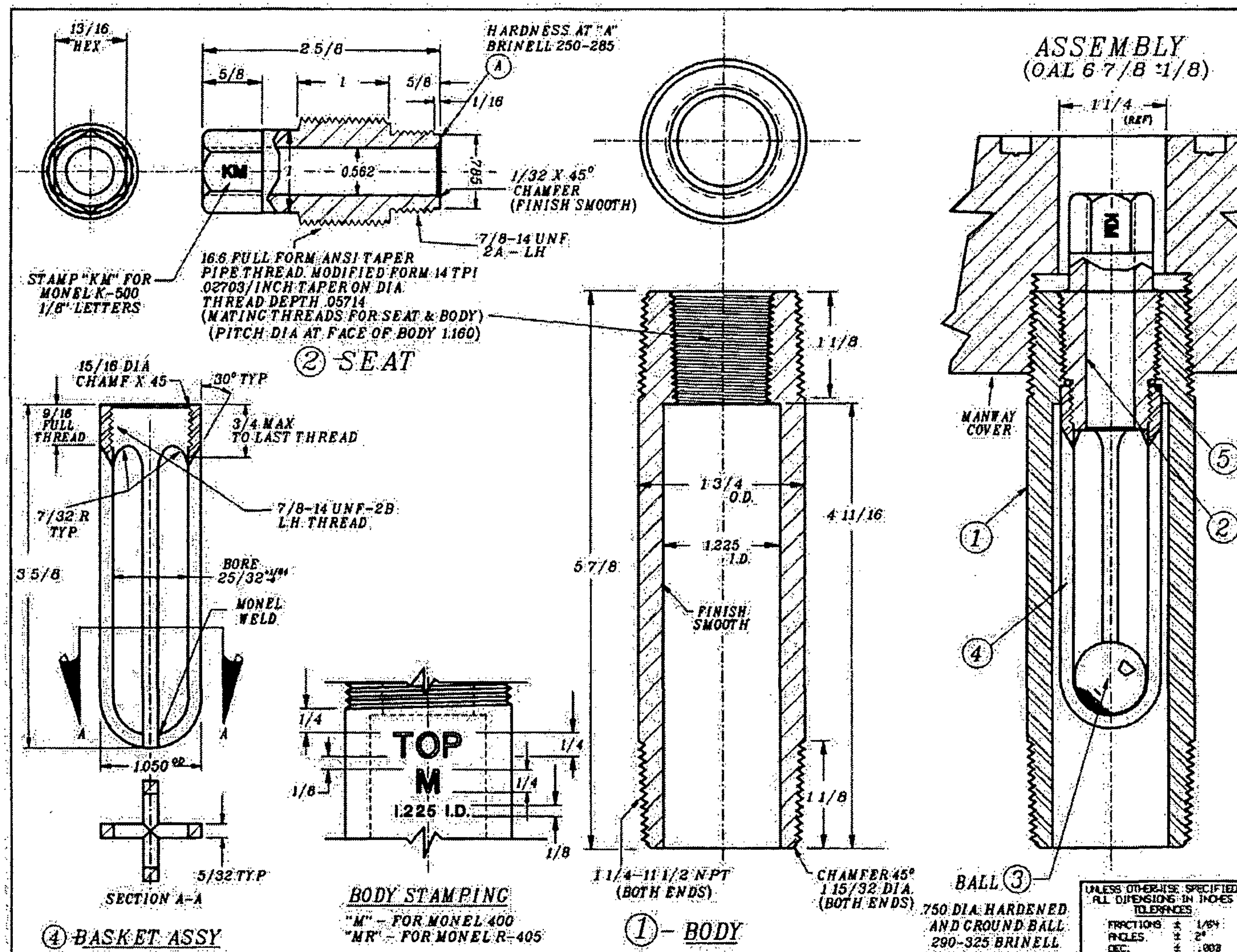
WASHINGTON, D.C.
STANDARD CHLORINE ANGLE VALVE PARTS
(SHEET 2 of 2)
DRAWN A. KASS 8-93
TRACED
SCALE = 1" = 3"
CHECKED MEL
APPROVED
DWG. NO. 105-2
ISSUE 10
UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
DIMENSIONS ± .015
ANGLES ± 2°

303 of 593



ITEM	PART NAME	MATERIAL
1	BODY	MONEL 400 or R 405
2	SEAT	MONEL K-500
3	BALL	MONEL K-500
4	BASKET	MONEL 400 or R 405
5	"O" RING	321SS (SEE NOTE 6)

NOTES:

1. ALL THREAD TOLERANCES AND GAUGING SHALL CONFORM TO ANSI B2.1(NPT) AND ANSI B1.1 (SCREW THREADS)
2. BREAK ALL SHARP EDGES
3. BODY ASSEMBLY MUST BE PRESSURE TIGHT AT 90 PSIG
4. THIS VALVE IS DESIGNED FOR USE UNDER THE GAS ANGLE VALVES ON CHLORINE BARGE AND MOTOR VEHICLE TANKS.
5. BASKET ASSEMBLY - STOCK 3/4 SCH. 80 MONEL PIPE
6. "O" RING (ITEM #5) 1.020 O.D. X .062 TUBE O.D. X .010 WALL THICKNESS

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ISS	DATE	REVISION	APPR
6	7/93	REDRAWN	
5	9/73	MAT'L MONEL R-405 CITED	CCSS
4	9/71	NOTE 1 AND MATERIAL UPDATED	CCSS
4	9/71	TAPERED THREAD NOTE ADDED	CCSS
3	5/69	NOTES REVISED	CCSS
2	6/65	BASKET ASSY. REDESIGNED	CCSS
1	7/59	INITIAL ISSUE	CCSS

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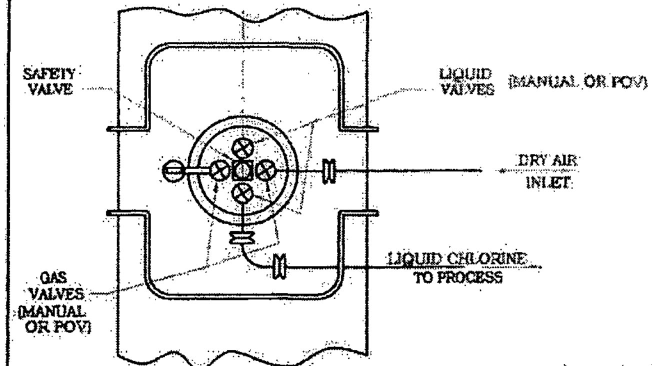
EXCESS FLOW VALVE WITH REMOVABLE BASKET

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/64
ANGLES ± 2°
DEC. ± .003

DRAWN	A. KASS	7/93	
TRACED		SCALE 1" = 1"	
CHECKED	MEL		
APPROVED			
DWG. NO.	106	ISSUE	6

304of593

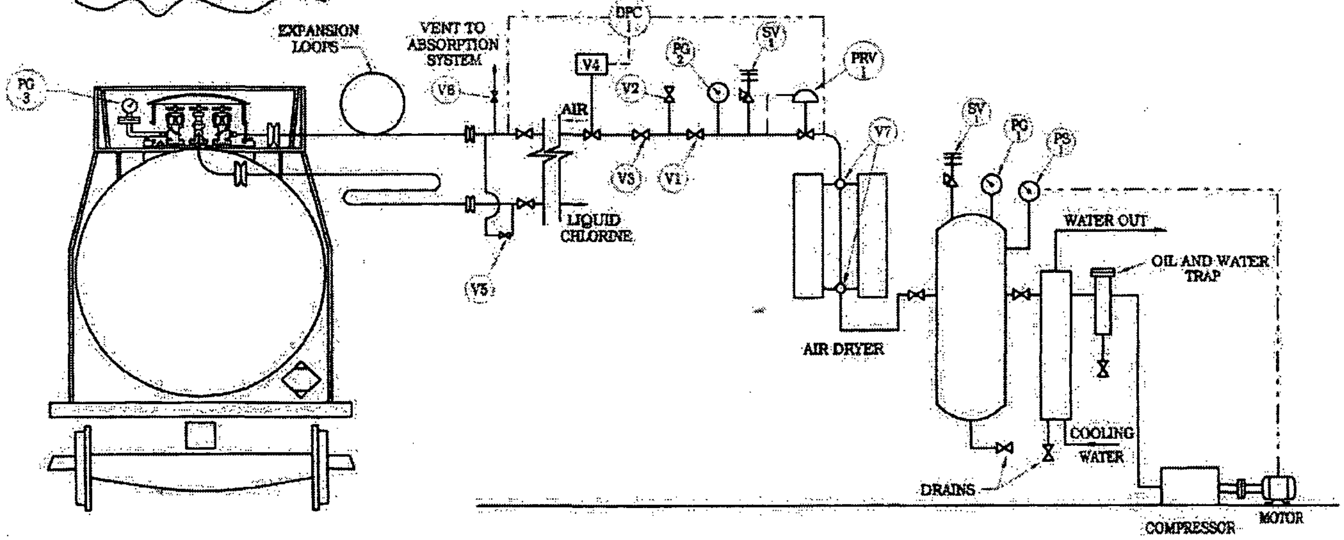


LIST OF VALVES AND GAGES

DPC-1	DIFFERENTIAL PRESSURE CONTROLLER - SEE NOTE 2
PG-1	PRESSURE GAGE - RANGE 150% MAX. READING
PG-2	PRESSURE GAGE - RANGE 150% MAX. READING
PG-3	PRESSURE GAGE WITH GAGE PROTECTOR
PRV-1	PRESSURE REDUCING VALVE
PS-1	PRESSURE SWITCH - SET 15 PSI ABOVE PRV-1
SV-1	SAFETY VALVE - SET 40 PSI ABOVE PRV-1
SV-2	SAFETY VALVE - SET 15 PSI ABOVE PRV-1
V-1	BLOCK VALVE
V-2	VENT AND AIR SAMPLE VALVE
V-3	BLOCK VALVE
V-4	VALVE OPERATED BY DPC-1
V-5	BY-PASS VALVE
V-6	VENT VALVE
V-7	AIR DRYER MULTIPORT CYCLE VALVES

NOTES:

1. PS-1 IS SET AT 15 PSI ABOVE REDUCING VALVE DISCHARGE PRESSURE AND CONTROLS THE COMPRESSOR MOTOR. SOME USERS INSTALL A SECOND PRESSURE SWITCH ON THE RECEIVER TO INITIATE AN ALARM IF THIS PRESSURE IS NOT MAINTAINED.
2. DPC-1 IS SET TO OPEN V-4 ONLY IF THE PRESSURE AT THE DRYER OUTLET IS 10 TO 15 PSI ABOVE THE CAR PRESSURE.
3. CONTINUOUS ON LINE DEWPOINT MEASUREMENT FOR COMPRESSED AIR SYSTEMS IS RECOMMENDED.
4. ENSURE AN OILFREE COMPRESSOR OPERATION WITH NO CARRYOVER TO AIR.
5. FOR EMERGENCY SHUT-OFF RECOMMENDATIONS, SEE INSTITUTE PAMPHLET #57.



ISS	DATE	REVISION	APPR
6			
5			
4			
3			
2	8/93	REDRAW	STC
1	5/81	INITIAL RELEASE	CCSS

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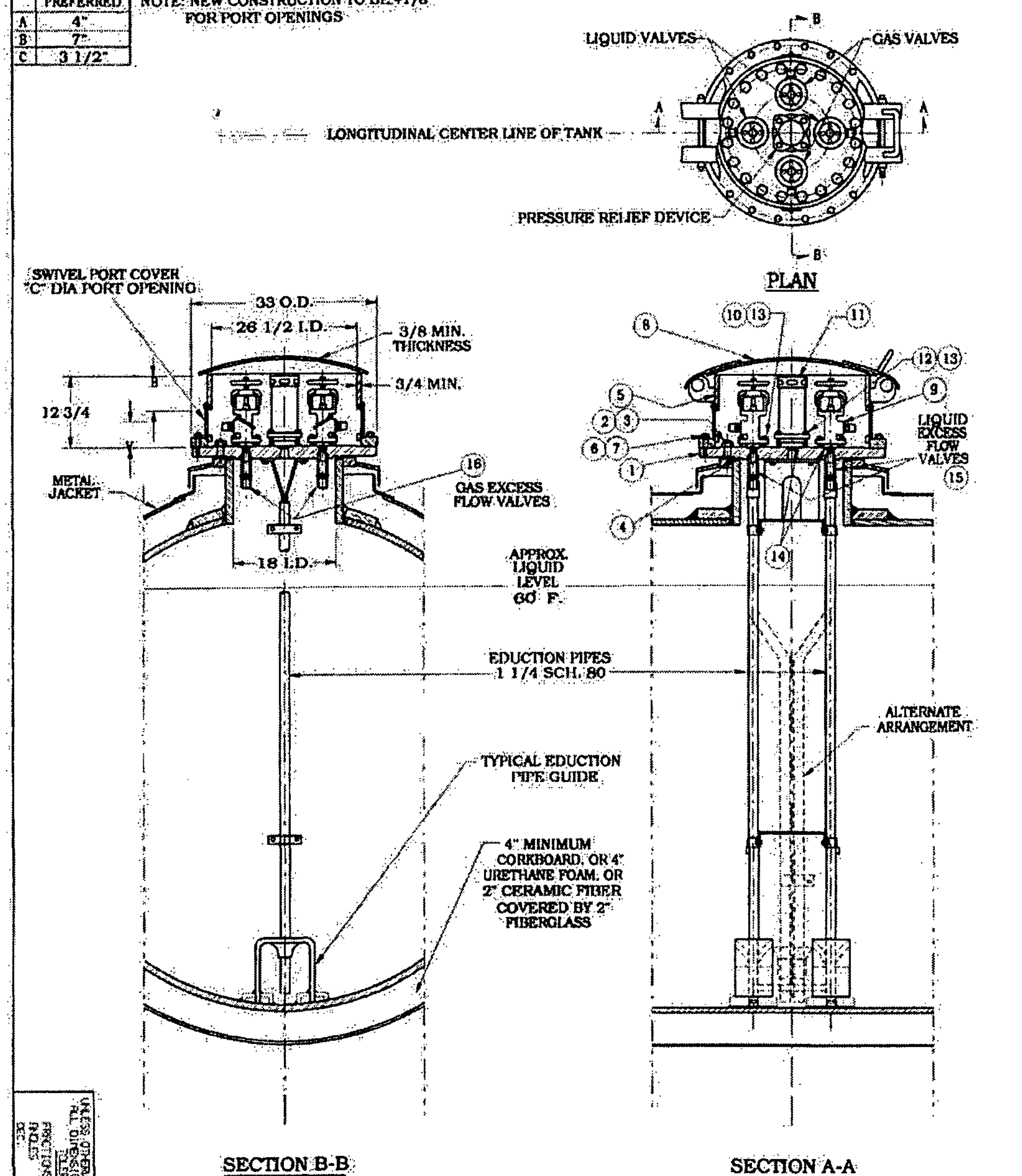
CHLORINE TANK CAR AIR PADDING

DRAWN	A. KASS	8-93
TRACED		SCALE = NONE
CHECKED	MEL	
APPROVED		
DWG. NO.	119	ISSUE 3

	PREFERRED
A	4"
B	7"
C	3 1/2"

NOTE: NEW CONSTRUCTION TO BE +1/8" FOR PORT OPENINGS



ITEM	NAME OF PART	QTY	DWG
1	MANWAY COVER	1	103
2	MANWAY COVER STUD	20	102
3	MANWAY COVER NUT	20	102
4	MANWAY COVER GASKET	1	102
5	PROTECTIVE HOUSING	1	
6	PROTECTIVE HOUSING STUD	20	102
7	PROTECTIVE HOUSING NUT	20	102
8	PROTECTIVE HOUSING COVER	1	
9	ANGLE VALVE - 1"	4	104
10	ANGLE VALVE STUD	16	102
11	PRESSURE RELIEF DEVICE (1 1/2JQ225)	1	H 51970
12	PRESSURE RELIEF DEVICE STUD	4	102
13	VALVE NUT	20	102
14	VALVE GASKET	5	102
15	LIQUID EXCESS FLOW VALVE	2	101
16	GAS EXCESS FLOW VALVE	2	106

NOTES:

1. CLAMPING ARRANGEMENTS FOR EDUCTION PIPES VARY.
2. DOT REGULATIONS REQUIRE EXCESS FLOW VALVES UNDER ALL ANGLE VALVES.

UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/64
ANGLES ± 2°
DEC. ± .005

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ISS	DATE	REVISION	APPR
6			
5	11/96	ADOPTED PRD NOMENCLATURE	
4	7/93	REDRAW	
3	9/82	REV. INSULATION NOTE	STC
2	9/71	REDRAWN- ADD NOTES & DIM	CCSS
1	11/62	INITIAL RELEASE	CCSS

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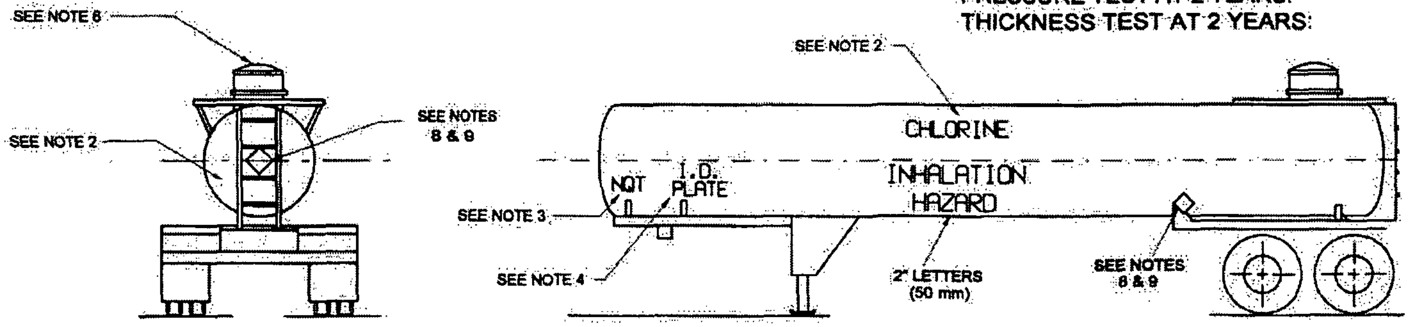
TYPICAL MANWAY ARRANGEMENT CHLORINE CARGO TANK

DRAWN A. KASS 7-93
TRACED
CHECKED RBP SCALE = 1" = NONE
APPROVED
DWG. NO. 137 ISSUE 5

306 of 593

TEST AND INSPECTION STENCILS (NOTE 7)

EXTERNAL VISUAL INSP. AT 1 YEAR:	(MO - YR) V
INTERNAL VISUAL INSP. AT 2 YEARS:	(MO - YR) I
LEAKAGE TEST AT 2 YEARS:	(MO - YR) K
PRESSURE TEST AT 2 YEARS:	(MO - YR) P
THICKNESS TEST AT 2 YEARS:	(MO - YR) T



NOTES:

1. DOT REQUIREMENTS FOR MARKING CHLORINE CARGO TANKS (INCLUDING STENCILING AND STAMPING) ARE ILLUSTRATED FOR GUIDANCE. FOR STATE, PROVINCIAL AND LOCAL ADDITIONAL REQUIREMENTS, IT IS ASSUMED THAT SHIPPERS AND CARRIERS WILL INVESTIGATE WITH SUCH REGULATORY AGENCIES.
2. PER DOT 172.328(b) THE WORD CHLORINE MUST BE DISPLAYED ON EACH END AND SIDE IN LETTERS AT LEAST 2 INCHES (50 MILLIMETERS) HIGH.
3. PER DOT 172.328(c) NQT (TO INDICATE CONSTRUCTION OF OTHER THAN QUENCHED AND TEMPERED STEEL) MUST BE DURABLY MARKED IN LETTERS AT LEAST 2" HIGH IN THE AREA ADJACENT TO THE IDENTIFICATION PLATE.
4. PER DOT 178.337-17, A NON-CORROSIVE METAL PLATE MUST BE PERMANENTLY AFFIXED ON THE LEFT SIDE (RIGHT SIDE FOR TRAILERS CONSTRUCTED BEFORE 7-1-85) NEAR THE FRONT OF THE CARGO TANK IN A PLACE READILY ACCESSIBLE FOR INSPECTION AND MAINTAINED LEGIBLE. THE FORMED LETTERS, IN CHARACTERS AT LEAST 3/8" HIGH, MUST INCLUDE THE FOLLOWING IN ADDITION TO THAT REQUIRED BY THE ASME CODE:

   VEHICLE MANUFACTURER
   VEHICAL MANUFACTURER'S SERIAL NUMBER
   DOT SPECIFICATION NUMBER MC-331 (OR ICC MC-330)
   VESSEL MATERIAL SPECIFICATION NUMBER
   WATER CAPACITY IN POUNDS (SEE DOT 173.315 (a) TABLE-NOTE 1)
   ORIGINAL TEST DATE

   EACH INSULATED TANK MUST HAVE AN ADDITIONAL PLATE SIMILAR TO THE ABOVE AFFIXED TO THE JACKET AT THE LOCATION SPECIFIED ABOVE.
5. PER DOT 173.315(i)(13), THE PRESSURE RELIEF DEVICE ON A CHLORINE CARGO TANK MUST CONFORM TO THE STANDARD OF THE CHLORINE INSTITUTE, INC. TYPE 1-1/2 JQ 225. THE PRESSURE RELIEF DEVICE MUST BE PERMANENTLY MARKED WITH THE START TO DISCHARGE PRESSURE, THE ACTUAL RATE OF DISCHARGE OF THE DEVICE IN CUBIC FEET PER MINUTE OF AIR AT 60 DEG F AND ATMOSPHERIC PRESSURE, THE MANUFACTURER'S NAME AND CATALOG NUMBER. ALL OF THIS SHOULD BE ON THE NAMEPLATE ATTACHED TO THE PRESSURE RELIEF DEVICE.
6. PER DOT 178.337-9(c), ALL TANK OUTLETS AND INLETS (EXCEPT PRESSURE RELIEF DEVICES) MUST BE MARKED TO DESIGNATE WHETHER THEY COMMUNICATE WITH VAPOR OR LIQUID.
7. PER DOT 180.415, THE DATE OF THE LAST TESTS AND INSPECTIONS OF THE CARGO TANK SHALL BE IN LETTERS NOT LESS THAN 1-1/4" HIGH NEAR THE METAL CERTIFICATION PLATE OR ON THE FRONT HEAD. (SEE DOT 180.407(c) TABLE FOR FREQUENCIES) ALTHOUGH NOT REQUIRED THE INSTITUTE RECOMMENDS A THICKNESS TEST EVERY 2 YEARS. THE PRESSURE TEST INCLUDES EITHER REPLACEMENT OR TESTING OF THE PRESSURE RELIEF DEVICE, A VISUAL INSPECTION AND A HYDROSTATIC TEST.
8. PER DOT 172.504, 172.506, 172.514 AND 172.540 SHIPPER SHALL PLACARD TANK ON EACH SIDE AND END WITH 10 3/4 INCH POISON GAS PLACARD.
9. PER DOT 172.332 CHLORINE IDENTIFICATION NUMBER (1017) MUST BE SHOWN ON PLACARDS IN 3 1/2 INCH HIGH LETTERS OR ON SEPARATE ORANGE PANEL IN 4 INCH HIGH LETTERS ON EACH SIDE AND END.
10. PER DOT 172.313, THE WORDS "INHALATION HAZARD" ARE NOT REQUIRED IF THEYAPPEAR ON THE PLACARD.

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ISS	DATE	REVISION	APPR
6			
5	10/98	CHANGE NOTES	STC
4	7/93	REDRAW	STC
3	1/89	CORRECTED PLACEMENT-SIDE VIEW	STC
2	9/84	UPDATE	STC
1	3/73	INITIAL RELEASE	CCSS

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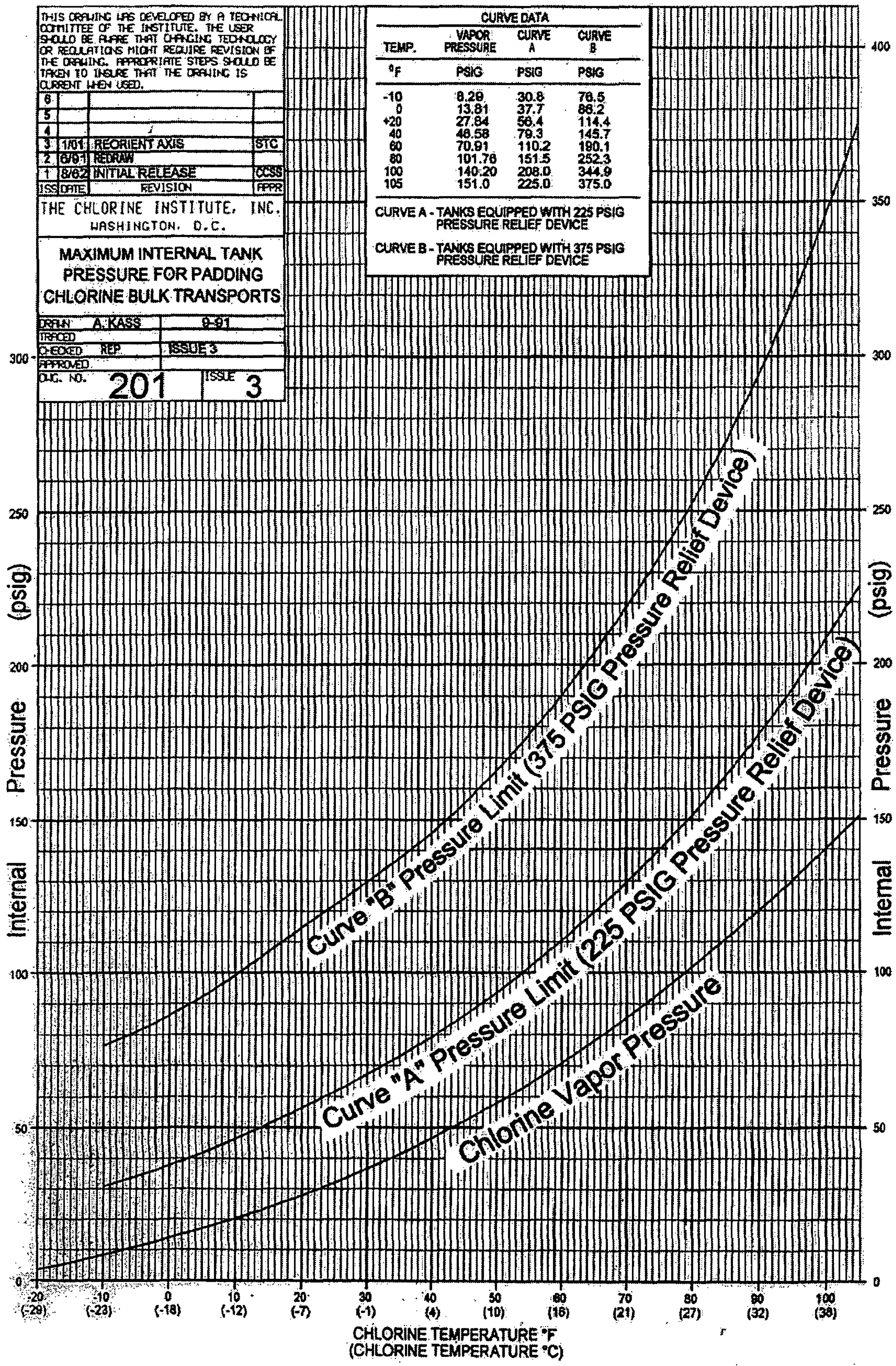
CHLORINE CARGO TANK MARKING AND PLACARDING

DRAWN	A. KASS	7-93
TRACED		
CHECKED	REP	
APPROVED		
DWG. NO. 168	ISSUE 5	



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ISS	DATE	REVISION	APPR
6			
5			
4			
3	1/01	REORIENT AXIS	STC
2	6/91	REDRAW	
1	8/62	INITIAL RELEASE	CCSS

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MAXIMUM INTERNAL TANK PRESSURE FOR PADDING CHLORINE BULK TRANSPORTS

DRAWN	A. KASS	9-91
TRACED		
CHECKED	REP	ISSUE 3
APPROVED		
DWG. NO.	201	ISSUE 3

CURVE DATA

TEMP. °F	VAPOR PRESSURE PSIG	CURVE A PSIG	CURVE B PSIG
-10	8.29	30.8	76.5
0	13.81	37.7	86.2
+20	27.84	56.4	114.4
40	48.58	79.3	145.7
60	70.91	110.2	180.1
80	101.76	151.5	252.3
100	140.20	208.0	344.9
105	151.0	225.0	375.0

CURVE A - TANKS EQUIPPED WITH 225 PSIG PRESSURE RELIEF DEVICE

CURVE B - TANKS EQUIPPED WITH 375 PSIG PRESSURE RELIEF DEVICE

309 of 593

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A LEGACY OF SAFETY STEWARDSHIP since 1924 THE CHLORINE INSTITUTE, INC.

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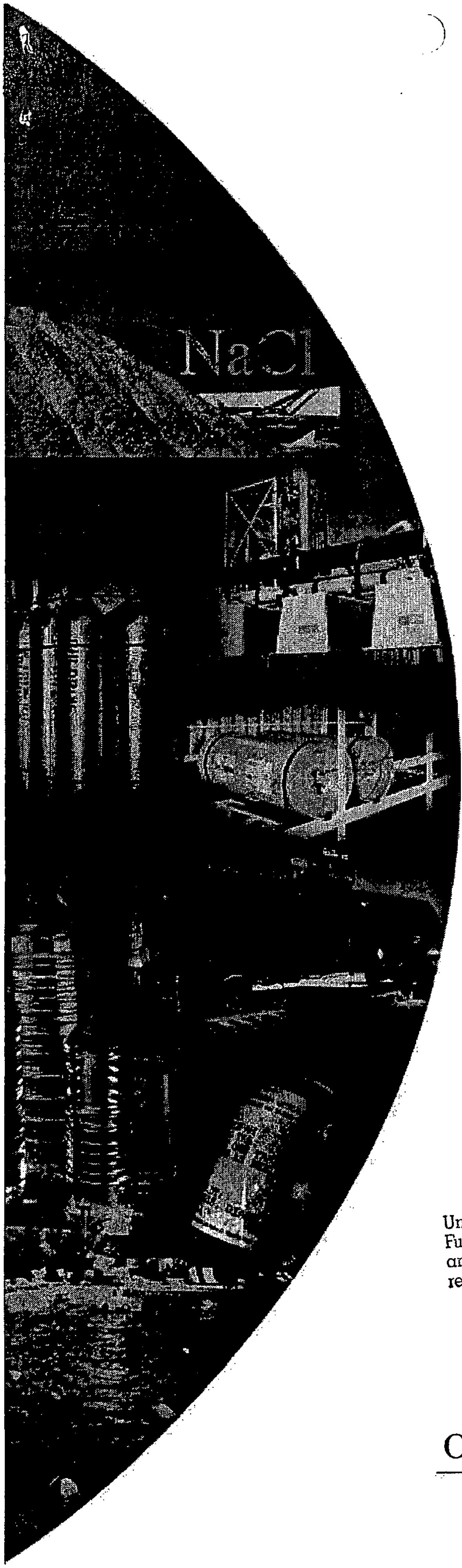

THE CHLORINE INSTITUTE, INC.

Pamphlet 64

Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities

Edition 6 - Revision 1

ACCEPTED
with COMMENTS
in EPA Letter Dated:

JUL 19 2010

Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 1148-707

October 2008

TABLE OF CONTENTS

1. INTRODUCTION

1.1 SCOPE

This publication is intended to give the user the basics of an emergency response plan. Such a plan would be utilized during an accidental release or potential accidental release of chlorine, sodium hydroxide, potassium hydroxide, sodium hypochlorite, anhydrous hydrogen chloride, or hydrochloric acid (collectively referred to in this pamphlet as chlor-alkali products) or in response to a breech in security to minimize the impact of such an incident. This pamphlet does not include all federal, state or local requirements that may be applicable to your facility, nor does it cover other potential emergencies that may arise in a typical chlor-alkali manufacturing facility.

The federal requirements cited in this pamphlet are current as of the date of publication, but users of this pamphlet should recognize that they are subject to change.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. 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.

1.3 DEFINITIONS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHLOREP	CHLOREP (CHLORine Emergency Plan) is administered and coordinated by the Chlorine Institute and provides an organized and effective system for responding to chlorine emergencies in the United States and Canada.

Chlor-alkali Product(s)	As used in this pamphlet, this term includes chlorine, sodium hydroxide, potassium hydroxide, sodium hypochlorite, anhydrous hydrogen chloride, and/or hydrochloric acid.
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
Emergency Response Plan (ERP)	An Emergency Response Plan presents the action to be taken by the producer/user, governmental agencies, and the general public to minimize the effect of an accidental chlorine release.
LEPC	Local Emergency Planning Committee
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PSM	Process Safety Management
RMP	Risk Management Program

1.4 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require changes in the recommendations contained herein. Appropriate steps should be taken to ensure that the information is current when used. These recommendations should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.5 RECOMMENDATION

It is the recommendation of the Chlorine Institute that all producers and users of chlor-alkali products have a written emergency response plan and that the plan should be communicated to the area community. The degree of complexity of the ERP will depend on the products handled by the facility, its size, and its proximity to populated areas.

1.6 APPROVAL

The Health, Environmental, Safety & Security Issue Team approved Edition 6, Revision 1 of this pamphlet on October 28, 2008.

1.7 REVISIONS

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

1.7.1 Significant Revisions in Current Edition

Changes have been made to Sections 2.4 and 2.5 in response to recommendations made by the U.S. Chemical Safety Board.

1.8 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. ORGANIZATIONAL PLANNING

2.1 INTRODUCTION

The necessity for an Emergency Response Plan (ERP) becomes evident when one considers the hazardous properties of chlor-alkali products. Prevention of injuries and impact on the local environment are key considerations of an ERP. Having trained personnel at all facilities handling chlorine and first responders within the community are vital elements of any plan.

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 (40 CFR 355, Reference 5.1.1 requires all facilities in the United States that meet the minimum threshold inventory quantities for extremely hazardous substances to have an adequate plan to deal with emergencies. The threshold planning quantity for chlor-alkali chemicals is shown in Table 1.

Table 1. EPCRA Threshold Planning Quantities for Chlor-Alkali Chemicals

Chemical	Quantity (pounds)
Chlorine	100
Sodium hydroxide	-
Potassium hydroxide	-
Sodium hypochlorite	-
Hydrogen chloride (gas only)	500

OSHA's Process Safety Management rule (Reference 5.1.2, 29 CFR 1910.119) and EPA's Risk Management Program rule (Reference 5.1.1, 40 CFR 68) also require facilities with processes covered under these regulations to have emergency response plans.

The development of an ERP must be given sufficient priority by management to insure that the safe and effective handling of such emergencies will be provided for. It is fundamental to the success of an ERP that all elements outlined in this pamphlet be included. However, the degree of detail is dependent on the size of the facility and the potential for exposure both internal and to the general public.

To the question, "When does one start planning for emergencies?" the answer is, "before the need arises." The Chlorine Institute recommends that each facility handling chlor-alkali products has a written Emergency Response Plan both to: (1) protect its employees, the surrounding community, and the general public; and, (2) comply with the law. The best time to incorporate the elements of a comprehensive ERP is during the design stage of new facilities or facilities undergoing modification. The potential dangers of chlorine within the facility and to the general public, and the perceived dangers by the public make it imperative that an ERP be completed prior to the start-up of all new units.

2.2 PURPOSE OF EMERGENCY RESPONSE PLANNING

The purpose of an ERP is to prevent or minimize injuries, lessen the impact on the general public, provide guidance to personnel who will have to respond to emergencies, and minimize equipment and property damage.

2.3 MANAGEMENT'S ROLE FOR DEVELOPING THE EMERGENCY RESPONSE PLAN (ERP)

The responsibility for the development of the ERP lies with the management of the facility. Points for management to consider include:

a. Insuring that the ERP meets the facility's needs and regulatory requirements;

b. Providing adequate resources for development, effective use, and maintenance of the plan.

c. Setting a timetable for completion of the plan;

d. Establishing a training program for implementation.

e. Insuring that the ERP can be put into action with the available personnel at the facility during periods when staffing is at the lowest levels; and

f. Insuring that the ERP is communicated to appropriate outside agencies (e.g., fire, law enforcement, local emergency planning committee).

g. Providing a system that will monitor the timeliness and effectiveness for: developing the plan; training on the plan; using the plan; and addressing corrections or necessary changes to the plan.

2.4 PLANNING FOR DIFFERENT TYPES OF EMERGENCIES

Since it is impractical to have a separate ERP for every type of emergency, it is important that the ERP be comprehensive. The following potential causes of a chlor-alkali product release should be considered:

a. Equipment or human failure;

   Specific events that have occurred in the past that should be considered for inclusion in a facility ERP are:

   1. Chlorine and HCl loading/off-loading hose failure;
   2. Overchlorination of a bleach manufacturing unit;
   3. Overchlorination of a process scrubber;
   4. Piping and equipment mechanical failures; and
   5. Reactive chemical incidents (including chlorine-iron fires, chlorine-hydrogen explosions, and chlorine-titanium fires)

b. Loss of utilities, i.e., power, steam, water, air, nitrogen;

c. Natural disasters, i.e., hurricanes, tornadoes, floods, earthquakes;

d. Barge, railroad, truck, container incidents;

e. Pipeline incidents inside and outside the plant;

f. Bomb threat;

g. Civil disturbance; and

h. Intentional sabotage.

2.5 SCOPE OF THE EMERGENCY

It is seldom easy to predict the exact scope of an emergency, but all attempts should be made to estimate the size and impact of releases that may be caused by the different types of potential emergencies at the facility. The facility's response to these potential emergencies should be predetermined. Modeling of the potential chemical release is recommended. CI Pamphlet 74 (Reference 5.2.8) provides examples of typical release quantities and impact zones. The ERP should also address the following scenarios:

a. Inside a chlor-alkali product facility – controllable by unit personnel;

b. Inside the overall facility – controllable by plant-wide personnel;

c. Inside the overall facility – requires additional emergency responders (e.g. Fire Department or Local Emergency Planning Committee (LEPC), and

d. Outside the overall facility – requires outside emergency responders (e.g. Fire Department, CHLOREP, LEPC).

2.6 PROCEDURE FOR KEEPING AN ERP CURRENT

Keeping the ERP current must be considered as a high priority. Each facility should consider the following:

a. Annual review of the ERP by persons competent in emergency response;

b. Review of the ERP whenever the facility is modified;

c. Updating the ERP whenever there are personnel/organization changes;

d. Implementing the recommended changes resulting from ERP drills or actual emergencies; and

e. Periodic personnel training coupled with timely retraining after significant changes to the ERP.

Keeping the ERP current can be facilitated by referring to all responsibilities within the plan by job title and by keeping a separate roster of names and phone numbers readily available.

3. PLANNING FOR HANDLING THE EMERGENCY

3.1 INTRODUCTION

The intent of this section is to present the aspects of emergency response that must be planned for in the event of a significant chlor-alkali product release. This information is outlined into several key categories:

a. Emergency response personnel:

    1. Responsibilities;

2. Selection;
3. Training; and
4. Audits, drills, and drill critiques.

b. Incident command

c. Internal communication

d. External communications

e. Emergency response equipment

f. Post release mitigation

g. Evacuation and/or sheltering and accounting of personnel

h. First aid/medical services

i. Utilities considerations

In addition, the facility should have procedures in place to respond to emergencies other than a chlor-alkali product release.

3.2 EMERGENCY RESPONSE PERSONNEL

(This section refers to people inside the plant or facility. See Section 4 for community or outside agencies.)

3.2.1 Responsibilities

The responsibilities for each emergency response team member should be specifically defined to include the following:

a. The types of emergencies to which the team member will respond;

b. The role each member will be expected to play during the emergency, (i.e. spill assessment, spill control, communications, first aid, etc.);

c. To whom each team member reports in the event of an emergency;

d. Considerations for who will respond to emergency situations, (i.e. operator, supervisor); and

e. Provisions for notification, access routes, and plant entry.

3.2.2 Selection

The selection of emergency response personnel is important to the development of the ERP in that the capabilities and availability of the assigned personnel will be reflected in the execution of the plan.

a. Consider who will be assigned responsibilities during days, nights, and weekends;

b. Plan for substitutes during vacations or absences;

c. Consider use of personnel from other work areas; and

d. Consider the capabilities and limitations of each person being considered for a position, (e.g., use of respiratory equipment, personnel rescue, process equipment shutdown, etc.).

3.2.3 Training

a. Utilizing the Written Emergency Response Plan

The ERP should include a clear definition of roles and responsibilities of each position.

Some facilities have found it helpful to include the following items as part of their emergency response plans:

1. A list of "do's and don'ts" to act as a quick reference guide;
2. Pocket cards or booklets listing the most important duties and information;
3. Checklists for actions to be taken;
4. Telephone lists for all personnel/agencies to be notified; and
5. Access to personnel certified in first aid and CPR training.

b. Orientation and training of personnel should be part of the ERP and should address the following key areas:

1. Assignment of training responsibilities;
2. Timetable or schedule for the training; include: start date, number of sessions held, and a target completion date;
3. List of all materials needed - classroom training aids such as copies of the ERP and any associated checklists, diagrams, safety data on chlor-alkali products, (e.g., MSDS), clearly detailed maps showing the location of hazardous materials, emergency response and safety equipment, and rally points;

4. Yearly ERP refresher training is typical of a facility handling chlor-alkali products;

5. Documentation of all training; include: a list of personnel trained, date training completed, materials/subjects covered, and a means to verify that training was successful (e.g., verbal or written test results, documentation that trainee successfully demonstrated proficiency in the information being presented); and

6. Training should be in accordance with federal, state and local statutes, and OSHA prescribed training requirements for emergency responders (29 CFR 1910.120, Reference 5.1.2).

3.2.4 Audits and Drills

Two effective ways to determine the adequacy of an ERP training program are through the use of audits and drills. Audits should be performed periodically with various emergency response teams or members to test their knowledge of duties, communication needs, and equipment, as well as periodic auditing on actual use of the equipment. Drills should be conducted to test the participant's reactions and effectiveness in implementing the ERP as well as to test the actual mechanics of the plan. There are basically three types of drills: the full-scale drill, the in-plant drill, and the table-top drill.

Consideration should be given to conducting full-scale drills at least once a year. Consider including the following:

a. While planning the drill, involve outside emergency response agencies, near-plant neighbors, and the potentially affected community

b. To make the drill more realistic, during the drill involve outside agencies, management personnel, and off-shift personnel,

Periodic in-plant drills should use different simulated events and involve as many of the various crews as possible. These drills should be conducted similarly to full-scale drills except that outside emergency response services and the community are typically not involved.

Table-top drills also should be conducted periodically to test the ability of the emergency response crews to analyze an event, communicate effectively to other emergency response personnel, and respond to staged problems. This type of drill is usually conducted with just the supervisors or key members of the emergency response teams, both in-plant personnel and outside agencies.

Following any drill, a critique should be made to assess the effectiveness of the plan and to pinpoint any weaknesses in it or in the training and competency of personnel. It should address the three main parts of the plan:

a. People

b. Procedures

c. Equipment

A written report of the drill should be issued and the ERP should be modified as needed.

3.3 INTERNAL COMMUNICATION

Timeliness and accuracy of communications is paramount in performing effectively at the time of an emergency response event. The following outlines considerations that should be taken when determining communication flow.

3.3.1 In-Plant and Emergency Response Personnel

This group includes people who are directly involved in the implementation of the ERP and those people who could be affected by the emergency. To ensure proper communication, there must be a clear understanding of the following items:

a. The person and event responsible for initiating the emergency procedures (i.e. operator, supervisor, or plant manager);

b. The person responsible for the overall coordination (Incident Commander or Emergency Response Coordinator) of the response effort, (i.e., operator, supervisor, plant manager or outside agency official such as the local fire chief);

c. Notification procedures and information content for in-plant personnel (i.e. consequences and magnitude of the release, climatic conditions such as wind speed, direction, temperature, and characterization (e.g., clear, cloudy, rainy, icy, etc.), and the time sequence of the events); and

d. Procedures and activation for communication to:

   1. Outside emergency services;

   2. Management personnel; and

   3. Near-plant neighbors/community if necessary (refer to Section 4).

3.3.2 Supervision and Management Personnel

The ERP should include proper communication to management personnel. A common procedure is to have a single person who is responsible for communicating with supervisory and management personnel. The use of a priority list (of whom to contact first) should be considered.

3.3.3 Emergency Response Headquarters

The headquarters serves as the base from which the incident commander operates. The headquarters should be: clear of any potential effects from the event that could jeopardize the response team; readily accessible; and linked with good communication systems to all parties involved. In addition, an alternate location should be selected in the event that the primary site is inaccessible.

3.3.4 Communications Equipment

Various communications equipment and back up systems should be evaluated for each facility. This equipment may include:

a. Sirens or horns to alert in-plant and off-site personnel;

b. Coded siren systems to indicate nature and location of emergency;

c. Flashing lights for improved visual awareness;

d. Manual or automatic alerting systems;

e. Existing telephone dialing system;

f. Special telephone numbers to avoid congestion of incoming calls;

g. Direct emergency telephone lines;

h. Mobile/cellular telephones;

i. Shutdown of telephone system to incoming calls;

j. Automatic paging system;

k. Two-way radios;

l. Public address or intercom systems; and

m. Megaphones.

A program should be in place to inspect and test all communication equipment.

3.3.5 All Clear Communication

The ERP should specify who has authority to end the emergency response and authorize the All Clear signal and how this communication is to be made.

3.4 EMERGENCY RESPONSE EQUIPMENT

Defined equipment should be identified and maintained for responding to an emergency. The ERP should define: the equipment needed, where the equipment is located, who is responsible for the equipment, training requirements or certifications required for use of the equipment, and maintenance and periodic inspections of the equipment.

3.4.1 Emergency Protection Equipment

The personal protective equipment (PPE) most often used during an emergency is respiratory protection equipment and/or protective clothing. Respiratory protection should be provided for emergency response personnel and other in-plant personnel who need to remain in the affected area.

A release of sodium or potassium hydroxide requires a response quite different from that of a chlorine or hydrogen chloride release. In most releases, the primary danger is direct contact of the chemical to a person's eyes or skin. Appropriate PPE is needed to protect against such an exposure. In severe cases involving of spraying of sodium or potassium hydroxide, respiratory protection is needed.

A release of sodium hypochlorite will require a response similar to that of a sodium or potassium hydroxide release unless the solution comes in contact with an acidic material. If contact with acid should occur, chlorine gas may be released and the PPE used will have to protect the eyes, skin, and the respiratory system.

Reference 5.2.6 provides specific Institute PPE recommendations for emergency responders to chlor-alkali products releases. Reference 5.2.7 provides detailed information on all aspects of normal and emergency handling of sodium hypochlorite solutions.

The following respiratory protection equipment should be provided if the incident involves the release of chlorine or hydrogen chloride:

a. Respirators must be used until the concentration of the released gas is determined to not require respirator use. Respirators with air provided should be used if an individual is required to remain in elevated concentrations of chlorine or hydrogen chloride. These types of respirators include the following:

   1. Self-contained breathing apparatus (SCBAs); and

   2. Air-line breathing apparatus having a smaller escape bottle of air.

If other types of respirators are used, it should be ascertained that the individual will not be exposed to chlorine concentrations in excess of the respirator's design.

b. Escape respirators should be provided for personnel that will not respond in the event of a chlorine release, especially in areas where chlorine is produced, stored or handled and can be of the following types:

   1. Hood-type escape respirator with small capacity compressed air feed;

   2. Mouth-bite escape respirator approved for chlorine service; and

   3. Other approved respirators.

All personnel required to wear respiratory protection equipment should be trained and tested annually on its proper use. All respirators, regardless of type, should be inspected periodically as well as before and after each use. Respiratory protection equipment used for emergency response should be inspected monthly and after each use.

Appropriate personal protective equipment should be provided and be readily accessible to all emergency response personnel (Reference 5.2.6). The following types should be considered:

a. Chemical protective clothing and suits;

b. Gloves;

c. Boots;

d. Goggles;

e. Face shields;

f. Hard hats;

g. Hoods; and

h. Safety glasses.

3.4.2 Tools

Tools for emergency response personnel should be provided at designated locations. These may include:

a. Hand tools;

b. Flashlights;

c. Emergency kits for chlorine container, depending on the type container used at the facility (References 5.2.1, 5.2.2, 5.2.3, and 5.2.4);

d. Portable chlorine or hydrogen chloride monitor;

e. Diking or absorbent materials adequate to contain or clean up liquid spills;

f. Equipment to recover/transfer liquid spills; and

g. Neutralization chemicals for liquid spills.

A complete list and location of the tools should be included in the ERP. These tools should be inspected periodically and personnel should be trained in their proper use.

3.4.3 Building Ventilation/Isolation

Consideration should be given to steps that can be taken to minimize the impact that a release can have on a building's occupants in the design and operation of building ventilation system. These include:

a. Providing elevated air intakes to buildings;

b. Providing outside air intake cutoffs for buildings;

c. Providing building pressurization;

d. Closing doors and windows during an emergency;

e. Making occupants aware that chlorine is heavier in air and will tend to accumulate at the floor area and/or lower levels of a building. Hydrogen chloride is slightly heavier than air and, to a lesser extent, it may accumulate at lower levels.

f. Providing air filtration equipment to remove chlorine and/or hydrogen chloride from air make-up.

g. Providing chlorine and/or hydrogen chloride monitors where occupants may seek shelter in the event of a chlorine and/or hydrogen chloride release.

3.4.4 Wind Direction Indication

Wind direction indicators mounted in strategic locations throughout the facility and visible at all times are highly beneficial in helping personnel respond to the emergency.

3.4.5 Transportation Equipment

Each facility should evaluate its need for emergency response transportation equipment. Consider transportation for:

a. First aid purposes;

b. Control and repair of the release;

c. Air sampling purposes;

d. Evacuation; and

e. Traffic diversion.

These uses should be coordinated with local emergency response agencies to determine what they will provide and what each facility will provide. This equipment should be maintained to ensure reliable operation.

3.4.6 Air Sampling/Modeling

In the event of a chlorine and/or hydrogen chloride release, consideration should be given to conducting ground level air sampling and/or computer modeling to determine the extent of the release.

a. Portable sampling and monitoring instruments exist that can directly read chlorine and/or hydrogen chloride concentration.

b. Computer software exists that can perform calculations and effectively model the areas likely affected during a chlorine and/or hydrogen chloride release.

c. Reference 5.2.8 provides information to estimate the area affected by a chlorine release.

Consideration should be given to the installation of permanent monitoring devices to allow for early detection and rapid response to abnormal levels of chlorine and/or hydrogen chloride (Reference 5.2.9).

3.5 Post Release Mitigation

Authorization for the corrective action up to and including equipment shutdown should be clearly defined so that prompt action can be taken when necessary. Procedures must be established for what equipment is shutdown, how it is to be shutdown, and how units can be isolated. Personnel should be knowledgeable about techniques that can be beneficial in mitigating the effects of a chlorine and/or hydrogen chloride release. (Reference 5.3.1)

3.6 Evacuation/Sheltering/Accounting/Rescue

It is beyond the scope of the pamphlet to discuss whether a facility should use evacuation or sheltering as the primary means of protection of plant personnel. Each facility should assess the advantages and disadvantages of each option and decide which is preferable.

3.6.1 Evacuation

Procedures should be developed for all personnel in the plant who are to be evacuated during an emergency. Escape respiratory protection equipment should be provided to these people. Specific assembly areas should be pre-assigned along with alternate locations so that all personnel evacuating have a designated site to go to, depending on the location of the emergency and wind direction. All in-plant personnel should be trained on evacuation procedures including the concept of going cross-wind during a release.

3.6.2 Sheltering

Procedures should be developed for all in plant personnel who are to be sheltered. Sheltering measures include closing off all ventilation, doors, and windows, and subsequent confining of the personnel for the duration of the event. (See Appendix 6.2 for more information concerning sheltering-in-place.)

3.6.3 Accounting for Personnel

There should be a procedure that accounts for all people in the facility at the time of the emergency. This procedure often involves the development of a log of all visitors to the facility and the assignment of accountability of subordinates by assigned personnel.

3.6.4 Rescue

Consideration should be given to developing and training of rescue teams. These teams should be properly equipped with safety communication equipment. The teams should be trained in equipment and trained to always work in pairs so they can assist one another in difficult situations.

Employees should not enter atmosphere immediately dangerous to life or health (IDLH) without proper respiratory equipment [References 5.1.2 (29 CFR 1910.120) and 5.2.6] and without trained, properly equipped backup personnel available for rescue.

3.7 FIRST AID/MEDICAL SERVICES

Procedures should be developed for the proper treatment of injured including on-site treatment or treatment at an emergency medical facility. (Reference 5.2.5)

3.8 UTILITIES CONSIDERATION

An evaluation should be made to determine what impact a loss of utilities would have on the functioning of the emergency response plan. Consideration should be given to the following items:

a. Provision for alternate power supply such as an on-site generator;

b. Automatic emergency lighting for key areas such as stairways, doorways, safety equipment locations, and the emergency response headquarters;

c. Availability of safety showers and eyewash stations;

d. Impact that an air loss would have on process control equipment; and

e. Availability of chlorine and/or hydrogen chloride scrubbing/neutralizing equipment during a power, air, or water supply failure.

3.9 RESPONSES TO EMERGENCIES OTHER THAN A CHLOR-ALKALI PRODUCT RELEASE

The facility should have procedures established to handle emergencies that could occur, other than a chlor-alkali product release. Some such causes include the weather (e.g., flood, tornado, hurricane, lightning strike, and winter storm), an earthquake, an erupting volcano, a bomb threat, a civil disturbance, and a breech in security, a fire, a chemical release other than a chlor-alkali product, an explosion, or injury (ies) to personnel.

Appendix A provides as an example an emergency response due to a bomb threat.

3.10 RECOVERY NEEDS

A written plan should exist that addresses the needs of the community and facility after the emergency is over. The following should be considered in preparing the plan:

3.10.1 Community

a. The need to medically evaluate the emergency responders;

b. The need to identify damage and unsafe conditions requiring immediate attention or isolation;

c. The need to document levels of exposure and contamination;

d. The need to critique the effectiveness of the emergency response organization and the timeliness of the effort; and

e. The need to critique the effectiveness of the actions taken at the scene and the emergency response equipment.

3.10.2 Facility

a. Assign information gathering responsibilities for the post incident analysis and critique.

b. Verify that the contractors used for clean up and recovery are trained per Reference 5.1.2, 29 CFR 1910.120.

c. Characterize and properly dispose of any materials (water, PPE, etc.) generated during the response and any subsequent cleanup.

3.11 BREECH IN SECURITY

Since the events of September 11, 2001, the United Sates has become more aware of the need to prevent a breech in security from occurring. References 5.2.12 and 5.3.2 provide guidance on measures facilities can take to prevent against a breech in security. If there is a breech in security by terrorists, in addition to potentially causing a chemical release or inflicting material property damage, employees need to be made aware that their lives can be at risk due to violence done by terrorists. The facility should have a plan in place for employees to follow in the event of a breech in security by a terrorist group.

4. PLANNING FOR COORDINATION WITH OUTSIDE AGENCIES

4.1 COORDINATION WITH FEDERAL, STATE, OR LOCAL EMERGENCY GROUPS

In the United States, all Federal, State and Local governing bodies are required to meet statutory requirements of EPCRA (Reference 5.1.1, 40 CFR 355), the objective being a higher degree of preparedness to deal with incidents involving extremely hazardous materials. For example, EPCRA established the mechanism to create Local Emergency Planning Committees (LEPC). Many aspects of emergency response, especially direct interaction with the public, will be handled through various local agencies such as the fire department, law enforcement departments, health department, and/or Coast Guard. Therefore, prior planning and coordination is necessary. In some cases where fast action is needed, it may become the facility's responsibility to work directly with the public to insure its safety.

In addition to EPCRA cited above, facilities in the United States are covered by the Occupational Safety and Health Act and may be covered by the EPA's Risk Management Program (RMP) regulation (Reference 5.1.1, 40 CFR Part 68) which requires incident prevention programs as well as emergency response planning. OSHA regulations

(Reference 5.1.2) prescribe such items as emergency action plans (29 CFR 1910.38); Process Safety Management (PSM) (29 CFR 1910.119); hazardous waste operations and emergency response (29 CFR 1910.120); respiratory protection (29 CFR 1910.134); medical services and first aid (29 CFR 1910.151); and hazard communications (29 CFR 1910.1200). The threshold quantities for chlor-alkali products are shown in Table 2.

Table 2. PSM and RMP Threshold Quantities for Chlor-Alkali Chemicals

Chemical	**PSM Threshold Quantity (pounds)**	**RMP Threshold Quantity (pounds)**
Chlorine	1,500	2,500
Sodium hydroxide	-	-
Potassium hydroxide	-	-
Sodium Hypochlorite	-	-
Hydrogen chloride	5,000	5,000
Hydrochloric acid (as 100%)	5,000	5,000

4.2 PLANNING PRIOR TO AN INCIDENT

Primary Contact - A good primary contact for ER planning purposes is your LEPC. If an LEPC does not exist, start one where appropriate. Review your facility ER plan with your LEPC and use this opportunity to integrate your ER plan into the community ER plan.

Training - Identify and implement training of outside agency people where it is appropriate. Planners and responders need to be familiar with your facility and operations. This may be necessary because of the unique equipment and processes that exist in your facility.

Drills - Consider conducting a drill at least once per year. Involve outside emergency response agencies, near-plant industrial neighbors and potentially affected community in the planning.

Industrial Coordination - Where multiple industrial companies exist in an area, consider combining each facility ER plan with the community ER plan. In this way the overall industrial, agency, community ER plan will be more effective.

4.3 MAJOR EMERGENCY CONTROL

For the purposes of this section, a major emergency is defined as any condition that is beyond the capability of the facility to control and that could extend beyond the facility boundaries thus impacting the surrounding community.

a. Control within the facility's boundaries generally will be by the facility's personnel. One exception could be fire fighting, since many sites do not have large fire fighting capabilities.

b. Control outside the facility's boundaries generally will be handled by the local agencies.

4.4 EMERGENCY RESPONSE AGENCIES

Local agencies provide a capable resource for dealing with emergencies. As part of your ERP, the following should be considered.

a. Alert emergency organizations immediately and place on standby. Have them help before a minor situation becomes a major emergency.

Examples of emergency organizations include LEPCs, law enforcement, fire departments, hospitals, utility emergency units, and health departments.

b. Include local emergency responders in tours of your facility. Items that might be covered in the tour include a review of your emergency response plan, emergency response equipment, and the on site capabilities of the facility. Facility layout and the basics of your operations should also be reviewed.

4.4.1 Traffic Control

Traffic Control is an important part of emergency response and involves working with law enforcement agencies in limiting access to certain areas and designating road blocks and alternate routes. In some cases it may be necessary for plant personnel to handle traffic diversion until the law enforcement agencies arrive. The plan should cover the following areas:

a. Predesignating road blocks and alternate routes;

b. Designating an individual to work with law enforcement agencies during an emergency;

c. Providing for the monitoring of wind speed, direction and other weather conditions and providing needed information to traffic control personnel;

d. Keeping the facility entrance clear;

e. Keeping railroad crossings clear;

f. Supplying equipment (e.g., reflective vests, flashlights) for employees directing traffic; and

g. Providing alternate route for incoming employees in case of congested traffic; consider identification cards for emergency crew.

4.4.2 Notification/Evacuation/Sheltering

The need for local notifications, evacuations and shelter in place happen quickly in an emergency. An evacuation and/or sheltering plan should be developed with the local authorities before an incident happens. Local authorities know populations and potential evacuation routes best. They also have appropriate authority to enforce these cases.

a. Consider all wind directions, not just the prevailing case.

b. Plan routes and traffic control for evacuations.

c. Shelter in place requires rapid notification and response. Plan notification methods and provide training to residents.

d. Special consideration must be given to sensitive populations such as senior citizens, schools, hospitals, etc.

Once it has been determined an event has the potential to become a major emergency, the impact on the community and the need to evacuate or shelter-in-place potentially affected residents must be quickly evaluated.

a. Some ways to determine the need to evacuate or shelter include air sampling and dispersion estimates (see Section 3.4.6).

b. Consideration should be given to the possibility of wind shifts.

c. Evacuation or sheltering usually is best managed by the local authorities and must be carried-out quickly.

4.4.3 Other External Agencies/Contacts

Facilities should provide information to others who need it. For example; industrial neighbors; Coast Guard (when a facility is located on a navigable waterway); the railroad (when next to a railroad mainline or freight yard). When developing detailed plans, these organizations should be involved.

4.5 <u>MEDICAL</u>

Facilities should be prepared to provide medical assistance as needed.

a. Assistance can come from a facility's own medical resources, employees trained in first aid and cardiopulmonary resuscitation (CPR), fire and law enforcement officials, paramedics, doctors and local hospitals.

b. Make contacts with your local medical providers and provide information on treating chlorine inhalation including a copy of the MSDS.

c. Have an appropriate number of individuals within the organization trained in first aid and CPR.

MSDSs should be consulted concerning information on first aid and medical management to personnel exposed to a specific chlor-alkali product. These should also be provided to medical personnel actually involved in emergency treatment if possible. References 5.2.5 and 5.2.10 provide additional such information to personnel exposed to chlorine.

4.6 COMMUNICATIONS

Internal and external communications are critical during an emergency. Procedures should be set up so that there is only one point of communication (with designated back up) with outside agencies. Continual updates on emergency status are important. Examples of typical communication methods/devices are as follows:

a. Direct lines to law enforcement agencies, fire departments and local emergency planning committees;

b. Siren systems - facility's or public;

c. Radio stations;

d. Hand held radios;

e. Automatic telephone calling systems; and

f. Emergency dial number (911 or other).

4.7 COMMUNICATING WITH THE MEDIA AND THE GENERAL PUBLIC

This section provides guidance for communicating with the news media, and communicating with the general public.

4.7.1 Communicating with the News Media

To assure current and accurate information is provided to the news media and subsequently to the public via the media, the following practices are suggested:

In advance:

a. Prepare media background information on chlorine.

b. Develop model/sample press statement.

c. Establish location for media activity.

d. Train individual(s) to interact with the media.

e. Establish a working relationship with the local media.

During an emergency:

a. Escort media representatives to previously established media area.

b. Have the trained individual remain with media representatives.

c. Provide information/prepared statement as soon as possible.

d. Advise the media regarding periodic updates and follow through on any commitments.

e. Be prepared to handle requests for photographs and TV pictures.

Following an emergency:

a. Advise that the emergency has ended.

b. Provide facts on any injuries, community impact, and cause (if known) in a media brief and/or formal press release. Be prepared to answer the following questions:

   1. What prevention measures and approaches did the facility have in place? What new measures have been identified that are needed?

   2. What is the accident history of the facility?

   3. Does the facility have equipment to detect a release?

   4. What type of emergency response equipment does the facility and community have on the site/area?

   5. What type of training is available for the employees with respect to handling emergencies?

6. What routes are used by the facility to ship and transfer hazardous materials?

7. Was the facility required to report anything under current government regulations? If yes, what did you report and when?

c. Provide opportunity/contact for follow-up after investigation is complete.

d. Escort media representatives from facility.

4.7.2 Communicating with the General Public

The news media generally will provide information to the public. Accurate, concise and prompt information to the media is important.

a. Consider using radio and television stations to provide prompt information on the emergency.

b. Communicate with employees so they know what to tell their friends and neighbors.

c. Following the emergency, consider communicating the facts through the following media:

1. Public meetings;

2. Direct mail;

3. Local media (newspaper, radio, or television).

4.8 EMPLOYEE RELATIONS

Injured employees need prompt appropriate medical care. Their families should be notified of their condition quickly and before news releases if at all possible. Consideration should also be given to the families of uninjured employees since news releases will spread concern throughout the community.

4.8.1 Families of Injured

Consider the following for families of the injured:

a. Having a designated company official notify them promptly;

b. Being prepared to assist families with transportation needs; and

c. Being prepared to give employees and their families post injury emotional and physical assistance.

4.8.2 Others

For others, consider the following:

a. Developing a procedure to control telephone calls

   Examples:

   1. Control out-going and limit incoming calls.

   2. Consider the use of "emergency use only" telephone numbers to be given to key employees and emergency groups.

b. Notifying nearby industrial neighbors; and

c. Informing all employees of what happened and corrective measures taken as soon as practicable after the incident.

4.9 REPORTING REQUIREMENTS (UNITED STATES)

Chlorine, sodium hydroxide, potassium hydroxide and hydrogen chloride are listed on the Comprehensive Environmental Response and Liability Act of 1980 (CERCLA) (40 CFR 302) List of Hazardous Substances and Reportable Quantities (Reference 5.1.1).

United States law requires immediate notification of a release equal to or in excess of the reportable quantity. The reportable quantity for these materials is as follows:

Chemical	Reportable Quantity (pounds)
Chlorine	10
Sodium hydroxide	1,000
Potassium hydroxide	1,000
Sodium hypochlorite	100
Hydrogen chloride	5,000
Hydrochloric acid (as 100%)	5,000

Should a reportable release occur, the law requires these agencies be notified:

a. National Response Center (1-800-424-8802);

b. State Emergency Response Commission; and

c. Local Emergency Planning Committee.

In addition state and local laws may require reporting to the appropriate state and/or local environmental agencies.

While the laws/regulations do not require direct notification of the Coast Guard, many facilities have found it mutually beneficial to directly notify the Coast Guard regarding releases that might affect the use of a waterway.

In most cases, the initial report will be by telephone for expediency. A follow up written report is also required. It is suggested that the following information be given during the telephone report:

a. Name of company involved;

b. Name of caller;

c. Plant location;

d. Chemical released (if chlorine or hydrogen chloride, state that it is on the Extremely Hazardous Substances List);

e. Date, time and duration of release;

f. Release quantity estimate;

g. Information as to whether or not the release is continuing or has been stopped;

h. The medium or media into which the release occurred (air, water, land);

i. Any known or anticipated acute or chronic health risks associated with the emergency and, where appropriate, advice regarding medical attention for exposed individuals. (Health Hazard Data and First Aid information from the current Material Safety Data Sheet may be utilized;

j. Proper precautions to take as a result of the release, including evacuation/sheltering;

k. Wind speed and direction; and

l. Name and telephone number of person to contact for further information.

If any agency notified has emergency response capabilities and/or responsibilities, it should also be informed of any assistance needed. (See Section 4.3).

A written follow-up emergency notice is required as soon as practicable after a reportable release. This document should:

a. Set forth and update the verbal information given previously;

b. Discuss actions taken to respond to and contain the release;

c. Discuss any known or anticipated acute or chronic health risks associated with the release; and

d. Where appropriate, give advice regarding medical attention for exposed individuals.

It is also suggested, but not required, that the final report list cause and corrective actions, with a timetable if appropriate. If the report is mailed, it is recommended it be sent certified, return receipt requested.

4.9.1 Federal Reporting Requirements

In addition to reporting to the National Response Center, the State Emergency Response Commission, and the Local Emergency Planning Committee, certain facilities are required to make annual reports of emissions of hazardous substances per the requirements of 40 CFR 372 (Reference 5.1.1).

4.9.2 State Reporting Requirements

Varies from state to state, but usually includes:

a. State Emergency Response Commission. Immediate notification required;

b. State Environmental Department or environmentally responsible agency. This may be more than one agency. Reporting time limits vary; and

c. State Police. Reporting time limits vary.

4.9.3 Local Reporting Requirements

Varies considerably depending on exact location, but usually includes:

a. Local Emergency Planning Committee. Immediate notification required.

b. Town or city leadership groups. Reporting time limits vary.

c. Local police or sheriff. Reporting time limits vary.

d. Local fire department(s). Reporting time limits vary.

e. Local Health Department. Reporting time limits vary.

5. REFERENCES

5.1 CODE OF FEDERAL REGULATIONS

5.1.1 Title 40, Various Parts.

5.1.2 Title 29. Part 1910. Various Sections. (Occupational Safety and Health Standards).

5.2 CHLORINE INSTITUTE PUBLICATIONS

5.2.1 Instruction Booklet: Chlorine Institute Emergency Kit "A" for 100-lb. and 150-lb. Chlorine Cylinders, ed. 10; IB/A; The Chlorine Institute Inc., Arlington, VA, **2003**.

5.2.2 Instruction Booklet: Chlorine Institute Emergency Kit "B" for Chlorine Ton Containers, ed. 9; IB/B; The Chlorine Institute, Inc., Arlington, VA, **2003**.

5.2.3 Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks, ed. 8; IB/C; The Chlorine Institute Inc., Arlington, VA, **2006**.

5.2.4 Instruction Booklet: CI Recovery Vessel for 100-lb. and 150-lb. Chlorine Cylinders, ed. 1; IB/RV; The Chlorine Institute Inc., Arlington, VA.

5.2.5 First Aid, Medical Management/ Surveillance and Occupational Hygiene Monitoring Practices for Chlorine, ed. 7; Pamphlet 63; The Chlorine Institute Inc., Arlington, VA, **2003**.

5.2.6 Personal Protective Equipment for Chlor-Alkali Chemicals, ed. 4; Pamphlet 65; The Chlorine Institute Inc., Arlington, VA, 2007.

5.2.7 Sodium Hypochlorite Manual, ed. 2, rev.1; Pamphlet 96; The Chlorine Institute Inc., Arlington, VA, 2006.

5.2.8 Guidance On Complying With EPA Requirements Under The Clean Air Act By Estimating The Area Affected By A Chlorine Release, ed. 4, rev. 1; Pamphlet 74; The Chlorine Institute Inc., Arlington, VA, **2006**.

5.2.9 Atmospheric Monitoring Equipment for Chlorine, ed. 7; Pamphlet 73; The Chlorine Institute Inc., Arlington, VA, 2003.

5.2.10 Health Effects from Short-term Chlorine Exposure; Video. H-VIDEO; The Chlorine Institute, Inc., Arlington, VA, 2006.

5.2.11 Guidance Document: Risk Management Plans for Hydrogen Chloride, ed. 1; Pamphlet 161; The Chlorine Institute Inc., Arlington, VA, 1998.

5.2.12 Site Security Guidance for Chlorine Facilities; The Chlorine Institute Inc., http://cl2.files.cms-plus.com/SiteSecurityGuidanceForChlorineFacilities.pdf, 2002.

5.3 OTHER REFERENCES

5.3.1 Prugh, R.W.; Johnson, R.W. Guidelines for Vapor Release Mitigation; Center for Chemical Process Safety of The American Institute of Chemical Engineers: New York, NY, 1988. [This book is now out of print, but is frequently available on the web in used condition.]

5.3.2 Site Security Guidelines for the U.S. Chemical Industry: American Chemistry Council, Chlorine Institute, and Synthetic Organic Chemical Manufacturers Association, http://www.chlorineinstitute.org/Files/PDFs/SecurityguidanceACC1.pdf, 2001.

6. APPENDICES

6.1 EXAMPLE EMERGENCY RESPONSE PLAN

6.1.1 Background Information

The ABC Chemical Company is a fictitious chlorine repackaging plant located in Cityville, Any State. This repackager buys chlorine in 90 ton railroad tank cars and repackages the material into one ton containers. ABC Chemical Company has four packaging operations in the mid-western United States. Relevant facts pertaining to the Cityville facility are as follows:

a. Staffing (Organization Chart Attached):

1. Manager
2. Two Supervisors
3. One Clerk
4. Ten wage-roll employees

b. Operations:

1. Repackages chlorine during two 8-hour shifts, Monday -Friday (7am - 11pm).
2. Has two combination safety shower and eyewash stations.
3. Has a first-aid facility capable of administering oxygen.
4. Has two employees qualified to provide first aid on each shift.
5. When not operated, the facility is locked and protected by an industrial type chain link fence.
6. Has no emergency back-up electrical supply.
7. Has back-up battery-operated emergency lighting.
8. Is located in a small industrial park with three neighbors.
9. Two neighbors operate Monday - Friday (7am - 5pm).
10. The third neighbor operates 24 hours a day Monday - Friday.

11. There is a residential subdivision of some 50 homes about 1/2 mile northeast of the plant.

12. Has five (5) Self-Contained Breathing Apparatus with five (5) replacement bottles located at designated areas per the map mounted in the clerk's office.

13. The following emergency/protective equipment is available:

    a. One "C" Kit;

    b. One "B" Kit;

    c. Miscellaneous Tools; and

    d. Flashlights, rubber gloves, goggles, and hard hats for all personnel.

14. The facility is located in a county of some 200,000 people.

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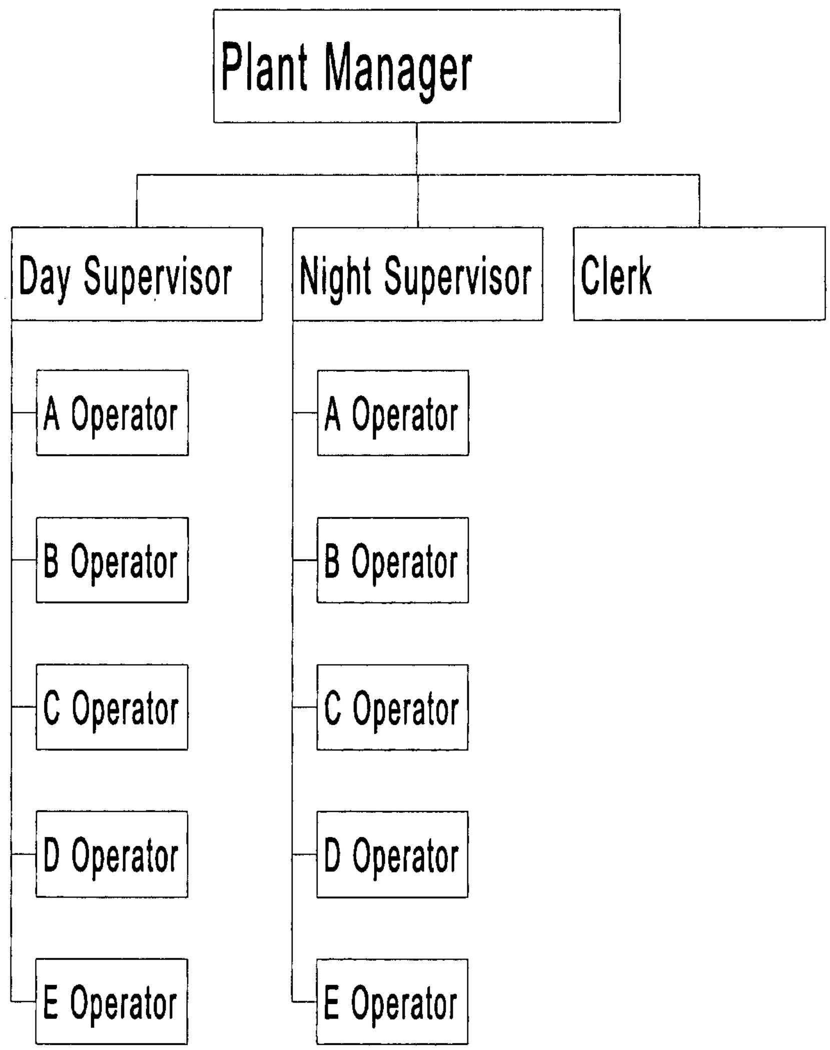
Organizational Chart
Cityville Plant



EMERGENCY RESPONSE PLAN

ABC Chemical Company

Cityville Plant

This prototype plan is presented as a guidance document to assist facilities in developing and maintaining an Emergency Response Plan. In this prototype plan, the facility has pre-determined its actions regarding internal and external communications, and regarding frequency of training. Another facility may determine different course of actions and still be consistent with the recommendations of this pamphlet.

Phone List			
Plant Personnel			
Title	**Name**	**Home Phone**	**Cell Phone**
Plant Manager	John Smith	555-1122	555-7894
Day Shift Supervisor	Wilma Reynolds	555-5579	555-7895
Evening Shift Supervisor	Dave Jacobs	555-1729	555-7896
Clerk	Tammy Edwards	555-7526	
Day Shift Operators			
A	Tom Miles	555-6217	
B	Mike James	555-9874	
C	Mary Roberts	555-8645	
D	Brian McNicoll	555-6823	
E	Bill Daniel	555-6186	
Night Shift Operators			
A	Mike Rizzo	555-1495	
B	Pat Garza	555-9845	
C	Sandy Davies	555-3796	
D	Donald Hines	555-5671	
E	Roger Suggs	555-6718	
ABC Corporate Personnel			
Title	**Name**	**Home Number**	**Office Number**
President	Michael Roberts	1-606-555-1211	1-606-555-1100
Vice President	Sancha Roso	1-606-555-1817	1-606-555-1100
Regulatory Contacts			
National Response Center (NRC)		1-800-424-8802	
Local Emergency Planning Committee (LEPC)		555-2211	

Phone List (Continued)	
Regulatory Contacts (Continued)	
Regional Air Pollution Control Commission	1-617-555-8800
State Police	911
County Sheriff	911
Cityville Fire District C	911
Other Contacts	
CHEMTREC/CHLOREP	1-800-424-9300
Cityville Community Hospital	555-3600
Neighboring Plants	
Sandy Manufacturing	555-6700
Alliance Glass	555-4388
Reliable Fabricators	555-6111

CITYVILLE PLANT

1. PURPOSE

The purpose of the Emergency Response Plan (ERP) is to effectively respond to a chlorine or sodium hydroxide release to minimize injuries, lessen the impact in the community, minimize plant damage, and provide guidance to local emergency response personnel.

2. TYPES OF EMERGENCY

a. Chlorine Release

In the event of an equipment or human failure, potential sources for a chlorine release include:

1. Chlorine tank car;
2. Tank car unloading and transfer line; or
3. One ton chlorine container.

b. Sodium Hydroxide Release

In the event of an equipment or human failure, potential sources for a sodium hydroxide release include:

1. Sodium hydroxide tank truck;
2. Tank truck unloading and transfer line; or
3. Sodium hydroxide storage tank and associated piping.

At this facility, the loss of any utilities including electricity will not increase the potential for a chlorine or sodium hydroxide release.

3. SCOPE

The scope of this plan includes:

a. A chlorine or sodium hydroxide release contained within the plant facilities and controllable by plant personnel and equipment.

b. A chlorine release affecting or with the potential to affect the area surrounding the facility; such a release would require outside assistance.

An emergency caused by the release of sodium hydroxides should be within the capability of the plant to respond. The primary concerns should be to prevent the exposure of emergency responders to direct contact of the sodium hydroxide and to prevent or minimize the effects of the release from doing environmental damage to any receiving water stream.

4. PLANNING FOR HANDLING THE EMERGENCY

Responsibility:

The Plant Manager is ultimately responsible for the implementation of the plan. He is responsible for keeping the plan current and insuring that all employees are properly trained.

Activity	Responsibility		
	Day Shift	Night Shift	Other Times
Initiating the emergency response plan	any employee	any employee	call duty supervisor
Overall coordination	supervisor	supervisor	call duty supervisor
Inside communications	supervisor	supervisor	call duty supervisor
Outside communications	supervisor	supervisor	call duty supervisor
First aid/rescue	B & C operators	B & C operators	call duty supervisor
Phone answering	clerk	any available employee	call duty supervisor
Agency notification	ranking on-site supervisor	ranking on-site supervisor	ranking on-site supervisor
Emergency repair	D & E operators	D & E operators	as assigned
Employee accounting	B operator	B operator	not applicable
Visitor accounting	clerk	not applicable	not applicable

4.1 Alarm

The ERP is initiated by any employee sounding any of the emergency response alarms. There are four strategically placed alarm buttons around the facility, any of which sound the two tone electronic emergency response alarms. This alarm system will sound for about five minutes if activated during a power failure.

4.2 Assembly Area

Primary Clerk's Office

Secondary - Rear Gate

Upon hearing the alarm, each employee is to secure his job and report to the primary assembly area (Clerk's office). If inaccessible, he should report to the secondary assembly area (rear gate) and the office is to be closed off. As part of securing the job, any fans operating in the warehouse are to be shutoff. Each employee should be aware of any chlorine release and should note the wind direction (observe the wind sock on the outside roof of the warehouse). Walk crosswind or stay upwind of any chlorine release.

The clerk will account for any visitors by checking the sign-in log maintained in the office. B Operator will account for all employees. In the absence of the B Operator, the C Operator will perform this task. If anyone is not accounted for, the supervisor is to be immediately advised. In the absence of the Supervisor, the A Operator will be notified.

4.3 Overall Emergency Response Coordination

The shift supervisor is the responsible overall emergency response coordinator. Responsibilities include the following:

a. Determine the need for a rescue team.

   The rescue team consists of Operators B and C with Operator A serving as back up. It is the policy of this facility to certify these employees in the Red Cross First Aid Program. Rescue team members must wear self-contained breathing apparatus (SCBA) before entering an area.

b. Determine the need for an emergency repair team.

   The emergency repair team consists of Operators D and E, with Operator A serving as back up.

c. Determine the need for outside assistance and/or notification.

As overall emergency response coordinator, the shift supervisor is authorized to notify directly or through delegation, the appropriate outside agencies/neighbors. These may include the fire department, police (sheriff) department, Local Emergency Planning Committee (LEPC), industrial or residential neighbors, and anyone else who might provide assistance in responding to the emergency or who might be affected by it.

d. Contact additional plant personnel to assist in the response.

The plant manager and the off-shift supervisor are to be contacted as soon as practical to assist in the response. If there is no answer at the home phone, call that person's pager number. When someone is reached, have that person contact the other. That person can also be used to contact any needed non-supervisory personnel.

e. The A Operator is designated back up to the shift supervisor and is responsible for performing all the duties in the event of the unavailability of the supervisor.

4.4 Phone Answering

During the day shift, the telephone will be staffed by the clerk. During the evening shift, it will be staffed by any available employee. Any requests from the media are to be referred to the emergency response coordinator. If that person is unavailable, take the person's name, organization, and phone number. Persons assigned to answering the phone are not authorized to discuss the incident with the media or with any other callers except people involved with the emergency response. Simply state "We have had an emergency. We are responding to it now (or it is now ended). Someone from this facility will return your call as soon as possible if you will give me your name, organization, and phone number. I am not authorized to give you any information." Give your name if asked.

4.5 Non-Work Hours Procedures

The plant is not staffed during the 11 p.m. - 7 a.m. period, weekends, or holidays. It is the policy of the plant to have all tank cars and ton containers disconnected and secured during these periods. During non-working hours, all gates and building entrances should be closed and locked. A call-duty supervisor is to inspect the plant once a day during weekends and holidays. He is authorized to initiate the emergency response plan during these periods.

If the call-duty supervisor receives a call from a neighbor regarding a plant problem, he is authorized to initiate the emergency response plan.

The call-duty supervisor will use his own discretion in seeking additional help. In no event is he to enter an area containing fugitive chlorine unless there is another employee with him and appropriate respiratory protection is worn.

4.6 Outside Assistance

The overall emergency response coordinator will meet or will delegate an available person to meet at the front gate and escort any outside responders notified by the coordinator to assist in the response. If the front gate is not accessible, the responders should be met at the public road upwind of the release.

4.7 Media Inquiry

Media inquiries should be handled, as time permits, by the emergency response coordinator or other supervisory personnel. Arriving media representatives should be allowed to wait in the clerk's office, if accessible. No one other than plant employees and emergency responders are allowed access to the plant at anytime during the emergency without prior authorization.

When time permits, the media personnel should be given background information on the involved chemical(s) (e.g., Chlorine Material Safety Data Sheet). When facts are known about the incident and the cause, these should be given to the media. ANY PERSON DISCUSSING THE INCIDENT WITH THE MEDIA MUST NOT SPECULATE AS TO THE CAUSE OF THE INCIDENT. IF THE CAUSE IS KNOWN, SO ADVISE THE MEDIA. IF THE CAUSE IS NOT KNOWN, ADVISE THE MEDIA IT IS UNDER INVESTIGATION. NORMALLY THE QUANTITY OF THE CHEMICAL RELEASED DURING AN INCIDENT IS UNKNOWN UNTIL A THOROUGH INVESTIGATION IS COMPLETE. IF SUCH IS THE CASE, SO ADVISE THE MEDIA.

When dealing with the media remember to be honest, courteous, straight forward, and concerned. Do not speculate. Do not give "off the record" comments.

4.8 Shelter/Evacuation

Even though this facility has worked closely with the LEPC, a decision regarding whether to evacuate or to shelter affected outside persons is a difficult one. Generally for us, even a significant chlorine release is likely to last, at most, 30-40 minutes before it is contained.

Therefore, sheltering in place is the normal mode to be utilized during an emergency. While it is unlikely that this facility could have a chlorine release requiring evacuation, nevertheless, we must be prepared for such an eventuality. If it is anticipated that a release cannot be soon contained or is of a massive quantity, the evacuation option should be utilized.

4.8.1 Residences

Notify the fire department and suggest that sheltering of residences for 1/2 mile be implemented. In accordance with our past discussions with the LEPC, the fire department will make the necessary notifications in accordance with the previously agreed upon sheltering plan. Residences will be notified to shut windows and close any ventilation system and listen for further advisories.

4.8.2 Neighboring Facilities

The three neighboring facilities are to be directly notified if they are affected or potentially affected. These facilities have pre-established emergency response procedures which have been discussed with this facility's management.

4.8.3 Responsibility

These duties are the responsibility of the overall emergency response coordinator. (Section 4.3). He may choose to delegate some or all of these duties to Operator A.

4.9 CHLOREP - Outside Assistance

In the event we are unable to contain a chlorine tank car or ton container leak, contact the supplier per the phone list in the clerk's office. If assistance cannot be obtained, contact CHLOREP through CHEMTREC at 1-800-424-9300. The problem should be described with the required help needed. Be certain to give your name, phone number, company name, address and other information needed. The emergency response coordinator will make these contacts.

4.10 Emergency Treatment

As part of our response plan, ABC Chemical has pre-authorized the Cityville Community Hospital to treat any person showing up with alleged chlorine (or irritating gas) inhalation from within a 2 mile radius of the plant. We have provided the hospital with medical information concerning chlorine inhalation.

Any injured employee suffering from chlorine inhalation should be sent to the hospital. Any injured employee with possible chemical burns due to contact with sodium hydroxide to the face or eyes, or with anything other than incidental contact to be sent to the hospital. To the extent possible, the employee should be accompanied by another plant employee. Notification to the family should be made as soon as practicable by a supervisor per the plan outlined in the Employee Handbook.

4.11 All Clear

The overall emergency response coordinator is to give the all clear signal when the emergency condition is eliminated. This notification is to be given verbally to all plant employees, any emergency responders, to affected neighbors, and, if involved, the news media.

4.12 Recovery Needs

A written plans kept in the plant manager=s office. This plan addresses communications and activities that may be implemented after the emergency is over. This plan is reviewed annually by the plant manager and the two supervisors.

5. BOMB THREAT PROCEDURES

Most bomb threats are received by telephone and many are hoaxes. However, it is important to treat any threat received as serious. It is most important that the person answering the phone try to get as much information from the caller as possible. The bomb threat work sheet which is stationed by the outside phone is to be completed for any such threats (Attachment 1).

The procedure outlined in Figure 1 is to be followed.

Bomb threats received by mail should be taken as credible. There may be sufficient time to evaluate what to do depending what is contained in the letter. Employees should follow the pre-cautionary procedures posted above the postage machine prior to opening the mail.

6. BREECH IN SECURITY

This facility has implemented numerous steps to prevent against a breech in security. These steps are discussed in the facility's security plan. In the event of a breech in security, the personnel must make a decision as to the motives of those breeching the facility. Because of the steps taken, it is highly unlikely that a security breech could occur without an well thought out and executed plan by a terrorist group. In such an unlikely event, the police should be called to handle the situation. If the perpetrators are terrorists, they will likely seek to inflict maximum destruction as quickly as possible. In such a situation lives are at risk. Any personnel should attempt to seek outside help via dialing 911 without placing undue additional risk on oneself.

7. WEATHER THREAT PROCEDURES

For most severe weather conditions (e.g., hurricane, severe cold), there is ample warning and an agreed upon plan will be decided at the time. In the event of a tornado warning or of a tornado sighting, all chlorine packaging operations should be stopped by tripping the automatic closure values. Employees should then seek immediate shelter in the conference room within the change house building.

8. OUTSIDE REGULATORY AGENCY NOTIFICATION

Contact is to be made by the ranking supervisor at the facility.

8.1 Verbal Notification

The law requires that this Facility immediately report any releases of chlorine equal to or greater than ten pounds or of sodium hydroxide equal to or greater than 1,000 pounds to the following agencies:

1. National Response Center;
2. Local Emergency Planning Committee; and
3. State Emergency Planning Commission.

Information should include the following:

1. Chemical released – chlorine or sodium hydroxide;
2. Chlorine or sodium hydroxide is on the Extremely Hazardous Substances List;
3. Estimate quantity released. If not sure, for chlorine simply state, "10 pounds or more"; and for sodium hydroxide simply state, "1,000 pounds or more";
4. Time and duration of the release;
5. The medium or media into which the release occurred;
6. Medical information about the chemical released. Advise that pre-incident plans have been arranged with the LEPC and the Cityville Community Hospital.
7. Evacuation plans if needed;
8. Name and phone number of the person to be contacted for further information.

THE AGENCY NOTIFICATIONS ARE TO BE IMMEDIATELY AFTER THE INCIDENT HAS OCCURRED.

8.2 Written Follow Up

As soon as practicable after the release, a follow-up written notice is to be provided to theses agencies following the procedures in the ABC Chemicals Procedure Manual.

8.3 Other Environmental Agency Contacts

It is the policy of this plant to verbally notify the Regional Air Pollution Control Authority as soon as practicable after notifying the required agencies.

8.4 OSHA Notification

In the event of a fatality or multiple hospitalizations, OSHA is to be notified within 48 hours in accordance with OSHA regulations. This notification will be handled per the procedure in the ABC Chemicals Procedures Manual.

9. TRAINING

Annual refresher training for all personnel will be done in the second quarter of each year in accordance with the facility's annual training plan.

10. EXERCISES (DRILLS)

Exercises will be conducted as follows:

In-Plant:	One per quarter
External:	One per year (3rd quarter)

To the extent possible, the external drills should include participation by representatives of the LEPC, the Cityville Fire District C, and the County Sheriff. Our neighboring industrial plants, the Cityville Community Hospital, and other affected external groups should be offered should be invited to participate.

ATTACHMENT 1

BOMB THREAT PHONE CALL - ACTION OUTLINE

Time Call Received ________________ Time Caller Hung Up ________________

Exact words of person placing call ______________________________

____

____

____

Questions to Ask:

1. When is bomb going to explode? ______________________________

____

2. Where is bomb right now? ______________________________

____

3. What kind of bomb is it? ______________________________

____

4. What does it look like? ______________________________

____

5. Why did you place the bomb? ______________________________

____

Person (receiving) (monitoring) call ______________________________

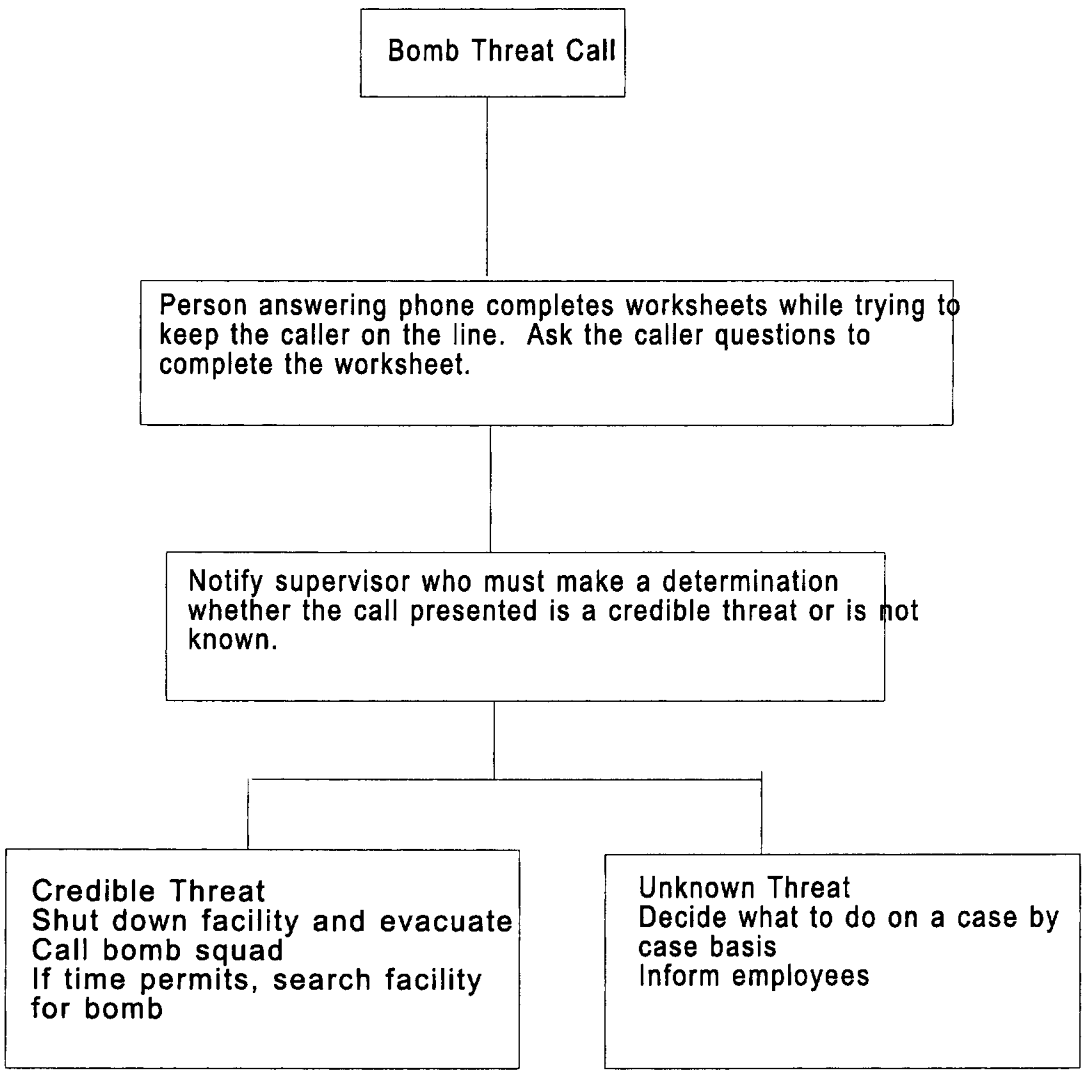
Department: ________________ Telephone Number: ________________

Home Address: ______________________________

Home Telephone Number: ______________________________

Date ______________________________

Figure 1
Bomb Threat Procedure



6.2 SHELTER-IN-PLACE INFORMATION

In the event of an emergency involving a chlorine release the local authorities must decide quickly what emergency response action to take. The decision to Shelter in Place or evacuate should be preplanned based on many factors. Because of the complexity of the decision making process as well as the uniqueness of each location this appendix does not provide an overall recommendation. Local authorities have the following options:

1. Evacuate the public to a safe location where the concentration of the toxic release will have no impact on human health.

2. Recommend that people in the impacted area to Shelter-in-Place.

The decisions related to chlorine gas releases from producer or user facilities should be pre-planned taking into account these factors:

1. The size and duration of the release.

2. The "quality" of the sheltering locations.

3. The knowledge of the individuals being asked to shelter in place.

4. The time available to take action.

5. The ability of people to evacuate safely.

Facilities should work with the local emergency response organizations to develop emergency response plans.

A brief discussion on these five factors is offered to assist in the planning process.

1. The size and duration of possible release.

   Reference 5.2.8 provides guidance on the impact and duration of worst case and alternate release scenarios.

   Generally speaking the longer the incident continues the less effective will be the sheltering in place. The concentration inside the building is a function of the concentration outside and the air infiltration rate into the building. Shifting wind directions may allow for longer sheltering in place but this can not be counted on in the planning phase.

2. The "quality" of the sheltering locations.

   The "quality" of the sheltering location depends on the air infiltration rate (both forced and natural). This varies widely. General housing and industrial buildings can have air change rates of between one half to four changes per hour. It can be easily measured but is not always easy to predict. In northern climates the houses are constructed fairly tight in order to reduce heating costs. However, since air conditioning is not generally installed, the windows are kept open in the summer to cool the house. This is also the time when people are sleeping in the residence. With advance warning, the "quality" of the shelter can be vastly improved. A search of the web for "Shelter in Place" brings up many government, non profit, and commercial documents on how to preplan for shelter in place. They discuss how to select and prepare a room to lower the air infiltration rate. The following is an example from the American Red Cross:

http://www.redcross.org/services/disaster/beprepared/shelterinplace.pdf

3. The knowledge of the individuals being asked to shelter in place.

   Knowledge is essential for effective sheltering in place. The people sheltering must understand how to reduce the air infiltration into their shelter. They must also have effective communication with the local authorities so that they will know when the hazard has passed and they should exit the shelter.

   The concentration inside the shelter is a function of the concentration outside and the air infiltration rate. During the incident the concentration inside the shelter will rise to match the concentration outside. (given enough time) Once the incident has passed, the concentration of toxic gases inside the shelter will start to drop but this reduction will be limited by the air infiltration rate.

   Good communication will allow notification of the individuals sheltering in place that it is better to leave the shelter.

   Running a local training exercise to practice sheltering in place is an excellent way to improve the knowledge of the community. This link provides access to the LEPC information exchange across the US. It contains many examples of Sheltering in Place procedures as well as training aids.

   http://www.lepcinfoexchange.com/vid-dvd

4. The time available to take action.

   The public must have sufficient time to evacuate to a safe area prior to the cloud reaching the area being evacuated. However, often there is little warning of these events. The emergency response team could decide to have a shelter in place strategy for those close to the incident and an evacuation strategy for those further away.

5. The ability of people to evacuate safely.

   Evacuations can lead to accidents, traffic jams and no place to shelter when the wind shifts during the evacuation. The evacuation plan will need to consider these factors as well as the congestion in the area.

6.3 Bomb Threat Procedures

6.3.1 Introduction

This section covers suggested procedures to follow when a bomb threat is received. Facilities should review these procedures as modify them as appropriate to fit individual needs.

Although most bomb threats experienced throughout the country turn out to be hoaxes, any bomb threat should be treated as real until determined otherwise. Because of the serious nature of a bomb threat, this procedure should be included in the ERP along with responses to other types of emergencies as listed in Section 2.4.

Upon receipt of a bomb threat, the Emergency Response Coordinator should be notified.

6.3.2 Receiving a Bomb Threat Call

The person receiving the call should make every effort to obtain as much information as possible from the caller. At the outset of the conversation, an attempt to trace the call should be made by having someone else call the telephone company operator on another phone and report: "This is ______________ at the __________________ Company, address, and phone number. We are receiving a bomb threat telephone call. Please attempt to trace the call. I will remain on this line if you wish."

A record should be kept of any bomb threat received.

6.3.3 Receiving a Bomb-Threat Letter

Employees opening the mail should be aware of suspicious packages. Letter bombs are not common in the United States but personnel should be aware that such devices exist and can be very small.

6.3.4 Possible Courses of Action and Considerations:

a. Initiation of the Emergency Response Plan;

b. Full, partial or non-evacuation of the affected area or plant;

c. Steps which may be taken to lessen the effect of the blast. These steps may include movement of flammable or explosive material away, repositioning tank cars and tank trucks, and/or shutdown of part or full process;

d. If detonation time has been stated, serious consideration should be given for personnel evacuation; and

e. Initiation of bomb search team.

A facility should decide in advance how much discretion should be given to the bomb search team. When procedures are non-discretionary, (e.g. mandatory shutdown and/or evacuation in certain instances), the procedures should be documented.
Major priorities for bomb surveillance include:

a. Personnel areas (control room, locker rooms);

b. Chlorine storage and production; and

c. Utility lines and centers (motor control center, transformer, power lines).

6.4 CHECKLIST

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

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

Yes	No	N/A	Question	Section
❐	❐	❐	1. Does the ERP address emergencies of different scopes?	{2.5}
❐	❐	❐	2. Does the facility have a procedure for keeping the ERP current?	{2.6}
❐	❐	❐	3. Are specific responsibilities for each emergency response team member specified?	{3.2.1}
❐	❐	❐	4. Is periodic training conducted for emergency response team members?	{3.2.3}
❐	❐	❐	5. Are periodic audits and drills of the ERP conducted?	{3.2.4}
❐	❐	❐	6. Does the plan specify who is responsible for specific tasks such as initiating the ERP, coordinating the implementation of the ERP, and making necessary notifications?	{3.3.1}
❐	❐	❐	7. Have primary and backup ERP headquarters been specified?	{3.3.3}
❐	❐	❐	8. Does the ERP address communication equipment needs?	{3.3.4}
❐	❐	❐	9. Does the ERP designate who will give, and how, the all clear communication?	{3.3.5}
❐	❐	❐	10. Does the ERP address emergency response equipment needs?	{3.4}
❐	❐	❐	11. Does the ERP address post-release mitigation needs?	{3.5}
❐	❐	❐	12. Does the ERP address evacuation or sheltering in place, accounting for personnel, and rescue efforts?	{3.6}

❐	❐	❐	13. Does the ERP address first aid and medical services needs?	{3.7}
❐	❐	❐	14. Does the ERP address utility needs?	{3.8}
❐	❐	❐	15. Does the ERP address responses to emergencies other than a chlorine release?	{3.9}
❐	❐	❐	16. Does the ERP address recovery needs?	{3.10}
❐	❐	❐	17. Has the facility addressed security issues?	{3.11}
❐	❐	❐	18. Has the facility coordinated its ERP with appropriate outside agencies?	{4.1 - 4.5}
❐	❐	❐	19. Has the facility established procedures for communicating with the general public and the news media?	{4.7}
❐	❐	❐	20. Has the facility established procedures for communicating with its employees and their families?	{4.8}
❐	❐	❐	21. Has the facility established procedures for required communications with various regulatory agencies?	{4.9}

REMINDER:

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

364 of 593

THE CHLORINE INSTITUTE, INC.

A LEGACY OF SAFETY STEWARDSHIP

since 1924

THE CHLORINE INSTITUTE, INC.

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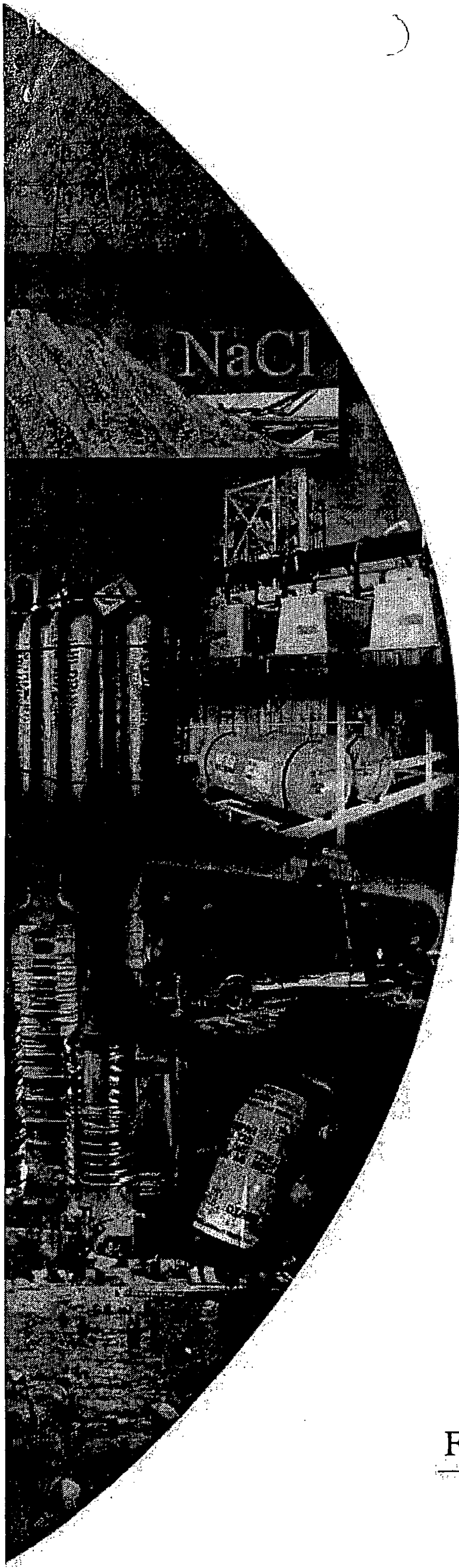

THE CHLORINE INSTITUTE, INC.

Pamphlet 65

Personal Protective Equipment for Chlor-Alkali Chemicals

ACCEPTED
with COMMENTS
in EPA Letter Dated:

JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

Edition 5

A LEGACY OF SAFETY STEWARDSHIP
since 1924

February 2008

366of593

TABLE OF CONTENTS

367 of 593

368of593

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, sodium hypochlorite, hydrochloric (muriatic) acid, sulfuric acid and anhydrous hydrogen chloride (the Institute's mission chemicals). 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°F.

Exposure to these chemicals at elevated temperatures (> 120°F) may require additional personal protective equipment for thermal protection and to ascertain that the PPE used is suitable at such temperatures and 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 the 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, head protection (except for chemical exposure), and air purifying respiratory protection equipment used solely for escape purposes 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 Reference 13.10.1 (NIOSH Certified Equipment List) and Reference 13.6.4 (29 CFR 1910.134).

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 publications Pamphlet 125 (Reference 13.1.4) and Pamphlet 137 (Reference 13.1.5) for a discussion of personal protective equipment requirements pertaining to mercury or asbestos. Institute Pamphlet 139 (Reference 13.1.6) addresses personal protective equipment requirements pertaining to cell house electrical systems used in chlor-alkali operations. Institute Pamphlet 63 (Reference 13.1.1) 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, Inc. 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
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	Code of Federal Regulations
CGA	Compressed Gas Association

CI	The Chlorine Institute
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guidelines (AIHA)
ESLI	End-of-Service-Life Indicator
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)
JSA	Job Safety Analysis
KOH	Potassium Hydroxide
mg/m^3	Milligrams Per Cubic Meter (milligrams of vapor or gas per cubic meter of contaminated air at 25°C 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	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit (OSHA)
Per Cent (%)	In this pamphlet, it always refers to weight per cent
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, Environment, Safety and Security Issue Team approved this pamphlet for publication on February 19, 2008.

1.7 REVISIONS

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

1.8 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or part, without prior Chlorine Institute permission.

2. CHEMICALS AND THEIR PHYSIOLOGICAL EFFECTS

2.1 EXPOSURE LEVEL GUIDELINES

OSHA has established Permissible Exposure Limits (PELs) (Reference 13.6.6 - 29 CFR 1910.1000 - 1910.1052) for regulating employee exposure to numerous chemicals. Similarly, ACGIH has established Threshold Limit Value (TLV) guidelines (Reference 13.2.1) and NIOSH has developed Recommended Exposure Limits (REL) (Reference 13.10.3). These may be expressed as TWAs, STELs, Ceilings, or a combination.

2.1.1 TWA

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

2.1.2 STEL

STEL is the employee'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.

2.1.3 Ceiling

Ceiling is the employee'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.

2.1.4 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." (Reference 13.10.2).

2.1.5 ERPGs

The American Industrial Hygiene Association (Reference 13.3.1) 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 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. (Reference 13.1.1 is one of several sources providing more information on the health effects of exposure to chlorine.) The following table summarizes health effects to humans:

Exposure Level (ppm) [1 ppm = 2.90 mg/m^3]	**Effect**
0.2 - 0.4	Odor threshold (decrease in odor perception occurs over time)
< 0.5	No known acute or chronic effect
0.5	TLV - TWA REL - Ceiling
1	PEL - Ceiling TLV - STEL ERPG-1
1 - 3	Mild, mucous membrane irritation, tolerated up to 1 hour
5 - 15	Moderate irritation of the respiratory tract
3	ERPG-2
10	IDLH
20	ERPG-3
30	Immediate chest pain, vomiting, dyspnea, cough
40 - 60	Toxic pneumonitis and pulmonary edema
430	Lethal over 30 minutes
1000	Fatal within a few minutes

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.

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°C (-29°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. Reference 13.1.1 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 corrosives and can cause mild to severe irritation of the eyes, mucous membranes (nose, sinus, throat, and lungs), and skin. 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 caustic solutions, 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 (Reference 13.10.3). The following table summarizes health effects upon humans:

Exposure Level (mg/m^3)	**Effect**
0.5	ERPG - 1
0.5-2	Minor respiratory irritation
1	Mild watering of the eyes
2	REL - Ceiling TLV - Ceiling
>2	May cause damage to upper respiratory tract
5	ERPG - 2
10	IDLH
50	ERPG-3
1% aqueous solution	Eye irritation
5% aqueous solution	Can cause severe skin irritation and/or burns

2.3.2 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. See Section 2.3.1.

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

Sodium Hypochlorite (NaOCl) solutions are classified as a 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. 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 effected 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, 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 corrosive. Skin contact with the liquid may result in dermatitis and deep burns. Eye contact may result in burns and permanent injury. Inhalation causes irritation of the respiratory tract and inflammation of the lungs may result. Ingestion may result in severe gastric irritation including nausea, vomiting and severe pain. Ulceration and perforation of the G.I. tract may also occur. Severe inhalation overexposure to hydrochloric acid vapors (hydrogen chloride) may cause pulmonary edema (abnormal accumulation of fluid), laryngeal spasms and laryngeal edema. The following table summarizes health effects upon humans:

Exposure Level (ppm) [1 ppm = 1.49 mg/m^3]	**Effect**
0.2 - 0.8	Odor threshold (varies with individuals)
3	ERPG - 1
5	PEL - Ceiling REL - Ceiling TLV - Ceiling
5 - 10	Immediately Irritating
20	ERPG - 2
50	IDLH
150	ERPG - 3

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

Sulfuric acid is an odorless chemical (Reference 13.10.3) 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 ACGIH lists sulfuric acid contained in strong inorganic acid mists as a suspected human carcinogen (Reference 13.2.1). 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, diarrhea, and collapse of blood pressure. Symptoms may be delayed up to 48 hours.

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:

Exposure Level (mg/m^3)	Effect
1	PEL - TWA REL - TWA TLV - TWA
2	ERPG - 1
3	TLV - STEL
10	ERPG - 2
15	IDLH
30	ERPG - 3

2.6.1 Sulfuric Acid Mist

Because sulfuric acid mist is listed as a suspected carcinogen by the ACGIH, the IARC and the NTP and because the Chlorine Institute had 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	Sulfuric Acid Concentration - mg/m^3
6" above container	0.09
Samples tested at 120°F	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)

Due to its high water solubility, gaseous anhydrous hydrogen chloride (AHCl) dissolves quickly in water to form hydronium ions (H_3O+) (Reference 13.8). 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:

Exposure Level (ppm) [1 pmm = 1.49 mg/m^3]	**Effect**
0.2 - 0.8	Odor threshold (varies with individuals)
3	ERPG-1
5	PEL - Ceiling REL - Ceiling TLV - Ceiling
5-10	Immediately irritating
20	ERPG -2
50	IDLH
150	ERPG-3

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. Irritation of the eye, when exposed to gaseous AHCl, begins to occur at the 1-10 ppm level.

2.7.2 Exposure to Liquid AHCl

Liquid anhydrous hydrogen chloride is a chilled compressed gas. At atmospheric pressure, liquid anhydrous hydrogen chloride vaporizes at -85°C (-121°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 HCL from the contaminated clothing. Immediate medical attention should be obtained for any personnel exposed (by inhalation or skin contact) to liquid or gaseous AHCl. Respiratory symptoms, including pulmonary edema, may be delayed. Persons receiving significant exposure should be observed 24-48 hours for signs of respiratory distress. As appropriate, qualified personnel should administer oxygen.

3. REGULATIONS

The following OSHA regulations (Reference 13.6) have potential application in chlor-alkali production facilities and other facilities using the chemicals discussed in this pamphlet. This list should not be considered inclusive of all OSHA regulations necessarily applicable to a facility.

29 CFR 1910.95	Occupational Noise Exposure
29 CFR 1910.119	Process Safety Management of Highly Hazard Chemicals
29 CFR 1910.120	Hazardous Waste Operations and Emergency Response
29 CFR 1910.132	General Requirements (PPE)
29 CFR 1910.133	Eye and Face Protection
29 CFR 1910.134	Respiratory Protection
29 CFR 1910.135	Occupational Head Protection
29 CFR 1910.136	Occupational Foot Protection
29 CFR 1910.137	Electrical Protective Devices

29 CFR 1910.138	Hand Protection
29 CFR 1910.156	Fire Brigades
29 CFR 1910.1000 - 1910.1052	Air Contaminants
29 CFR 1910.1030	Bloodborne Pathogens
29 CFR 1910.1200	Hazard Communications

4. PERSONAL PROTECTIVE EQUIPMENT SELECTION

The information contained in Sections 5 through 10 of this pamphlet provide 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-toed shoes.

4.1 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 (Reference 13.1.2) and has trained its employees in these procedures. OSHA regulations (29 CFR 1910.132, Reference 13.6.4) 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 employee needs to select the appropriate PPE, communicate the selection decision with each affected employee, 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 (References 13.1.3 and 13.6.2).

These recommendations also assume the facility has not performed a detailed job safety analysis (JSA) 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 employee(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 (Reference 13.6.4) 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 pursuant to the following requirements."

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

Chemical burn injuries have occurred to employees after completing the assigned task while removing the PPE. Section 11.2 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. Initial line break is considered a maintenance activity and does not include (1) material sampling activities or (2) connecting or disconnecting of containers for loading/unloading purposes.

Chemical burn injuries have occurred to maintenance employees working on process equipment after the initial line break has occurred. In such cases, the employees 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 maintenance employees wear the same PPE as recommended for the initial line break until the equipment has been decontaminated and verified.

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 (1910.120 - Reference 13.6.3). 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) (Reference 13.6.4).

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) (Reference 13.6.3)] 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.

4.2 Bases 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 4.1, 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 fire fighting operations. OSHA has additional specific requirements [29 CFR 1910.156(e) (Reference 13.6.5)] 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 5 through 10.

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 "Faceshields are secondary protection and shall be used only with primary protection" (Reference 13.4.1). 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.

4.3 Levels of Protection

In the United States, OSHA has developed guidelines [29 CFR 1910.120, Appendix B (Reference 13.6.3)] 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 re-selection 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 face piece and an auxiliary self-contained air supply (escape air provision). Appendix A 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.
- 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

Enhanced Level B protection provides fully encapsulated protective equipment, but is not gas tight.

- 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.

  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 C protection should be used when:
  - 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 D protection should be used when:
  - 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.

4.4 CRITERIA FOR PPE SELECTION

The PPE recommended for the specific tasks should meet the criteria as listed in Table 4.1. 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 (Reference 13.9.1) and liquid splash-protective suits (Reference 13.9.2) for hazardous chemical emergencies and has issued standards for certification of certain PPE for emergency response personnel.

NFPA 1991 (Reference 13.9.1) 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 (Reference 13.9.2) 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 4.1 - 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 D2136-94 modified to -30°F (low temperature flex text)

II ASTM F739-99a (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

IV ASTM F1052-97 (pressure test)

V ASTM F903-99a (chemical resistance – penetration; no penetration in 60 minutes)

Reference 13.5 provides a further explanation of these tests.

* For all tests, NFPA 1993, Appendix C (Reference 13.9.3) 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.

5. PERSONAL PROTECTIVE EQUIPMENT SELECTION - CHLORINE

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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 chlorine liquid or gas below 120°F.

5.1 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

5.2 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.

5.3 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 4.1, 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.

5.4 Emergency Response

In addition to the assumptions stated in 4.1, these recommendations also assume that no other hazardous materials requiring additional PPE would be encountered by the responders.

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. See Section 2.2.2.

Prior to an individual re-entering 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.

Through their collective experience the members of the Institute have determined that Enhanced Level B, as defined by the Institute in Section 4.2, provides appropriate protection to emergency responders for liquid chlorine releases.

Recommendations:

Chlorine Gas - Level B

Chlorine Liquid - Enhanced Level B

5.5 SUMMARY OF RECOMMENDATIONS

Tables 5.1 and 5.2 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 5.1 - 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

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

Table 5.2 - 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 D2136-94 modified to -30°F (low temperature flex text)

II ASTM F739-99a (chemical resistance - permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

IV ASTM F1052-97 (pressure test)

V ASTM F903-99a (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 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.

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

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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°F. Materials for PPE should be chemically resistant against 10-50% sodium or potassium hydroxide at 120°F or the applicable.

Where sodium/potassium hydroxide products are being sampled/handled, and the product temperature is above 120°F, 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.

6.1 Initial Line Break

Recommendations:

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

6.2 Material Sampling

Recommendations:

- 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 employee 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.

Recommendations:

- 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 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.

6.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 4.1, 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/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 10 - 50 % Sodium or Potassium Hydroxide Below 120ºF

	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 6.2 - 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 F739-99a (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

V ASTM F903-99a (chemical resistance – penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 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 - SODIUM HYPOCHLORITE (3 - 20 WT %)

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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. Typically, sodium hypochlorite must be maintained below 100°F to minimize decomposition. Materials for PPE should be chemically resistant against 3-20% sodium hypochlorite at 100°F or the applicable temperature.

7.1 Initial Line Break

Recommendations:

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

7.2 MATERIAL SAMPLING

Recommendations:

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

7.3 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 employee 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.

Recommendations:

- 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.

7.4 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.

7.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 4.1, 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.

Recommendation:

- 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.

7.6 SUMMARY OF RECOMMENDATIONS

Tables 7.1 and 7.2 summarize the recommendations contained in this section. Table 7.1 also includes specific examples of PPE that provide protection for specific body parts.

Table 7.1 - Summary of PPE Recommendations for Tasks Involving Potential Exposure To 3 - 20% Sodium Hypochlorite Below 100°F

	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
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 7.2 - 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 F739-99a (chemical resistance – permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

V ASTM F903-99a (chemical resistance – penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 provide a further explanation of these tests.

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

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

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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°F. Materials for PPE should be chemical resistant against 7-37% hydrochloric acid at 120°F or the applicable temperature.

8.1 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:

Recommendations:

- SCBA or full face air supply respirator with escape bottle.

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

8.2 <u>MATERIAL SAMPLING</u>

As stated in Section 4.1, 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:

Recommendations:

- 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,

Recommendations:

- 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.)

8.3 LOADING/UNLOADING

In addition to the assumptions discussed in Section 4.1, 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,

Recommendations:

- 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,

Recommendations:

- 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.)

8.4 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 4.1, 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.

8.5 SUMMARY OF RECOMMENDATIONS

Tables 8.1a, 8.1b, and 8.2 summarize the recommendations contained in this section. Tables 8.1a and 8.1b 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 8.1a - Summary of PPE Recommendations for Tasks Involving Potential Exposure to 7 - 37% Hydrochloric Acid Below 120°F

See Table 8.1b 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 8.1b – Summary of Respiratory Protection Recommendations for Tasks Involving Potential Exposure to 7 – 37% Hydrochloric Acid Below 120°F			
	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 8.2 - 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 120oF or applicable temperature
Ensemble System	III

II ASTM F739-99a (chemical resistance - permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

V ASTM F903-99a (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 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 - SULFURIC ACID (38 - 98 WT %)

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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. 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.

9.1 INITIAL LINE BREAK

Recommendations:

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

9.2 MATERIAL SAMPLING

As stated in Section 4.1, these recommendations are made for sampling in the absence of site engineered sampling stations.

Recommendations:

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

9.3 LOADING

In addition to the assumption discussed in Section 4.1, the PPE recommendations listed below assume the actual loading operation can be started and stopped while the employee 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.

Recommendations:

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.

9.4 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.

9.5 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 4.1, 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 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.

9.6 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.

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 9.1 - 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	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 9.2 - 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 or applicable temperature
Ensemble System	III

II ASTM F739-99a (chemical resistance - permeation, no break through in 60 minutes)

III ASTM F1359-99a (shower test)

V ASTM F903-99a (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 provide further explanation of these tests.

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

10. PERSONAL PROTECTIVE EQUIPMENT SELECTION - ANHYDROUS HYDROGEN CHLORIDE (AHCl)

As stated in Section 4.1, the recommendations in this pamphlet assume that the facility has not performed a detailed job safety analysis (JSA) of the specific task being performed. If such a detailed JSA of the specific task has been performed and documented, and it concludes that a different level of PPE will protect the employee(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. Materials for PPE should be chemical resistant against gaseous anhydrous hydrogen chloride at 120°F or the applicable temperature. Special precautions should be taken for liquid AHCl since temperatures can reach 121°F (see Section 10.4).

10.1 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,

Recommendations:

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

AHCl Liquid - Enhanced Level B.

10.2 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,

Recommendations:

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.

10.3 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 4.1, 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,

Recommendations:

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.

10.4 EMERGENCY RESPONSE

In addition to the assumptions stated in Section 4.1, these recommendations assume that no other hazardous materials requiring additional PPE will be encountered by the emergency responders.

Prior to an individual re-entering 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 4.2, 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 it's low temperature (boiling point of -85°C 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 re-entering 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.

10.5 SUMMARY OF RECOMMENDATIONS

Tables 10.1 and 10.2 summarize the recommendations contained in this section. Table 10.1 also includes specific examples of PPE that provide protection for specific body parts.

Table 10.1 - 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 10.2 - 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 D2136-94 modified to -30°F (low temperature flex text)

II ASTM F739-99a (chemical resistance - permeation, no breakthrough in 60 minutes)

III ASTM F1359-99a (shower test)

IV ASTM F1052-97 (pressure test)

V ASTM F903-99a (chemical resistance - penetration; no penetration in 60 minutes)

Table 4.1 and Reference 13.5 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.

11. MAINTENANCE OF PERSONAL PROTECTIVE EQUIPMENT

11.1 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.

11.2 DECONTAMINATION

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

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

- Allow the safe removal of the PPE;
- Permit the safe reuse of previously contaminated PPE;
- Provide for safe assistance to the wearer (changing air cylinders, etc.); 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 insure 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.

11.3 INSPECTION

An effective PPE inspection will feature the following elements:

- Inspection and operational testing 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.

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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.

11.4 REPAIR

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

11.5 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, extreme temperatures and sunlight. 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.

11.6 DISPOSAL

Personal protective equipment that can not 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.

12. TRAINING IN THE USE OF PERSONAL PROTECTIVE EQUIPMENT

12.1 Operations and Maintenance

The OSHA Hazard Communication Standard (1910.1200 - Reference 13.6.7) requires that all employees be provided information and training on hazardous chemicals in their work areas. Training should include measures employees can take to protect themselves such as specific procedures the employer has implemented to protect employees 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 (1910.134 - Reference 13.6.4) and persons who may require them should be trained in their use.

12.2 Emergency Response

The Chlorine Institute recommends that all producers and users of chlorine have a written emergency response plan (ERP) (Reference 13.3.1). 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 (29 CFR 1910.120 (Reference 13.6.3). See Appendix B for a further discussion.

13. REFERENCES

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13.1.2 Emergency Response Plans for Chlorine Facilities, ed. 6; Pamphlet 64; The Chlorine Institute: Arlington, VA, 2006.

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13.3 AIHA PUBLICATIONS

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925-422-4599
925-423-2943 (fax)
http://www.llnl.gov

National Fire Protection Association (NFPA)
1 Batterymarch Park
Quincy, MA 02169
617-770-3000
617-770-0700 (fax)
http://www.nfpa.org/index.asp

National Institute for Occupational Safety and Health (NIOSH)
4676 Columbia Parkway
Cincinnati, OH 45226
800-232-4636
513-533-8347 (fax)
http://www.cdc.gov/niosh

Occupational Safety and Health Administration (OSHA)
200 Constitution Ave., NW
Washington, DC 20210
http://www.osha.gov

The Chlorine Institute, Inc.
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5760
703-741-6068 (fax)
http://www.chlorineinstitute.org

423of593

APPENDIX A - SAMPLE PPE INSPECTION CHECKLIST GUIDE

A PPE inspection checklist should cover the following items:

- <u>GENERAL INFORMATION</u>
  - Date of inspection
  - Name of inspector
  - Actual findings
  - Comments

- <u>CHEMICAL PROTECTIVE GARMENT</u> (e.g., suit, jacket, pants, apron)
  - Before each use

    (1) Determine that the clothing material is correct for the specified task at hand

    (2) Visually inspect for:

      - defective seams and closures
      - non-uniform coatings
      - tears and holes
      - discoloration
      - swelling
      - stiffness

    (3) Flex the item:

      - observe for cracks
      - observe for other signs of deterioration

  - During Use: The user should be aware of and monitor the following:

    (1) Evidence of chemical attack such as discoloration, swelling, stiffening, and softening

    (2) Defective closure on seams

    (3) Tears or holes

- CHEMICAL PROTECTIVE BOOTS AND GLOVES

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

  - Cracks
  - Punctures
  - Signs of pliability (stiffness)
  - Signs of deterioration
  - Discoloration

- RESPIRATORY PROTECTION EQUIPMENT

  Appendix C has information on respiratory protective equipment inspection and maintenance.

- EYE AND FACE PROTECTION EQUIPMENT

  Inspect for:

  - cracks
  - fogging
  - crazing
  - lenses properly secured

APPENDIX B - EMERGENCY RESPONSE DUTIES, FUNCTIONS AND TRAINING

Hazardous waste operations and emergency response duties, function and competence of emergency responders and corresponding training requirements are divided into four levels: (1) First Responder - Awareness Level; (2) First Responder - Operations Level; (3) Hazardous Materials Technician; and (4) Hazardous Materials Specialist. For comprehensive competency/training requirements refer to the OSHA standard 1910.120 6(i), (ii), (iii), and (iv) - (Reference 13.6.3). Reference 13.3.1 provides additional guidance. The following excerpts briefly describe operation of each level and PPE training requirement.

<u>Hazardous Waste Operations/Emergency Response Duties</u>

First Responders - Awareness Level:

These are individuals likely to witness or discover and report a hazardous substance release. PPE in most cases will not be used at this level except for an escape respirator, glasses and gloves.

First Responders - Operations Level:

These are individuals who respond to releases or potential releases of hazardous substances as part of the initial response to the site for the purpose of protecting nearby persons, property or the environment from the effects of the release. They are trained to respond in a defensive fashion without actually trying to stop the release. This level requires at least 8 hours of comprehensive training or have sufficient competency in the required training which includes but is not limited to how to select and properly use PPE provided.

Hazardous Materials Technicians (HMTs):

These are individuals who respond to releases or potential releases for the purpose of stopping the release. HMTs must have received at least 24 hours training equal to the first responder operation level plus training or demonstrate competency in other required areas including but not limited to PPE provided to HMTs.

Hazardous Materials Specialists (HMSs):

These are individuals who respond with and provide support to HMTs. HMSs must have received at least 24 hours training equal to the HMT level and have competency in other required areas including but not limited to being able to select and use proper specialized PPE provided to the HMS.

Trainers - PPE

Trainers who teach any of the above training subjects must have satisfactorily completed a training course for teaching the subject they are expected to teach or must have training and/or academic credentials and instructional experience to demonstrate competency.

Refresher Training:

Employers shall have annual refresher training of sufficient content and duration to maintain their competencies or shall demonstrate competencies in those areas at least annually. Records of training or statements on method(s) of demonstrating competency must be maintained.

APPENDIX C - RESPIRATORY PROTECTION

Elements of a Respiratory Protection Program

Introduction:

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.

Specific Responsibility Assignment:

One individual should be assigned the responsibility and authority to see the respiratory protection program is carried out effectively. This individual should be knowledgeable about industrial hygiene principles, or have access to such a knowledgeable person, and should become expert in all aspects of the program. Most importantly, he/she should know the potential hazards in each operation and the corresponding proper protection.

Documentation:

A written description of the respirator program is necessary for effective administration. In the United States OSHA requires a written program [Reference 13.6.4 (29 CFR 1910.134)]. 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.

Training:

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

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) (29 CFR 1910.134 (Appendix A). (Reference 13.6.4) 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 (Appendix B-1), and the manufacturer's face piece fitting instructions.

Cleaning of Respirators:

Frequent cleaning of face piece is helpful in preventing skin irritation, especially in warm climates. Proper cleaning procedures should be part of the training program.

Respirator Maintenance:

An efficient maintenance plan for respiratory equipment is essential. Well defined procedures and schedules should be established. Thorough training is necessary for respiratory equipment maintenance personnel. A description of the maintenance plan should be part of the written respirator program. Each user must understand the basis for cartridge and canister replacement. A record of replacements should be maintained.

Inspection and Storage:

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), face piece crimping, expiration date printed on cartridge or canister, and condition of valves and straps.

Medical Examination:

Certain physical conditions may limit an employee's ability to use a respirator. In the United States, each employee is required to be evaluated by a physician or other licensed health care professional to determine his/her fitness to perform job tasks while using a respirator (29 CFR 1910.134(e)) (Reference 13.6.4). The evaluator needs to know the job assignment, types of respirator to be used, and conditions that may require respirator use ((29 CFR 1910,134 (e)(5)).

Program Evaluation:

In addition to the program evaluation requirements of 29 CFR 1910.134(l), a periodic audit of the respiratory protection program should be conducted and include the following:

- A review of inhalation incidents to determine the adequacy of the program;
- A review of conditions to determine whether changes warrant amending the program;
- A review of the elements of the program to verify compliance;
- A review of the documentation to verify that necessary records are being maintained; and
- A review of whether any engineering or administrative controls can be implemented to lessen or eliminate the need for 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. (Reference 13.7.1)

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 (Reference 13.6.4)) in a continuous flow with a demand or pressure demand regulator.

Continuous flow types may be equipped with either a quarter, half or full tight-fitting face piece 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 face piece. 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 13.6.4 (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.

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

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 Reference 13.10.1.

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.

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. (Reference 13.8.1)

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).

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 face piece 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 D - CHECKLIST

This check list 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?	5
❐	❐	❐	2. Does the facility comply with the PPE recommendation for specific tasks involving 10-50% sodium hydroxide?	6
❐	❐	❐	3. Does the facility comply with the PPE recommendation for specific tasks involving 10-50% potassium hydroxide?	6
❐	❐	❐	4. Does the facility comply with the PPE recommendation for specific tasks involving 3-20% sodium hypochlorite?	7
❐	❐	❐	5. Does the facility comply with the PPE recommendation for specific tasks involving 7-37% hydrochloric acid?	8
❐	❐	❐	6. Does the facility comply with the PPE recommendation for specific tasks involving 55-98% sulfuric acid?	9
❐	❐	❐	7. Does the facility comply with the PPE recommendation for specific tasks involving gaseous or liquid anhydrous hydrogen chloride?	10
❐	❐	❐	8. Does the facility have a preventive maintenance program for PPE that complies with Institute recommendations?	11
❐	❐	❐	9. Does the facility include in its Hazard Communication training, information on measures that employees can take to protect themselves from exposure to hazardous chemicals?	12

432of593

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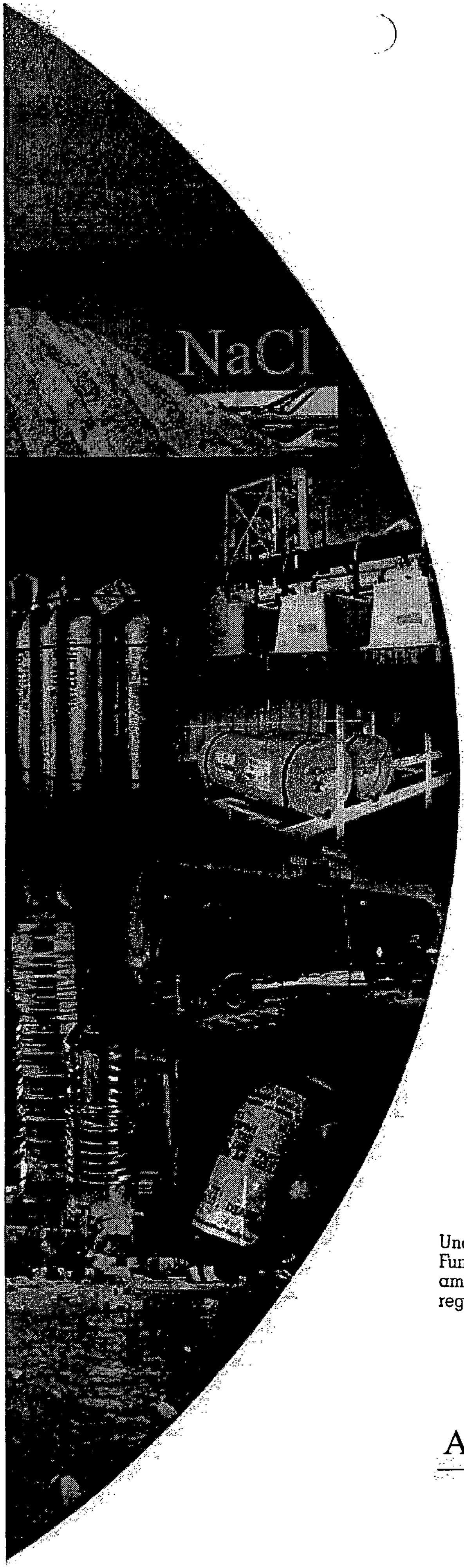
433 of 593



THE CHLORINE INSTITUTE, INC.

Pamphlet 66

Recommended Practices for Handling Chlorine Tank Cars

Edition 4 - Revision 1

A LEGACY OF SAFETY STEWARDSHIP since 1924

ACCEPTED
with COMMENTS
in EPA Letter Dated:

JUL 19 2010

Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

April 2009

434 of 593

TABLE OF CONTENTS

4350f593

4360f593

1. INTRODUCTION

1.1 SCOPE

This pamphlet provides guidelines, recommended practices and other useful information for the safe handling of chlorine tank cars at loading and unloading facilities. This includes receiving, spotting, loading, unloading, routine maintenance, inspecting, testing and tank qualification. It represents a compendium of Institute membership experience as of the date of publication.

1.2 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 improvements. For more information on the Institute's stewardship program, visit CI's website at www.chlorineinstitute.org .

1.3 DEFINITIONS

In this pamphlet, the following meanings apply unless otherwise noted:

AAR	Association of American Railroads
AEI tag	automatic equipment identification tag
ASME	American Society Mechanical Engineers
CFR	Code of Federal Regulations (U.S.)
chlorine	DRY chlorine, either gas or liquid
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980 (42 U.S.C. 9601 et seq.), also known as the superfund law
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation

Dry air or nitrogen	air or nitrogen dried to a dew point of -40F (-40C) or below measured at the operating pressure
EPA	U.S. Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FRA	Federal Railroad Administration, U.S. DOT
gas padding	the addition of clean, dry, oil free, compressed air, nitrogen or chlorine in order to increase system pressure
gas purge	the use of clean, dry, oil free, compressed air or nitrogen to displace chlorine, moisture or other contaminants from a tank or system
Institute	The Chlorine Institute, Inc.
marking	A descriptive name, identification number, instruction, caution, weight, specification or UN mark that is required to be applied to the tank car. A marking can be applied with a stencil or decal
NDE	nondestructive examination
OSHA	Occupational Safety and Health Administration, U.S. DOL
POV	Pneumatically operated angle valve
psig	pounds per square inch gage
pressure relief device	A mechanism designed to prevent internal pressure from rising above a predetermined maximum in a pressure vessel
tank car	a tank car tank mounted on or forming part of a rail car structure, including all components necessary and proper for railroad service
sniffing	to remove residual chlorine by pulling a minimum two inches of mercury vacuum on the tank
stencil	a marking applied with paint or a decal
TC	Transport Canada

1.4 SAFETY PROGRAMS

Every site handling chlorine should have an on-going safety program. Periodic training sessions and safety inspections must be conducted in accord with applicable regulations. Special attention should be directed to the appropriateness of emergency procedures and to equipment to be used in an emergency. Additional information on safety programs is available from the Institute and from chlorine suppliers.

1.5 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require a change in the recommendations herein. Appropriate steps should be taken to insure that the information is current when used. These recommendations should not be confused nor conflict with federal, state, provincial, municipal or insurance requirements, or with national safety codes.

1.6 APPROVAL

The Institute's Transportation Issue Team approved Edition 4 of this pamphlet on March 20, 2007.

1.7 REVISIONS

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

1.8 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. GENERAL INFORMATION

2.1 CHLORINE IN COMMERCE

Chlorine has both a liquid and a gas phase when transported in tank cars. Chlorine is classified for transportation as Class 2.3 (poison gas) with a subsidiary corrosive hazard. In Canada, chlorine has a secondary classification as a Class 5, Division 5.1, oxidizer. The classification in Mexico is the same as that in Canada. The United Nations identification number for chlorine is U.N. 1017. Chlorine tank cars built after July 1, 1996 must meet DOT (or TC) 105J300W or 105J500W requirements. DOT (or TC) 105A300W, 105A500W, 105S300W, 105S500W stenciled cars are being phased out of chlorine service or are being reclassified to J class in order to remain in chlorine service.

DOT regulations under HM-175A (and equivalent Canadian regulations) mandate that the cars that do not meet the 105J classification requirements cannot be used for chlorine (or other Class 2 materials) rail transportation after July 1, 2006. After this date, only DOT (or TC) 105J300W or 105J500W cars will be permitted in chlorine service.

2.2 Related Institute Publications

General information on chlorine including physical properties, packaging, technical data reference can be found in The Chlorine Manual (Reference 13.1.1) Additional information about personal protective equipment can be found in Pamphlet 65 Personal Protective Equipment for Chlor-Alkali Chemicals (Reference 13.1.6). A more comprehensive list is contained in section 13 of this pamphlet.

2.3 Nitrogen Trichloride - Hazard Awareness

The presence of nitrogen trichloride in liquid chlorine is the suspected cause of explosions that have occurred, although infrequently, in chlorine systems including chlorine transportation containers. Nitrogen trichloride is formed from nitrogen that enters the system during the chlorine production process.

Pamphlet 152 Safe Handling of Chlorine Containing Nitrogen Trichloride (Reference 13.1.9) provides methods for the detection, prevention and destruction of nitrogen trichloride. Bulk shipping containers (barge tanks, tank cars and cargo tanks) should not be unloaded in the gas phase. If present, nitrogen trichloride will concentrate in the liquid phase because of nitrogen trichloride's higher boiling point. Due to the relatively large amount of chlorine in the bulk container, the nitrogen trichloride in the liquid phase could concentrate to dangerous levels if only gases are removed.

3. EMERGENCY RESPONSE

3.1 Emergency Planning

Facilities and Transfer Sites

All facilities should have an emergency response plan in place. All personnel responsible for transfer operations must be completely familiar with the facility's emergency plan for handling spills and leaks of product.

Transportation

The DOT and TC have specific training requirements applicable to handling of hazardous materials (see 49 CFR Subpart H, 172.700 to 172.704 and the Canadian equivalent). Shippers must familiarize themselves with these requirements and OSHA requirements.

3.2 CHLOREP

The Chlorine Emergency Plan (CHLOREP) is an industry-wide program established by the Institute to improve the speed and effectiveness of response to chlorine emergencies in the United States and Canada.

Under this plan the United States and Canada have been divided into regional sectors where chlorine emergency teams from producing, packager and consuming plants are on constant alert on a 24-hour basis, to handle threatened or actual chlorine leaks. During a chlorine emergency, any carrier, customer, or civil authority can obtain basic emergency information and be put in contact with the closest chlorine emergency group by phoning an emergency dispatch agency.

3.3 CHEMTREC AND CANUTEC

For transportation-related incidents in the U.S., one should utilize CHEMTREC, the Chemical Transportation Emergency Center in Arlington, VA, as the dispatch agency. CHEMTREC operates around-the-clock, 24 hours-a-day, seven days-a-week to receive direct-dial, toll-free calls from any point in the United States and Canada at 1-800-424-9300 (703-527-3887 for all other calls). CHEMTREC provides immediate advice for those at the scene of emergencies, then, if the emergency involves chlorine, promptly contacts the designated CHLOREP team, the shipper and others as required. Registration with CHEMTREC is provided through the American Chemistry Council. In Canada, one should utilize CANUTEC, the Canadian Transport Emergency Centre in Ottawa as the dispatch agency. Their telephone number is 613-996-6666 (call collect). CANUTEC, administered by TC, operates in a similar manner to CHEMTREC.

3.4 EMERGENCY KITS

Leaks that may occur in chlorine tank cars usually involve the angle valves or pressure relief devices and can be controlled with the Institute's Emergency Kit C. An Emergency Kit C should be on site in a location sufficiently away from the tank car so it will be accessible during an emergency. The kit should be inspected frequently to ensure the equipment is ready for use.

3.5 PERSONAL PROTECTIVE EQUIPMENT

Pamphlet 65 (Reference 13.1.6) provides information on personal protective equipment for chlorine. Since it is unlikely the concentration of chlorine present in an emergency situation can be adequately monitored, it is recommended that self contained full face piece breathing apparatus with at least 20 minutes of air operated in the positive pressure mode be on site and readily available.

3.6 REPORTING OF RELEASE

Chlorine is identified as hazardous substances in Table 302.4 – List of Hazardous Substances and Reportable Quantities of 40 CFR 302.4. CERCLA requires immediate notification of a release equal to or in excess of the reportable quantity. The reportable quantity of chlorine is 10 pounds (4.54 Kg.). Should a reportable release occur in the U.S., the law requires the National Response Center (1-800-424-8802) to be immediately notified.

In Canada appropriate provincial response authorities must be immediately advised of a chlorine release of any quantity. State, provincial and local laws may require reporting to the appropriate state and/or local environmental agencies.

4. REGULATORY REQUIREMENTS

4.1 DOT REGULATIONS

The DOT regulates the acceptance and transportation of hazardous materials including the specifications for shipping containers in Title 49 CFR Parts 171-180. Because chlorine is a hazardous material, it is imperative that personnel involved in any aspect of handling, packaging and/or transportation of chlorine are knowledgeable of the regulatory requirements pertaining to chlorine. Publications should be readily available for reference. See Section 13 for ordering information.

4.2 EPA REGULATIONS

In the United States, when chlorine is used for disinfection of drinking water, waste water and swimming pools it is considered to be a fungicide and is subject to EPA regulations issued under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The EPA regulations, found in 40 CFR Subchapter E Part 156, require shipper registration with EPA and appropriate labeling. (Reference 13.4)

4.3 OSHA REGULATIONS

The OSHA's occupational safety and health standards are found in Title 29 CFR Part 1910. Title 29 CFR regulates material handling and storage, process safety management, the emergency response to hazardous substance releases and personnel protective equipment. (Reference 13.5)

4.4 CANADA REGULATIONS

The Canadian regulations for the Transportation of Dangerous Goods (TDG) parallel the DOT requirements in most respects. The Canadian regulations can be found in the Canadian Transportation of Dangerous Goods Act and Regulations. These regulations include, by reference, various standards, published by agencies such as the Canadian Standards Association (CSA) and the Canadian General Standards Board (CGSB) and particularly with reference to tank cars, CGSB-43.147 (Reference 13.6).

4.5 MEXICO REGULATIONS

The Normas Officiales de Mexico (Official Mexican Standards), often referred to as Normas or NOMs, support the Mexican Hazardous Materials Land Transportation Regulation. The Mexican Secretariat for Communications and Transport is responsible for publishing and applying the NOMs. The Mexican NOMs are fairly consistent with those of the United Nations Recommendations on the Transport of Dangerous Goods (UN Recommendations) and TC and DOT regulations.

4.6 LOCAL REQUIREMENTS

In addition to federal requirements, state, provincial or local requirements might affect these operations. The reader is cautioned to check applicable codes.

5. TANK CAR DESCRIPTION

5.1 SIZE AND TYPE

Tank cars for chlorine use are permitted by regulation to have a maximum capacity of 90 tons (81648 kg) of chlorine. Chlorine tank cars have 55, 85 or 90 ton capacities. Tanks may not be loaded with chlorine in excess of the load limit stenciled on the side of the car (see Section 7.3.1).

Typical Dimensions and Weights of Tank Cars

Typical Dimensions and Weights of Tank Cars						
Car	Length Over Strikers(1)	Overall Height(2)	Extreme Width(3)	Height to Valve Outlet (4)	Weight Empty lbs.	Weight Loaded lbs.
55 Ton	29'9"-43'0"	14'3"-15'1"	10'5-1/2"-10'6-1/2"	13'2"-13'7"	57,000-94,000	167,000-204,000
85 Ton	43'7"-50'0"	14'11"-15'1"	10'5-1/2"-10'6-1/2"	13'2"-13'7"	79,000-90,100	249,700-260,100
90 Ton	45'8"-47'2"	14'11"-15'1"	10'5-1/2"-10'6-1/2"	13'2"-13'7"	79,700-83,000	259,700-263,000

Notes: (1) For overall length including both couplers, add approximately 3 feet.

(2) Heights are for empty cars and are measured from top of rail; heights of loaded cars may be reduced as much as two inches.

(3) Width over grab irons.

(4) Height to manway platform is 6 to 10 inches less than height to centerline of valves.

Important: Contact car owner for detailed weight and dimension data.

5.2 SAFETY SYSTEMS

DOT and TC regulations mandate chlorine tank cars be equipped with safety systems that meet the requirements of 49 CFR Part 173 and CGSB-43.147 Section 15. Cars meeting these requirements must be stenciled as 105J300W or 105J500W. The safety systems applicable to chlorine cars include thermal protection systems, insulation systems, tank head puncture resistance systems, coupler vertical restraint systems, and a protective housing as required by regulation.

The following reports document the compliance of commonly used chlorine car safety systems to these requirements:

- "Thermal Insulation Systems Study for the Chlorine Tank Car" (FRA/ORD-85/10), April 1995
- "Evaluation of the Thermal Effectiveness of Urethane Foam and Fiberglass as Insulation Systems for Tank Cars" (FRA/ORD - 87/11), July 1987
- "Chlorine Tank Car Puncture Evaluation" (NTIS DOT/FRA/ORD-92/11), November, 1992.

Insulation System

All chlorine tank cars have insulation covering the tank shell. Insulation for chlorine tank cars must have a thickness of at least two inches of ceramic fiber covered by at least two inches of glass fiber, or four inches minimum thickness of polyurethane foam. Insulation must be covered by a steel jacket of 11 gauge minimum thickness (0.1196 inch nominal thickness). The primary purpose of the insulation system on chlorine tank cars is to protect the tank shell and heads from fire and, to some extent, from other types of accident damage.

5.3 MANWAY ARRANGEMENT FOR TANK CARS

General

All chlorine tank cars should be equipped and assembled with manway arrangements in accord with Drawing 107 (Reference 13.1.17). The manway cover (pressure plate), valves, studs and gaskets are detailed on pertinent Institute drawings. Maintenance manuals should be provided by all valve manufacturers. Tank car valves must be approved by the AAR Tank Car Committee in accord with the requirement of AAR Specification M-1002 (Reference 13.2.1). See Section 13 for a complete listing of publications and drawings.

Angle Valves

Most chlorine tank cars are equipped with four one inch manual angle valves. The two angle valves on the longitudinal center line of the tank car are for liquid transfer. The two valves on the transverse center line are for vapor. Each liquid valve is equipped with a one and one-quarter inch eduction pipe extending to the bottom of the tank for unloading of the contents. All applicable angle valves for use in chlorine service can be found in Pamphlet 166 (Reference 13.1.10) Some chlorine tank cars are equipped with AAR approved pneumatically operated angle (POV) valves in combination with a check valve. The check valve in the POV replaces the excess flow valve under the conventional liquid angle valve.

Excess Flow Valves

Each eduction pipe is equipped with an excess flow valve. An excess flow valve contains a rising ball or plug which blocks the flow when the rate of flow or pressure differential exceeds a predetermined value. These valves are intended to close automatically against outward flow of chlorine if the angle valve is broken off during transit (See 49 CFR 179.100.13(d)) where there would be a sufficient pressure differential to ensure a flow that would activate the excess flow valve. Because excess flow valves may not activate with smaller leaks, excess flow valves must not be depended upon for an emergency shut off during cargo transfers. See Pamphlet 57 *Emergency Shut-Off Systems for Bulk Transfer of Chlorine* (Reference 13.1.4).

Chlorine cars may be equipped with excess flow valves having a maximum operating flow rate of 7,000, 15,000 or 32,000 pounds of liquid chlorine per hour. It is recommended the minimum pressure in a loaded tank car when offered for shipment be 20 psig for tanks equipped with excess flow valves per Drawing 101 (Reference 13.1.12) and 50 psig for excess flow valves per Drawing 114 (Reference 13.1.18). For other excess flow valves, the selection of fittings and minimum pressure should be in accordance with manufacturer's specifications to ensure proper operation.

Pressure Relief Devices

Chlorine tank cars are equipped with a pressure relief device, located in the center of the manway cover (pressure plate), which is set to discharge at 225 psig on tank cars stenciled 105J300W and 375 psig on tank cars stenciled 105J500W. The pressure relief device on a chlorine tank car is a combination device consisting of a breaking pin or rupture disc assembly in combination with a pressure relief valve.

6. TANK CAR RECEIVING AND SPOTTING

6.1 <u>RAIL SIDING</u>

Chlorine tank cars must be loaded or unloaded on a private track or siding. Derails and a blue flag should be provided for the open end or ends of the siding. A suitable platform should be provided for safe and easy access to the tank car manway area. Special attention must be given to lighting in the area. Even if night operations are not contemplated, effective lighting should be installed as an aid in dealing with possible night emergencies. Emergency lighting should be available in case of power failure.

6.2 <u>SECUREMENT AND PROTECTION OF CAR</u>

Setting Car Brakes

When the tank car has been placed at the desired location on the siding, and before connections to the tank car are made, the hand brake must be set, and the wheels properly chocked. Brake shoes should be in contact with the wheels. A check should be made to ensure the brake is holding.

Placing Derails

During the loading or unloading of a car, measures must be taken to prevent the tank car from being hit or moved by another car or locomotive. This is accomplished by using derails or stops 50 feet or more from both ends of the car. Derails should not be removed for any reason until all cars are disconnected from the loading/unloading rack. If a portable derail is used, it should be properly secured.

Caution Signs/Lights

A tank car positioned for loading or unloading must have caution signs (and/or lights) placed at or near each derail or stop to warn persons approaching the car. Caution signs must remain in place until the operation is completed, all connections removed, and angle valve outlets properly closed with pipe plugs.

6.3 STORAGE OF LOADED CHLORINE TANK CARS

Fully loaded chlorine tank cars, properly prepared for shipment, prior to shipment or following shipment, may be safely used for storage for any period of time not exceeding the next scheduled valve service (Reference 13.1.2).

7. CAR INSPECTION AND PREPARATION PRIOR TO LOADING

7.1 GENERAL

Prior to loading the tank car, there are a number of activities that must take place to ensure the tank car meets all applicable regulations and is ready to receive chlorine. This process starts with an inbound inspection of the car, and could include routine maintenance and repairs and activities related to the qualification of the car.

It is recommended an inspection checklist such as in Appendix B, be used for all aspects of the loading operation. This includes activities from the inbound inspection covered in this section through the post-load inspection covered in Section 8. Checklists will ensure all regulatory requirements, recommendations contained in this pamphlet and company procedures or facility specific requirements are met.

Checklists document that proper loading and securement procedures have been completed and, if necessary, proper corrective actions have been taken. Checklists should be kept following the company's document control policies.

7.2 TANK CAR INBOUND INSPECTION

The purpose of the inbound inspection is to identify all defects in the tank car or items out of regulatory compliance before loading chlorine. The inbound inspection should at a minimum include:

- An inspection of the tank, underframe, running gear, and safety appliances for obvious defects or damage. If damage has not been recorded on a defect card, company procedures should be followed.
- A check of the tank car's markings and stenciling including test and qualification dates to ensure all inspection and maintenance requirements are current.
- A check to determine if there is liquid chlorine in the car. If there is, company procedures should be followed to rectify the situation. Because of the risk of contamination or reactivity, any liquid chlorine should be analyzed before recovery or reuse.
- A check of the valves, housing and fittings.
- A check to verify the car is equipped with AEI tags.
- A check to see if there is a defect card or other defect notification marking.
- Some tank cars may have GPS tracking devices. These devices should be inspected to ensure that they are in working order prior to loading.
- Assure that inspections comply with the site security plan and any applicable regulatory or industry requirements.

7.3 TANK CAR MARKINGS

Tank car marking requirements are found in the AAR Specification M-1002, Appendix C (Reference 13.2.1). Rule 70 in the AAR Field Manual (Reference 13.2.2) also covers tank car marking requirements for lightweight and load limit stencils. Drawing 167 (Reference 13.1.21), included in the back of this pamphlet, shows the proper location, size and content for the tank car markings. All markings must be maintained in a legible condition. The markings needing the most attention at the point of loading are described in the following subsections.

7.3.1 Light Weight and Load Limit

A brief summation of light weight and load limit definitions and their applicability in regard to chlorine tank cars follows:

Light Weight (LT WT) - The total weight of an empty car. Light weight stenciling is to be rounded off to the nearest 100 pounds. (If weight is at an even 50 lbs. - the lower multiple of 100 lbs. is used).

Load Limit (LD LT) - The maximum permissible weight of chlorine that can be loaded into a particular tank car. The load limit is normally the total allowable weight on rails, i.e., gross rail load (See AAR Field Manual Rule 70 (Reference 13.2.2)) minus the stenciled light weight.

In some cases, the car owner must reduce the allowed gross rail load to a value below the maximum to ensure the 90 ton chlorine load limit (or some other limitation) is not exceeded. When this occurs, a "starred" load limit weight is applied. Consult AAR Field Manual - Rule 70 (Reference 13.2.2) for more complete instructions.

Examples of Starred (*) and Non-Starred Load Limits for Chlorine Tank Cars

Normal Maximum Weight on Rail	Actual Maximum	Light Weight	Load Limit
263,000 lbs	261,000 lbs	81,000 lbs	*180,000 lbs
263,000 lbs	262,500 lbs	82,500 lbs	*180,000 lbs
263,000 lbs	263,000 lbs	83,000 lbs	180,000 lbs
263,000 lbs	263,000 lbs	85,000 lbs	178,000 lbs

7.3.2 Marking of Test and Qualification Dates

The test dates and due dates for the tank test or qualification must be marked on the tank car tank and must comply with regulations. Refer to Drawing 167 (Reference 13.1.21)

7.3.3 Commodity Marking

A minimum four inch high marking reading "CHLORINE" must be applied to each side of the tank car as shown on Drawing 167 (Reference 13.1.21). The color must be in a sharp contrast to the color of the tank car.

7.3.4 Inhalation Hazard Marking

Because chlorine has been designated as having a poison-inhalation hazard, a minimum four inch high marking reading "INHALATION HAZARD" must be applied on each side of the tank car as shown on Drawing 167 (Reference 13.1.21).

7.3.5 Excess Flow Valve Stencil

A stencil showing flow rates of the excess flow valves and the minimum shipping pressure should be applied as per Drawing 167 (Reference 13.1.21).

7.3.6 Valve Marking

Valves on tank cars must be marked or tagged as follows. Refer to AAR Specification M-1002, Appendix A (Reference 13.2.1).

- Reclosing Pressure Relief Device - The following markings must be placed on the device or on a plate or plates securely fastened to the device:
  - the name or identifying mark of the manufacturer
  - manufacturer's design or type number
  - set pressure, psig (or psig and kPa)
  - official flow capacity, cubic feet per minute (or cubic feet per minute and cubic meters per second) of air at standard conditions
  - flow rating pressure, psig (or psig and kPa)
  - month and year of manufacture or retest

Note: The AAR requires a serial number on all pressure relief valves built after December 31, 2003.

- Liquid and vapor valves - All valves with a net free flow area of more than ½ square inch (323 square millimeters) must be marked to indicate:
  - the name or identifying mark of the manufacturer
  - manufacturer's design or type number
  - type of trim
  - pressure-temperature limitations

7.4 INSPECTION AND MAINTENANCE OF TANK AND SERVICE EQUIPMENT

It may be determined from the inbound inspection or from company records that the tank car is due for an internal inspection, valve servicing, or service equipment or tank qualification. Tank cars are required to be qualified periodically by an AAR certified facility. Before loading, the stenciled due dates on the car should be checked to ensure the tank car tank, safety systems and service equipment are not overdue for qualification. If the car is due for qualification, arrangements must be made to have the qualification performed by an AAR certified facility. Service equipment has been defined by DOT as the equipment used for filling, sampling, emptying, venting, vacuum relief, heating (if internal to the tank), measuring lading temperature, or measuring the amount of lading in the tank.

In addition to regulatory requirements, companies may have their own maintenance program for service equipment. Before loading, a check should be made to ensure the service equipment has been maintained in accordance with company procedures. The maintenance and installation of service equipment must be performed by an AAR certified or registered facility. Records of valve and pressure relief device replacements must be maintained throughout the qualification period. A pressure leak test, following company procedures, must be conducted after assembly of service equipment to determine if there is leakage between the nozzle flange and the manway cover (pressure plate), and between the manway cover (pressure plate) and service equipment. This test may be conducted using chlorine, dry air or an inert gas.

7.4.1 Internal Tank Inspection

An internal examination of the tank can take place without a person entering the tank. This is not a comprehensive internal examination and can give only limited information on the tank's internal surface condition. It is used to verify the general condition inside the car. It can be done during routine valve changeouts when, with a valve removed and the car under a partial vacuum, a light is inserted into the manway cover (pressure plate) opening and a visual examination made.

A more comprehensive internal inspection occurs when a person enters the tank when the tank is cleaned for a period inspection or for tank qualification. Other circumstances which could lead to an internal examination of the tank include:

- Customer complaint - difficult unloading, out-of-spec chlorine
- Returned car with large heel of chlorine
- Excess flow valve ball or plug missing
- Broken excess flow valve pins
- Corrosion on manway cover (pressure plate) that would prevent proper sealing of the emergency kit hood
- Corroded valve gasket grooves on manway cover (pressure plate).
- Liquid sheen/moisture seen inside tank using drop light through valve opening in manway cover (pressure plate).
- Hole or other defect in eduction pipe
- New or used tank car entering company's chlorine fleet for first time
- Evidence of railroad damage
- Evidence of leak (e.g. green discoloration around seals)
- Problem with pulling vacuum on the car

- Failed leak test
- Sludge in discharge of angle valve
- Car returning from repair shop

Prior to entering a chlorine tank for an internal inspection, residual chlorine must be removed. To accomplish this, conventional sniffing methods should be used. The tank should then be filled with water and washed to remove any remaining chlorine. It is critical to ensure all the liquid chlorine has been removed before water is added. This will prevent the possibility of the formation of hydrochloric acid which could damage the tank. The tank should be completely filled with water to ensure the displacement of any chlorine or inert padding gas.

All facility procedures and OSHA regulations for safe tank entry must be followed. (See 29 CFR 1910.146.) This includes properly securing the tank car, checking the tank atmosphere for oxygen and combustibles, having rescue equipment readily available, and having sufficient backup personnel. A tank entry checklist is recommended. Only properly trained personnel should be involved in tank entry.

Prior to removing the manway assembly, the correct orientation should be marked and the manway assembly tagged with the car number. Prior to the internal inspection, all rust, debris, and visible water should be removed and the tank thoroughly dried using clean dry rags. When conducting the internal inspection, a light beam directed parallel to the walls aids in the detection of pits, cracks and corrosion. If significant problems are found, the tank car owner should be notified.

Before re-installing the manway assembly, the manway nozzle gasket groove should be carefully cleaned with a wire brush and inspected for cuts, corrosion, nicks or damage. If significant defects are noted, the car will have to be shopped for repairs. The manway assembly should be cleaned and all parts inspected for damage including the eduction pipe assembly. The top of the manway cover should be free of pits that could prevent a seal of the Emergency Kit C valve capping hood. If damage is found in the manway cover (pressure plate) gasket sealing surface, the manway cover (pressure plate) should be replaced. A new gasket should be applied. Refer to Drawing 103 (Reference 13.1.14).

New or rebuilt excess flow valves should be installed when necessary. Refer to Drawings 101 (Reference 13.1.12) and 114 (Reference 13.1.18). Excess flow valve seats must be checked for tightness. All studs and nuts should be inspected for corrosion, defects and engagement according to Appendix D of AAR Specification M-1002, Appendix D (Reference 13.2.1). All replacements should conform with Institute Drawing 102 (Reference 13.1.13).

All mounting nuts should be tightened per 7.4.3. After the manway assembly and all valves have been installed, the tank should be dried using dry air or nitrogen and the tank leak tested with dry air.

7.4.2 Removal, Inspection, Reconditioning and Installation of Valves

To permit the removal and replacement of valves without chlorine emission, the internal tank pressure must be reduced to a partial vacuum. Precautions must be taken to prevent moist air from entering the tank. The entry of moisture to the chlorine car during this time is detrimental to the tank shell.

Angle Valves

Angle valves must be removed, examined, reconditioned, retested, and replaced at regular intervals. The frequency of the procedures should be established at each shipping point with consideration to:

- Service equipment qualification
- Prior valve performance history
- Padding air quality
- Loading/unloading frequency
- Other parameters as established by the shipper and end user

Maintenance manuals provided by the valve manufacturer should be reviewed for guidance when reconditioning angle valves.

When valves are removed with the manway cover (pressure plate) and protective housing in place, care must be taken to ensure no damage is incurred from tools used to remove valves and gaskets. A special crow foot wrench can be used to minimize damage potential. Care must be taken to avoid damage to the valve seat tongue and manway cover (pressure plate) groove. To prevent moist air from entering the tank, a soft rubber plug should be immediately installed in the manway cover (pressure plate) valve hole opening. All gaskets should be replaced each time a valve is removed. The manway cover (pressure plate) groove and valve tongue should be inspected and cleaned prior to replacing gaskets. Only proper gasket materials should be used. See Pamphlet 95 (Reference 13.1.8) for material options.

Prior to installation of the angle valve, a check should be made for the presence of excess flow valve balls or plugs under the liquid valves and for the tool tightness of the excess flow valve seat. The tongue and groove surfaces on the manway cover (pressure plate) should be checked. Sealing surfaces must not be scored and should be inspected per 7.4.3. The protection for the valve inlets and the rubber plug from the manway cover (pressure plate) opening must be removed to install the valves. Care must be taken not to damage the valve seat tongue. All mounting nuts should be tightened per 7.4.3.

Excess Flow Valves

When a liquid angle valve is removed from the manway cover (pressure plate) the excess flow valve should be checked. It should be verified that the excess flow valve ball or plug is in place, the valve seat is tool tight and in good condition.

To remove an excess flow valve, the manway assembly must be removed, the braces and clamps loosened or removed, and the excess flow valve unscrewed from the manway cover (pressure plate). Maintenance manuals provided by the valve manufacturer should be reviewed for guidance when reconditioning excess flow valves.

An excess flow valve is installed by screwing the top of the excess flow valve into the manway cover (pressure plate), screwing the eduction pipes onto the excess flow valve, and fastening the braces and clamps. A proper clearance of the eduction pipe to the tank bottom (1 inch, plus 1/4 minus 0 inch is preferred) should be verified. Care should be taken to ensure the excess flow valve pin welds are not damaged by the pipe wrench when removing or installing the excess flow valve.

Pressure Relief Device

If inspection of the pressure relief device indicates there is evidence of leakage or damage, the device should be removed from the car for reconditioning. When the valve is removed, the opening in the manway cover (pressure plate) should be immediately closed with a soft rubber plug until the replacement valve is installed. This will prevent the entry of moist air into the tank. Care must be taken to avoid damage to the valve seat tongue and manway cover (pressure plate) groove. Maintenance manuals provided by the valve manufacturer should be reviewed for guidance when reconditioning pressure relief devices.

If a new or reconditioned pressure relief device is to be installed, the proper device must be used. Cars that are stenciled 105J300W must be equipped with 225 psig devices. Cars that are stenciled 105J500W must be equipped with 375 psig devices.

Care must be taken not to damage the valve seat tongue and manway cover (pressure plate) groove when removing or handling the device. To install the valves, the protection for the valve inlets and the rubber plug from the manway cover (pressure plate) opening must be removed. All mounting nuts should be tightened per 7.4.3

Mounting Studs and Nuts

The proper mounting fasteners can be found in Drawing 102 (Reference 13.1.13)

7.4.3 Torque Guidelines

Flanged and Gasketed Bolted Joints – Torque Recommendations

It is recommended that all applicable federal and AAR guidelines be followed when securing pressure retaining flanged, bolted and gasketed joints on tank cars. It is also recommended that gasket manufacturers' guidelines are followed. All entities securing these joints should have established procedures to ensure safe and reliable tightening. Procedures should include, but not be limited to, the following:

- Ensure clean gasket mating surfaces, free of gouges, corrosion and other defects that exceed one-quarter (1/4) of the gasket thickness. Review thickness and height of tongue and groove.

- Ensure: the gasket is clean, the size and thickness is correct, and it is composed of the correct material. Only gaskets listed for Chlorine service per Pamphlet 95 should be used.

- Ensure that the mating fasteners are free of corrosion, grit, paint or any other debris. Also visually inspect for surface imperfection or defects. Specially coated fasteners should use friction factor associated with that coating (e.g. Teflon® coated fasteners). A light lubricant may be required to ensure a friction factor (k) range common to the industry (see note below). Fastener material should conform to the markings on Drawing 102.

- Some assurance of proper depth and dimensions of internally threaded tapped holes and proper engagement of studs, if applicable, should be made.

- Ensure proper placement and alignment of the gasket prior to assembling the flanges. Flanges should be assembled carefully as to not upset the alignment of the gasket or damage the mating surfaces.

- All nuts should be hand-tightened prior to the use of any mechanical assistance.

- When and only when all nuts are in contact with flange and are hand tight, should tightening begin using, at the minimum, a calibrated torque wrench with sequential values in a cross pattern arrangement per AAR M-1002, Appendix D. Several final rotational and reverse rotational passes are also recommended.

- A final inspection should include that all fastener markings are visible and no nut threads are showing.

- Perform leak testing as prescribed by AAR, and DOT or TC guidelines.

- A retorquing operation may be required based upon experience within each organization, with each procedure and with associated materials.

Typical Torque Ranges:

Joint	Fastener Size	Torque Range
Manway	1-1/8"	400 – 800 ft-lbs.
Pressure Relief Device	¾"	90 – 200 ft-lbs.
Load/Unload Valves	¾"	75 – 200 ft-lbs.

Note: A target torque value should be established based on the specific joint conditions. This should take into consideration the optimum compressive stress for the gasket material and the desired bolt stretch as a percentage of fastener yield stress. The torque values in the above table reflect typical chlorine fittings using lubricated or coated fasteners with k values between .18 and .22. All fasteners in a given fitting should be torqued to a common target torque value.

A proper torque value for any application can only be established by field testing and observation. Torque values that are too low or too high may result in gasket or fastener failure and product leaks.

Halogenated fluorocarbon lubricants identified as completely inert in liquid and gaseous chlorine should be used if this lubricant will come in contact with chlorine.

7.5 New Car Inspection

Chlorine tank cars are complex mechanical transportation containers subject to variations in manufacturing. Prior to placing a new tank car in service, a comprehensive internal and external inspection should be made. Gasket and packing material should be inspected. If defects are found or the car does not meet requirements, corrective action must be taken.

Manway Housing Assembly

The manway cover (pressure plate) assembly should be pulled from the car and a complete visual inspection of the tank interior performed. The tank must be completely clean. No rust scale, blast residue, or foreign materials should be present in the car. The interior must be free from visible moisture and/or indications of moisture (rust blush). The valves should be removed and retested prior to reapplication to the manway cover (pressure plate). These valves may be replaced with new, or reconditioned, pretested valves. The excess flow valve assembly (seat, ball and ball retainers) should be inspected at this time. All interior parts of the tank should be inspected for hydrocarbon oil residue from the fabrication process. This inspection can be done using the black light inspection procedures.

Marking and Loading Appurtenances

All marking and loading appurtenances must be inspected to ensure compliance with all AAR, DOT and/or TC requirements. See AAR Specification M-1002 Appendix S for details on loading appurtenances. (Reference 13.2.1) Make certain the start to discharge setting of the pressure relief device agrees with the stenciled pressure.

Certificate of Construction

A copy of the certificate of construction must be kept on file by the car owner.

8. TANK CAR LOADING

8.1 General

When loading a chlorine tank car, the safety aspects of the operation should be uppermost in the minds of loading personnel. The loader must verify that proper spotting and receiving procedures have been completed before beginning transfer operations. Proper marking and placarding should be confirmed. Proper personal protective equipment should be worn during the transfer operation, see Pamphlet 65 (Reference 13.1.6). Safety showers and eye wash facilities should be available.

A tank car loading record should be prepared for each car. The record should include reporting marks and car number, 3/16" shipping and return shipment security seal identification, light and loaded weights, tank car capacity and the test/qualification dates of the tank and service equipment.

Before a chlorine tank car is loaded, it must comply with AAR, DOT and/or TC requirements and all required inspection, testing and qualification must have been performed.

An inspection checklist should be used for all aspects of the loading operation. It should include all recommendations contained in this pamphlet plus any company procedures or special requirements specific to the facility. The checklist documents that the proper loading and securement procedures have been completed. The checklist should be retained as per company policy. Appendix B provides an example of a typical checklist.

8.2 EMERGENCY SHUT-OFF

Excess flow valves can not be relied upon as a means of mitigating a hose or piping failure during chlorine transfer. Pamphlet 57 Emergency Shut-Off Systems for Bulk Transfer of Chlorine (Reference 13.1.4) outlines recommended practices for emergency protection against releases during transfers involving chlorine tank handling systems. The pamphlet illustrates emergency shut-off systems that will quickly bring a release situation under control. Use of an emergency shut-off system that meets the standards in Pamphlet 57 is recommended during the loading of a chlorine tank car. Use of a proper transfer hose suitable for the transfer of chlorine as recommended in Pamphlet 6 (Reference 13.1.3) should be part of the transfer system.

8.3 LOADING CONSIDERATIONS

Before loading is started, the valves and fittings should be pressurized and checked for leaks. The manway cover (pressure plate) of cars recently returned from inspection which required pulling of the manway should receive particular attention to ensure the gasket joint will not leak. If leaks are detected at any time, loading must be discontinued until repairs are made.

Leak tests may be conducted by adding a small amount of chlorine to the tank car at the loading rack and then padding with dry air or nitrogen to a minimum pressure of 50 psig. Vapor from a squeeze bottle containing 10%-30% aqua ammonia (ammonium hydroxide) solution can be used to detect a minor chlorine release or leak. An ammonia inhaler can also be used. A white cloud will form if a leak is present. To avoid corrosion, ammonia solution should not be directly sprayed onto connections. Any efforts to detect the source of a leak should be carried out with full consideration for potential hazards. Appropriate personal protective equipment must be used.

To prepare a car for loading, a threaded nipple made from one inch schedule 80 carbon steel, about fifteen inches long, should be tightly screwed into the tank valve outlet. The threads on the nipple should be standard NPT, sharp and clean and prepared with an appropriate sealant. Teflon tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly.

If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed. To properly apply Teflon tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug. A thread gage can be used to ensure the acceptability of the threads. The threads should be of a proper length and without wear beyond tolerances to prevent damage to the valve seat or stem area. Care should be taken when tightening the nipple to prevent undue strain on the valve. A flexible transfer hose, per recommendations contained in Appendix A of Pamphlet 6 (Reference 13.1.3) or a flexible copper loop, per Drawing 118 (Reference 13.1.19), should be provided between the nipple and the process piping to compensate for the lowering of the tank during loading. Valve arrangements, incorporating fail safe features as described in Pamphlet 57 (Reference 13.1.4), mounted at the tank car and on the process piping feeding the tank car are recommended.

8.4 LOADING ON A TRACK SCALE

It is recommended chlorine tank cars be loaded on a track scale. The weight of the tank car with all chocks and loading connections in place should be determined and recorded. This weight should be used as the initial scale weight for filling. If the stenciled lightweight is significantly different than the scale weight, the weight discrepancy needs to be resolved prior to commencing with the loading to avoid overloading. If the weight difference is minimal (less than 500 lbs) loading can continue if the higher tare weight value is used as the initial tare weight for filling calculations. This will reduce the chance of overloading the car. If it is necessary to interrupt the loading operation before the car is completely filled, the connected weight of the partly loaded car should be determined and recorded before disconnecting and the weight of chlorine loaded calculated. When the car is reconnected, the connected weight of the car and the chlorine loaded should again be determined. This is to ensure the total weight of chlorine loaded does not exceed the required limit.

The weight of chlorine loaded into a tank must not exceed the load limit stenciled on the tank car. The load limit is calculated using the lowest of the following three factors:

1. 125% of the weight of water the tank will hold. This is defined as the filling density.

2. The weight of chlorine must not exceed 90 tons (See 49 CFR 173.314(c) note 6).

3. Gross rail load must not exceed 263,000 pounds

It is essential to comply with the load limit. Exceeding this limit is contrary to regulations and may result in an unsafe container and possible release of chlorine from the tank.

Periodic maintenance of track scales is of utmost importance. The AAR Scale Handbook (Reference 13.2.3) requires testing of scales at least annually. Frequency of use, presence of errors, or operation of scales in inclement or very cold atmospheric conditions may dictate more frequent tests. Electronic load cells have been known to malfunction in extreme cold temperatures.

The scale pit should be inspected for accumulation of water. Freezing water in the pits can render scales inoperative, potentially causing the overfilling of a tank car.

8.5 Tank Pressure

Conditions of loading and padding must be such that when the temperature of the chlorine increases, the chlorine pressure in the tank will stay below approximately 80% of the tank's pressure relief device setting. The final tank pressure when the car is ready to ship should not exceed the maximum values shown on Drawing 201 (Reference 13.1.22). If the tank pressure is excessive when loading is complete, the tank should be vented to a recovery system until the proper pressure is obtained.

It is recommended the minimum pressure in a loaded tank car when offered for shipment be 20 psig for tanks equipped with excess flow valves per Drawing 101 (Reference 13.1.12) and 50 psig for tanks equipped with excess flow valves per Drawings 114 (Reference 13.1.18).

For other excess flow valves, the minimum pressure should be in accordance with manufacturer's specifications. Without sufficient internal pressure, there will not be enough flow to close the excess flow valves if an angle valve is broken off.

When padding is needed, clean dry and oil free air or nitrogen padding may be added after the loading operation is complete in order to meet customer unloading requirements or to meet minimum tank pressure needs. Air used should be oil free and dried to a dew point of -40EF (-40EC) or below, measured at the operating pressure. Section 10 contains more information on tank car padding.

When loading is completed, the final connected weight and tank pressure should be recorded.

8.6 Leaks During Loading

Leaks in Connections and Piping

Chlorine piping systems should be tested, inspected and maintained in accordance with Institute recommendations. Refer to Pamphlet 6 (Reference 13.1.3). This should include inspections at regular intervals for signs of leakage, internal or external corrosion, insulation failure or support problems. If a chlorine leak should occur in equipment or piping, the chlorine transfer should be stopped immediately by closing the source of chlorine to the tank car, tank car angle valves, and the load lines pressure relieved so the necessary repairs can be made. When the leak has been located and the faulty equipment repaired, loading may be resumed.

Tank Car Fitting Leaks

Leaks around the tank car angle valve stems can usually be stopped by tightening the valve's packing gland nuts. If this does not stop the leak, the angle valve should be closed. Only if a tank car valve leak cannot be stopped by corrective measures should the capping devices in the Emergency Kit C be used. If the pressure relief device must be capped, regular monitoring of the tank car's internal pressure must be established.

8.7 DISCONNECTING

As soon as it is determined the tank is loaded, the loading header liquid supply valves should be closed followed by the tank car liquid angle valves and the loading line emptied before any other valves in the system are closed. The loading line should then be purged, evacuated and disconnected. This should be done with care to ensure the line has been cleared and chlorine will not be released upon disconnection. Appropriate personal protective equipment should be worn when disconnecting lines that have contained chlorine. Liquid chlorine should never be trapped in a line between valves, since extremely high pressure can develop from an increase in the temperature of the chlorine. This pressure may lead to hydrostatic rupture of the line.

Adequate back flow protection should be used to prevent chlorine contamination of the padding system. The ends of loading lines should be tightly capped/plugged to prevent moisture contamination.

8.8 POST LOADING INSPECTION

- Inspect angle valves to ensure they are closed.
- Using aqua ammonia, check for leaks from angle valves with the valves closed and the plugs removed, and from the manway cover (pressure plate) and the pressure relief device. All leaks must be eliminated prior to the release of the tank car.
- Tighten the outlet plugs of all angle valves, wrench tight with a suitable wrench and appropriate thread sealant. Teflon tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly. If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed. To properly apply Teflon tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug. Attach warning or instruction tags to angle valves. For valve marking or tagging refer to A7.00 of Appendix A of AAR Specification M-1002 (Reference 13.2.1).
- Close and secure the protective housing cover. A cable seal of not less than 3/16 inch thickness should be applied to the protective housing cover locking pin in such a manner that the pin cannot be removed without breaking the seal. An additional 3/16 inch cable seal for the return movement of the car should be placed inside the protective housing.
- Inspect tank car for defects that make the car unsafe for transportation.
- Check for the proper marking and placarding of the tank car. The placards must be installed in placard holders in four locations on the car.

- Check for a FIFRA label approved by the EPA if the car will be unloaded at water or sewage treatment facilities in the U.S.
- Complete shipping papers.
- Check that the scale ticket is retained and weights are shown on the bill of lading.
- Retain for an appropriate period of time the checklists of the inspection and preparation of the car including receiving, reconditioning, loading and shipping. All corrective actions must be documented.
- Check the tank pressure to ensure it is within the proper limits and that it is recorded.

Refer to 49 CFR 173.31(d) for additional post loading examination items. (Reference 13.3.1)

9. TANK CAR UNLOADING

9.1 GENERAL

Chlorine tank cars are unloaded by increasing the pressure in the vapor space above the liquid to a level sufficient to force the liquid chlorine up the eduction pipes and out the liquid angle valves. If the pressure in the tank car is not sufficient to unload the car when received or throughout unloading, the tank may be padded. If padding is to be used, the unloader should thoroughly review Section 10.

When unloading a chlorine tank the safety aspects of the operation should be uppermost in the minds of unloading personnel. The unloader must verify that proper spotting and unloading procedures have been completed before beginning transfer operations. Proper personal protective equipment should be worn during the transfer operation, see Pamphlet 65 (Reference 13.1.6). Safety showers and eyewash facilities should be available. In addition all suppliers' recommendations should be followed during product transfer.

9.2 TANK CAR INSPECTION CHECKLIST

An inspection checklist should be used for all aspects of the unloading operation. It should include all recommendations contained in this pamphlet plus any company procedures or special requirements specific to each facility. The checklist documents that proper unloading and securement procedures have been completed. The checklist should be retained for records retention as per company policy. Appendix B provides an example of a typical checklist.

The checklist for procedures to be followed after spotting the tank car should at a minimum include the following items:

- Verify the receiving and spotting procedures in Section 6 have been followed.
- Verify the tank car is loaded with chlorine by careful inspection of the bill of lading or other shipping documents, the reporting marks, the car number, commodity marking, placards and the reported shipping cable seal is intact.
- Open the housing cover and inspecting the manway fittings for evidence of a leak.
- If unloading to a storage tank, verify there is sufficient capacity to receive the chlorine to be transferred.
- Verify the angle valve is fully closed before removing the angle valve plug.
- Verify there is a FIFRA label approved by the EPA if the tank is to be unloaded at water or sewage treatment facilities in the U.S.

9.3 EMERGENCY SHUT-OFF

Excess flow valves can not be relied upon as a means of mitigating a hose or piping failure during chlorine transfer. Pamphlet 57 Emergency Shut-Off Systems for Bulk Transfer of Chlorine (Reference 13.1.4) outlines recommended practices for emergency protection against releases during transfers involving chlorine tank handling systems. The pamphlet illustrates emergency shut-off systems that will quickly bring a release situation under control. Use of an emergency shut-off system that meets the standards in Pamphlet 57 is recommended during the unloading of a chlorine tank car. Use of a proper hose suitable for the transfer of chlorine as recommended in Pamphlet 6 (Reference 13.1.3) should be part of the transfer system.

9.4 CONNECTIONS

Chlorine tank car angle valves are equipped with a one inch pipe plug closure secured to the valve body. This plug should be tightly in place when the car is received and spotted for unloading at the facility. Before any connection is made to a chlorine tank car, all piping should be clean, dry, free of oil, and in-test. Refer to Pamphlet 6. (Reference 13.1.3)

To prepare a car for unloading, a threaded nipple made from one inch schedule 80 carbon steel, about fifteen inches long, should be tightly screwed into the tank valve outlet. The threads on the nipple should be standard NPT, sharp and clean and prepared with an appropriate sealant. Teflon tape (T-tape) can be an effective lubricant/sealant of threaded pipe and plug connections to tank car angle valves if it is applied correctly. If the tape is incorrectly applied to these connections, it can be sucked into the internal components of the car's angle valves if the car is pulled under a vacuum during its preparation for loading, thereby preventing these valves from being able to be completely closed.

To properly apply Teflon tape to a pipe nipple or a pipe plug to be installed in an angle valve, use a thick grade of tape, i.e., one that meets Military Specification MIL-T-27730A or General Services Administration Commercial Item Description (CID) A-A-58092, and do not wrap the tape past the first thread at the end of the pipe nipple or valve plug. A thread gage can be used to ensure the acceptability of the threads. The threads should be of a proper length to prevent damage to the valve seat or stem area. Care should be taken when tightening the nipple to prevent undue strain on the valve. A flexible transfer hose, per recommendations contained in Appendix A of Pamphlet 6 (Reference 13.1.3) or a flexible copper loop, per Drawing 118 (Reference 13.1.19), should be provided between the nipple and the process piping to compensate for the rise of the car during unloading. Valve arrangements, incorporating fail safe features as described in Pamphlet 57 (Reference 13.1.4), mounted at the tank car and on the process piping feeding the chlorine to the process or to storage are recommended.

After all connections are made, it is advisable to allow a small amount of chlorine into the system. Each connection, valve packing and flange should then be checked for leaks with ammonia vapors. If a leak is found, it must be corrected before allowing more chlorine into the line.

Vapor from a squeeze bottle containing 10-30% aqua ammonia (ammonium hydroxide) solution can be used to detect a minor chlorine release or leak. An ammonia inhaler can also be used. A white cloud will form if a leak is present. To avoid corrosion, ammonia solution should not be directly sprayed onto connections.

Any efforts to detect the source of a leak should be carried out with full consideration for potential hazards. Appropriate personal protective equipment must be used.

9.5 OPENING ANGLE VALVES

The tank car liquid angle valve should be opened slowly and then left fully open. If it is opened rapidly, the excess flow valve may close and flow will not occur.

9.6 LINE PRESSURIZATION

A differential pressure must be maintained between the chlorine tank car and the system receiving the chlorine. While slowly opening the tank liquid angle valve, the pressure gage located at the beginning of the permanent piping should be observed. A rise in pressure indicates there is liquid flow. The line valve should be in a closed position at this point. As soon as the gage indicates a steady pressure, the tank liquid angle valve should be opened fully. The line valve should then be opened slowly until the liquid chlorine completely fills the line to the process. The line valve should be opened until the desired flow rate is obtained taking care to ensure the flow does not cause the excess flow valve in the tank car to check.

CAUTION: If liquid chlorine is trapped between two valves, extremely high pressure can develop upon increase in the temperature of the chlorine. Refer to Pamphlet 6 (Reference 13.1.3).

9.7 EXCESS FLOW VALVE UNSEATING

With the exception of those cars equipped with pneumatically operated angle/internal check valve combinations, all chlorine bulk transports are equipped with excess flow valves under the liquid angle valves. There may be times, due to opening the angle valve too rapidly or due to unusually high flow rates, the excess flow valve will close. If this occurs, the angle valve on the car should be closed and left closed until the metal ball or plug in the excess flow valve drops back into place. A noticeable click will be heard when it drops. If the ball or plug does not drop, a connection can be made to the other liquid valve on the car. The supplier should be consulted if neither of these two methods is successful.

9.8 MONITORING THE UNLOADING

Regulations prior to the issue of HM-223 required that throughout the entire period of unloading, and while the car is connected to the unloading device, the car must be attended by the unloader. CI strongly recommends that although not required in most cases by current DOT regulation it is best practice to provide continuous monitoring of unloading operations. If it is necessary to discontinue unloading a tank car for any reason, all valves must be tightly closed and unloading connections disconnected and plugs installed in the tank car valves. Past correspondence from the DOT indicates that "attending" the unloading includes having an employee physically present at the unloading site, electronic monitoring with remote shut-off equipment, television camera monitoring or by any means by which the tank car is monitored and the flow of chlorine can be stopped if unloading difficulties develop. Shippers/receivers have had successful experience utilizing all of these methods.

A number of regulatory exemptions have been issued by the DOT (SP 12443) to permit tank cars containing chlorine to remain standing with unloading connections attached when product is not being transferred. Special provisions must be followed to meet the terms of the DOT exemption including the designation of an employee responsible for on-site monitoring of the transfer facility.

It is anticipated DOT will soon provide additional clarification on the issue of monitoring the unloading of a tank car. It is the responsibility of each unloading site to ensure all applicable regulations are followed.

9.9 LEAKS DURING UNLOADING

Appropriate PPE per pamphlet 65 should always be used and capping equipment must be readily accessible.

Leaks in Connections and Piping

Chlorine piping systems should be pressure tested at regular intervals according to Institute recommendations. See Pamphlet 6 (Reference 13.1.3). Chlorine piping systems should also be inspected at regular intervals for signs of leakage, internal or external corrosion, insulation failure, or support problems.

If a chlorine leak should occur in equipment or piping, the chlorine transfer should be stopped immediately by closing the tank car angle valves, and the unloading line pressure relieved so the necessary repairs can be made. When the leak has been located and the faulty equipment repaired, unloading may be resumed.

Fitting Leaks

Leaks around the tank car angle valve stems can usually be stopped by tightening the packing gland nuts. If this does not stop the leak, the angle valve should be closed. Only if a tank car valve leak cannot be stopped by corrective measures should the capping devices in the Emergency Kit C be used. If the pressure relief device must be capped, regular monitoring of the tank car's internal pressure must be established. The shipper should be advised of the problem as soon as possible.

9.10 DETERMINING AMOUNT OF CHLORINE UNLOADED

Where chlorine tank cars cannot be unloaded on track scales, and reliable direct gauging devices are not readily available, the most common practice for estimating the quantity of chlorine remaining in the car is from the consumption records of the quantity removed. The contents should be unloaded to the maximum extent practicable.

9.11 DISCONNECTING

As soon as it is determined the car is as empty as possible, the liquid chlorine manifold header valves should be closed followed by the tank car liquid angle valves, and the transfer hoses emptied, before any other valves in the discharge system are closed.

The unloading lines should then be purged, evacuated and disconnected. This should be done with care to ensure the line has been cleared and chlorine will not be released upon disconnection. Appropriate respiratory personal protective equipment should be worn when disconnecting lines that have contained chlorine. Liquid chlorine should never be trapped in the discharge line between valves, since extremely high pressure can develop from an increase in the temperature of the chlorine. This pressure may lead to hydrostatic rupture of the line. If the car has been padded, the pad gas supply line should be shut-off, evacuated and disconnected.

9.12 PRE-RELEASE CHECK

Inspect angle valves to ensure they are closed.

Using aqua ammonia, check for leaks from angle valves with the valves closed and the plugs removed, and from the manway plate and the pressure relief device. All leaks must be eliminated prior to the release of the tank car.

Tighten the outlet plugs of all angle valves, wrench tight with a suitable wrench and appropriate thread sealant.

Indicate any unusual condition by applying a tag to any of the valves, describing the condition found.

Close and secure the protective housing cover. A cable seal of not less than 3/16 inch thickness should be applied to the protective housing cover locking pin in such a manner that the pin cannot be removed without breaking the seal.

Check for proper marking and placarding of tank car. Placards must be installed in placard holders in four locations on the car.

Complete shipping papers.

Notify the railroad agent that the car is empty.

Refer to 49 CFR 173.31(d) for additional pre-release examination items. (Reference 13.3.1)

10. PRESSURE PADDING

Chlorine tank cars are often unloaded by increasing the pressure in the vapor space above the liquid to a level sufficient to force the liquid chlorine up the eduction pipe and out the liquid angle valves. The process of increasing the pressure in the vapor space is called pressure padding.

10.1 NEED FOR PADDING

The vapor pressure of chlorine at various temperatures is given in Table 10.1. If more pressure is needed to unload the car, padding of the tank may be necessary. Dry air is commonly used, however, dry nitrogen can be used.

To minimize the need for padding, consideration should be given to reducing the pressure at the point of consumption and/or reducing the pressure drop in the piping system.

Table 10-1. Vapor Pressure of Chlorine

Temperature		Vapor Pressure		Temperature		Vapor Pressure	
°F	°C	psig	kPa	°F	°C	psig	kPa
0	-18	13.8	95	60	16	70.9	489
10	-12	20.3	140	70	21	85.5	589
20	-7	27.8	192	80	27	101.8	701
30	-1	36.6	252	90	32	119.9	826
40	4	46.6	321	100	38	140.1	965
50	10	58.0	400	105	41	151.3	1042

10.2 AIR PADDING

10.2.1 Air Quality

Even small amounts of moisture can cause excessive corrosion to tank car equipment and to piping and handling systems. It is essential the air used for padding be free from oil and foreign matter and be dried to a dew point of -40°F (-40°C) or below measured at the operating pressure. Chlorine and oil can react to produce heat and, under certain conditions, the reaction may create a fire.

10.2.2 Moisture Content

To ensure no moisture is entering the chlorine system, the moisture content of padding air should be continuously monitored when the tank car is connected for padding. This is easily done with a commercially available in-line dew point analyzer with alarm. The dew point of the dry air must always be sampled at the operating pressure, not at atmospheric pressure.

10.2.3 ISO Standards for Air Quality

Railcar Padding Compressed Air Quality Specification

With proper filtration, particulates, desiccants, oil, water and vapors can all be removed from the air supply to acceptable levels for chlorine railcar air padding.

The compressed air shall comply with the following ISO Quality Classes:

Component	ISO Class	Standard	Measurement Range
Solid Particles	Class 1	ISO 8573-4	0.1 Micron Maximum Size
Oil, Liquid & Vapor. Total Concentration	Class 1	ISO 8573-2 ISO 8573-5	≤ 0,01 mg/m^3 ≤ 0.008 ppm$_{w/w}$
Humidity and Liquid Water. See Note 1	Class 2	ISO 8573-3	≤ - 40°F ≤ - 40°C
Note 1: The dew point of the compressed air shall be measured at the operating pressure or a minimum pressure of 100 PSIG.			

10.2.4 Separate Air Padding System

Padding air should not be taken from the plant air system, but, ideally, should come from an independent air compressor. Unless safeguards are taken, in a common system a heavy demand for air elsewhere could lower the overall system pressure below the tank car pressure. Chlorine could then feed back into the air system with probable damage to equipment and danger to personnel.

If a common plant air supply is used to pad the chlorine cars, a backflow system should be installed with redundant instrumentation and a rigorous process safety review conducted. Figure 10.1 contains a typical design of a backflow system.

10.2.5 Air Padding Compressor

A suitable air compressor and an ASME Code receiver equipped with the appropriate instrumentation such as pressure gages and switches, temperature gages and switches, safety valves, automatic electronic drain valves and automatic pressure controls should be used.

The operating conditions and characteristics of the compressor should be considered when designing the system. For example, operating a typical compressor at 60-70% of maximum design rpms will reduce air outlet temperatures, compressor wear and long term oil carryover.

Table 10.2 shows the air flow required at tank car pressures for various constant unloading rates. Greater compressor capacity will be required when padding a tank car manually rather than automatically. This larger capacity requirement should be taken into consideration when purchasing an air compressor system. Depending on the type of dryer system installed with the compressor, dryer system outlet flow rates may be reduced to 85-90% of the compressor output capacity. This reduction must be considered in the final design. Multiple compressors should be considered for continuous duty.

Special consideration should be given to compressor location. Compressor rooms should be well ventilated. Air inlet filters should be considered to ensure clean air. Silencers should be used to reduce the sound level to acceptable standards. The inlet air supply to the compressor should be drawn from an area that is unlikely to be contaminated with chlorine or other chemical fumes that would quickly corrode and damage the compressor internal components.

10.2.6 After-cooler

An air after-cooler with a moisture and oil trap and electronic drain should be provided to remove condensed moisture and entrained oil. This package will reduce the moisture and oil content to the drying system. An air receiver should be installed upstream of the dryer with an automatic electronic drain to remove additional moisture and oil before the dryer system.

A water after-cooler may be used after careful design including redundant instrumentation and the appropriate process safety review procedures have been followed. Design considerations should anticipate failure of the air/water heat exchanger due to corrosion and loss of air pressure due to compressor failure or power failure. If these two conditions occur at the same time, water will enter the air receiver and dryer system. This will result in a piping system failure including valves, transfer hoses and other equipment.

10.2.7 Air Drying and Treatment Systems

Commercial regenerative type dryers, using activated alumina as the desiccant, are recommended since any oil carryover from the upstream components will be irreversibly absorbed by the activated alumina. The dryers should be fully automatic and may be either of the heatless, electric internal or external heater design. If continuous operation is desired and no down time for repair can be tolerated, dual units are required. The capacity of the dryer should exceed the output capacity of the compressor system so the dryer system is never in an overloaded flow condition. Consideration should be given to the inlet conditions of the air from the compressor with respect to pressure and temperature.

Some manner of indicating the capacity and condition of the activated drying media, such as a dew point monitor should be employed. This indicator should be checked on regular intervals, and the drying media should be replaced as required, according to manufacturer's recommendations.

All dryer packages should include a high efficiency prefilter for removal of water, oil mists and particles with typical removal efficiency of 99.99% at 0.5 micron particle size. The prefilter should include an automatic electronic drain for moisture and oil removal. Commercially available filter housings with built in pressure drop indicators across the filter are useful for scheduling proper maintenance. A particulate after-filter followed by a hydrocarbon vapor filter to remove gaseous hydrocarbon and organic vapors should be installed downstream of the dryer system. If down time can not be tolerated, redundant pre-filters and after-filters should be installed on each dryer installed on the system.

<u>Proper review of commercially available filter housings is required to ensure the correct pressure rating of the bowl and other components. Filter housings with non-metallic filter bowls should include a bowl guard to prevent or reduce the effect of damage caused by a rupture due to an over pressurized condition.</u>

A moisture analyzer shall be installed immediately downstream of the hydrocarbon vapor filter. To maintain correct operating pressure of the dryer system, consideration should be given to the installation of a back pressure regulator downstream of the moisture analyzer. This will maintain the upstream pressure in the dryer regardless of the downstream operating conditions.

Depending on operating procedures or design, the maximum flow rates of the dryer can be exceeded for short periods and the potential for premature desiccant failure can exist. Therefore, a flow orifice or resistor should be considered to increase the life of the desiccant and life of the after-filter.

10.2.8 Backflow Systems

Padding systems should be provided with automatic controls to provide backflow protection to the drying equipment. These controls should be redundant and designed to prevent the backflow of chlorine if one component should fail. The system should provide for easy testing of each component and the materials in potential contact with the chlorine vapor from the tank car should be as recommended by Pamphlet 6 (Reference 13.1.3). Figure 10.1 indicates one method of backflow protection. Other designs may be utilized. It is not the intent of Figure 10.1 to restrict the design of the backflow system. The use of check valve(s) as the sole means to prevent chlorine backflow is not adequate.

10.2.9 Oil Separation and Removal

Consideration should be given to the moisture and oil discharged from the compressors, after-coolers, receivers, and pre-filters of the dryer system. These discharge streams must be collected, the oil separated and collected and the water discharged and treated as required. There are many commercial units designed for this purpose.

10.3 NITROGEN PADDING

Tank cars can be padded with nitrogen in lieu of dry air. However, design considerations need to be given to the source of supply and available pressure. It is recommended the nitrogen be provided from a separate source to prevent contamination of the nitrogen should chlorine backflow into the supply header. Further considerations should be given to lowest ambient temperatures, maximum possible flow rates and highest desired padding pressure. If ambient temperature conditions are low, it is possible for the nitrogen vaporization equipment to supply inadequate pressure to the rail car. This could result in a chlorine backflow. Therefore, it is recommended to supply a backflow system for the nitrogen supply similar to the backflow equipment used in the dry air padding system. With the installation of a backflow system, potential damage to the nitrogen vaporization equipment will be reduced.

If it is necessary to use a common nitrogen supply line to pad the chlorine cars, a backflow system should be installed with redundant instrumentation. See Figure 10.1 for a typical installation. This should only be done after a rigorous process safety review. Since many common nitrogen systems can produce pressures of over 180 psig, controls should be installed to prevent over pressurization of the tank car.

10.4 PADDING PRESSURE CONSIDERATIONS

Temperature/Pressure Relationships

It is necessary to have a thorough understanding of the temperature and pressure relationships of chlorine and ways to prevent over pressurization. Chlorine in tank cars is a liquefied gas under pressure. The tank also contains some non-condensable gases in addition to the chlorine vapor. These gases may or may not be in equilibrium with the chlorine. The total pressure in the tank is the sum of the partial pressure of the chlorine and the partial pressure of the non-condensable gases. Therefore at equilibrium the tank car pressure will always be higher than the vapor pressure of chlorine at the estimated temperature.

Because of a lack of equilibrium, it is not possible to calculate the exact pressure by means of the ideal gas laws. The partial pressure of the chlorine is a function of its temperature. The partial pressure of the non-condensable gas is a function of the molecular weight of such gases, the volume of the vapor space, and the gas temperature.

Over pressure Prevention

Padding procedures should ensure tank car pressures are kept as low as necessary. This will help prevent over pressurization of the tank and subsequent opening of the pressure relief device due to ambient heating. After a tank car is loaded, ambient heat can cause an increase in the temperature of the chlorine resulting in an increase in both chlorine vapor pressure and total pressure in the tank car. Ambient heat will also cause the liquid to expand thus reducing the vapor space with resulting increase in the vapor space pressure. The combined effects of expansion of the liquid and increase in its vapor pressure may increase the total pressure enough to open the pressure relief device. For example, if a fully loaded car at 33°F (1°C) is padded from the vapor pressure of 40 psig to a total pressure of 125 psig and is then allowed to warm up to 88°F (31°C), the combined effects of expansion of the liquid chlorine and increase in its vapor pressure will raise the total pressure above 225 psig. A pressure relief device set at that pressure will open. To prevent the pressure in the tank from reaching the pressure relief device setting, the total pressure (the vapor pressure of the chlorine plus the pressure of the padding pressure) in the tank car should not exceed the applicable curves on Drawing 201.

It is especially important to prevent buildup of excessive pressure over periods when chlorine is not being withdrawn such as nights, weekends, plant vacation periods and shutdowns. Such cars should be inspected routinely for leaks and excessive pressure. If necessary, excessive pressure should be vented to a recovery system.

10.5 PREVENTIVE MAINTENANCE

Air and nitrogen padding systems require a preventive maintenance program to ensure a reliable high quality supply of padding gas.

10.6 FLOW REQUIREMENTS FOR PADDING

Table 10-2. Continuous Air/N_2 Flow Requirements for Padding				
Unloading Rate	**Required Air/N_2 Flow**			
lbs/hour of chlorine	ft^3/minute		m^3/second	
	P=125 psig	P=100 psig	P=862 kPa	P=684 kPa
30,000	40.0	30.0	.01888	.01416
15,000	20.0	15.0	.00944	.00708
11,000	14.6	11.0	.00689	.00517
7,500	10.0	7.5	.00472	.00354
6,000	8.00	6.0	.00378	.00283
4,000	5.33	4.0	.00252	.00189
1,000	1.33	1.0	.00063	.00047

- SCFM Air/N_2 = $\frac{\text{lbs/hr of chlorine x (P-25)}}{75{,}000}$
- P = total pressure in tank (psig)

Table 10-3. Air/N_2 Volume Requirements for Padding				
Chlorine Tank Car Capacity	**Total Air/N_2 Required**			
	ft^3		m^3	
	P=125 psig	P=100 psig	P=862 kPa	P=684 kPa
55 ton	10,560	7,920	299	224
85 ton	16,320	12,240	462	347
90 ton	17,280	12,960	489	367

- Ft^3 of air/N_2 = tons of chlorine x 1.92 x (P-25)
- P = total pressure in tank (psig)

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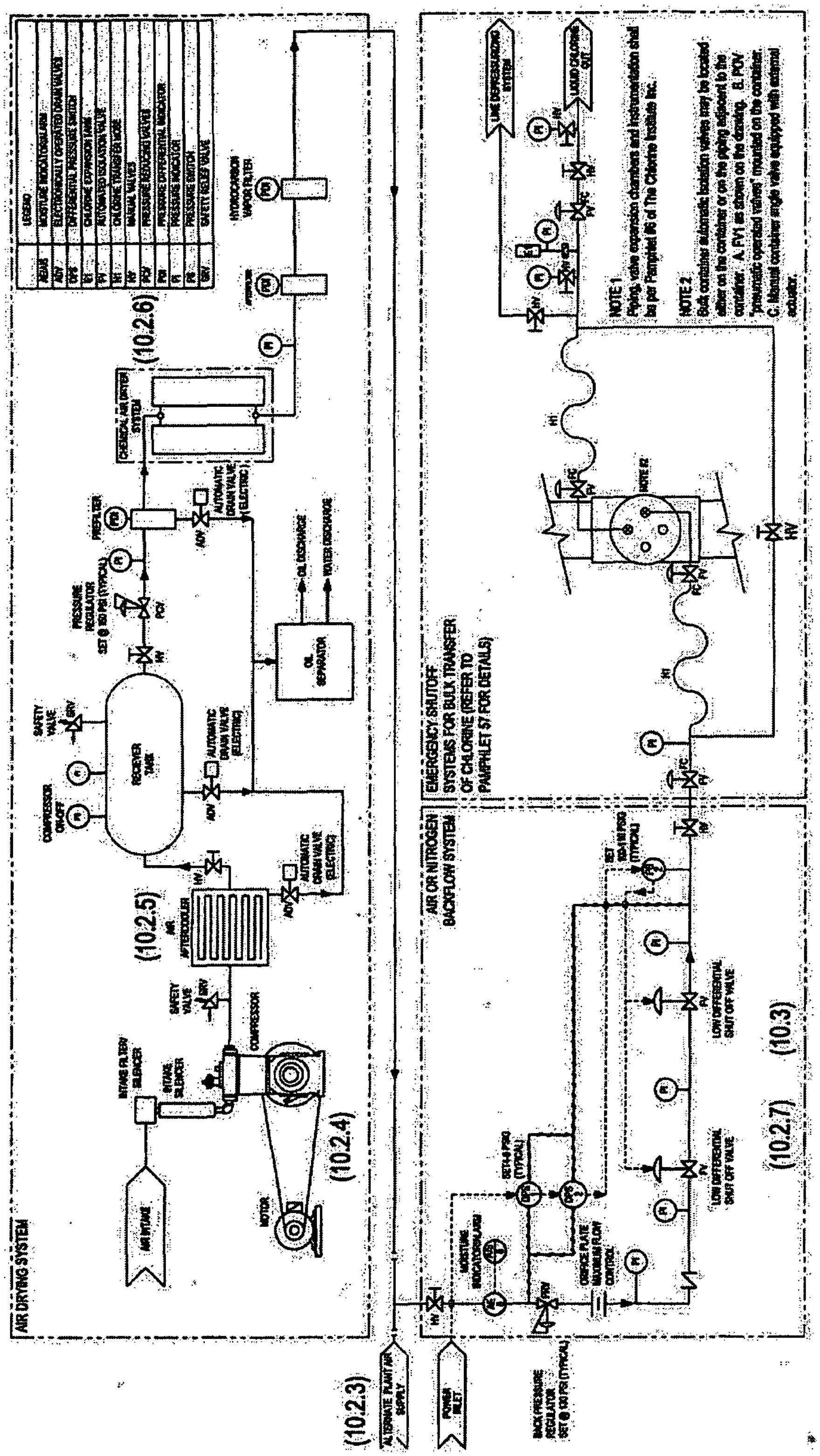

Figure 10.1

11. QUALIFICATION OF TANK CARS

11.1 GENERAL

DOT and TC regulations (49 CFR 180.509 and CAN/CGSB-43.147 Section 25) require all chlorine cars to be qualified using non-destructive testing techniques at an interval of no more than ten years. This replaces the requirement to hydrostatically test chlorine tank cars every two years. Qualification involves the inspection and testing of tank car tanks, service equipment and safety systems. There are record keeping requirements related to the qualification process in 49 CFR 180.517. The qualification of a tank car must be accomplished by a tank car facility approved by the AAR as per AAR Specification M-1002 Appendix B (Reference 13.2.1).

To facilitate the transition to the nondestructive testing requirements from a two year to a ten year interval, DOT has issued a special permit (formerly exemption) and TC issued a Permit which authorizes chlorine tank car owners the use of an alternate testing protocol. Companies wishing to obtain party status to the exemption should contact DOT or TC (See section 11.7).

11.2 QUALIFICATION OF THE TANK CAR

Tank car owners must ensure chlorine tank car are qualified at an interval of no more than ten years. Tank car qualification may only be performed by AAR certified facilities. Qualification is accomplished through the following:

- external and internal visual inspections.
- structural integrity inspections and tests using non-destructive evaluation including dye penetrant, radiography, magnetic particle, ultrasonic, direct or remote visual. Acoustic emissions may be used with a DOT exemption or TC Special Permit.
- tank shell thickness tests.
- safety system inspections including thermal protection systems, insulation, tank head puncture resistance system, coupler vertical restraint system.
- service equipment.

Generally, stub sill and Rule 88-b inspections are done in conjunction with tank car qualification. See 11.8.

11.3 QUALIFICATION OF THE TANK CAR SERVICE EQUIPMENT

The chlorine tank car owner must ensure the service equipment is qualified at an interval of no more than ten years. The chlorine tank car shipper may chose to perform the qualification of the service equipment with the permission of the tank car owner.

Based on past performance of the service equipment, the tank car owner or shipper may determine shorter inspection intervals are necessary to ensure reliability. Angle valves, pressure relief devices, and other service equipment components may be replaced at shorter intervals without changing the service equipment qualification interval or the qualification stencil due date. A leakage pressure test must be conducted when service equipment is replaced. Service equipment replacements, maintenance or qualification may only be performed by AAR certified or registered facilities. Refer to section 12 for additional details.

11.4 PREPARATION OF TANK CAR FOR QUALIFICATION

All liquid chlorine should be removed prior to purging and residual chlorine gas removed by conventional sniffing methods. It is desirable to pull a vacuum down to at least two inches of mercury and air purge the tank to a suitable scrubber (a caustic solution tank) until chlorine can no longer be detected with an aqua ammonia test.

For testing facilities that do not have the capability of pulling a vacuum on the tank, the tank must be air purged to a suitable scrubber until chlorine can no longer be detected with an aqua ammonia test. Caution: Larger amounts of chlorine can be expected when a tank is not degassed by vacuum. Scrubbers must be adequately sized to accommodate this condition in order to prevent a chlorine release.

The interior of the car must be cleaned and suitable for human entry prior to qualification.

Refer to Section 7.4.1 for information related to tank car cleaning.

11.5 TANK CAR PREPARATION AFTER QUALIFICATION AND PRIOR TO LOADING

Upon being returned to the shipper after full qualification, the car should be checked in accordance with the shipper's inspection procedure.

If the qualification of the service equipment has not been completed, it is the responsibility of the Class F and G loading facility to complete the service equipment qualification. Upon completion of the leakage pressure test, the service equipment portion of the qualification stencil should be completed including the completion date, due date stencil and station symbol.

Consideration should be given to weighing the car to verify the light weight stencil.

11.6 TANK CAR QUALIFICATION STENCILING

The tank car qualification stencil must be in accord with AAR Specification M-1002, Appendix C (Reference 13.2.1). The stencil must indicate the qualification data and the next qualification due date. Refer to Drawing 167 (Reference 13.1.21).

Tank cars may display separate station stencil markings when qualifying under 49 CFR 180.509 by two separate tank car facilities. The primary facility will provide all NDE inspection and documentation for service equipment up to installing the product valves and pressure relief devices.

The secondary facility (Class F) will install the product valves or pressure relief devices and complete the service equipment portion of the qualification process and apply its station stencil to the qualified tank car for the service equipment.

11.7 Alternate Tank Car Testing Protocol

Because, under the previous regulations, chlorine tank cars were required to be hydrostatically tested every two years, chlorine car owners had only two years after the July 1, 2000 implementation date to qualify their tank cars. To facilitate the transition to the tank and service equipment qualification, 49 CFR 180.509, the DOT and TC issued exemption DOT-SP-11941 and Special Permit SR 5394 that authorizes an alternate testing protocol for chlorine cars.

The exemption/permit allows party companies ten years from the exemption issued date to phase in the qualification of chlorine tank cars. Under the exemption, companies may qualify chlorine cars using a testing protocol that includes a hydrostatic pressure test, a service equipment and safety system inspection, internal visual inspections and thickness test of tank shell and heads. There are special provisions in both the exemption and the Special Permit. The DOT-SP 11941 special provisions are listed below. The special provisions in the Special Permit are similar.

a. Beginning on December 31, 2000, tank cars must be qualified in accordance with 180.509 at a rate such that 50 percent are qualified no later than December 31, 2004 and the remaining cars are qualified no later than December 31, 2008.

b. Annual progress reports must be provided to the FRA.

c. Cars must be marked with the exemption number DOT-SP-11941 and/or SR 5394 and marked with the inspection and test due dates in accordance with AAR Specification M-1002 Appendix C (Reference 13.2.1).

11.8 Stub Sill Inspections

Tank cars of stub sill design must receive inspections of the stub sill to ensure structural integrity of the sills. Generally, this inspection is due at the time of the tank car qualification. Reference is made to AAR Casualty Prevention Circulars CPC-1094 and CPC-1097. These inspections should be reported to the AAR using Form SS-3.

12. PERSONNEL QUALIFICATION AND FACILITY CERTIFICATION / REGISTRATION

12.1 Facility Certification and Registration

Each facility that performs maintenance on chlorine tank cars must be certified or registered by the AAR to the level of maintenance that will be performed. Facilities in Canada must also register with Transport Canada. Maintenance includes such things as tank and service equipment qualification, repairs, valve rebuilds, valve change-outs, inspections, and tests. The definition of facility classifications are established in AAR Specification M-1002 (Reference 13.2.1).

12.2 QUALITY ASSURANCE PROGRAM

Certified facilities must have a QAP that meets AAR M-1003 (Reference 13.2.4). Registered facilities must have an AAR approved QAP that meets 49 CFR 179.7. The QAP will:

- Ensure the finished product conforms to the applicable specification and regulations.
- Have the means to detect any non-conformities.
- Prevent non-conformities from recurring.
- The QAP for a registered facility must contain the following elements:
    - Statement of authority and responsibility
    - Organizational chart
    - Document control procedures
    - Incoming material inspection and identification program
    - Manufacturing, inspection and test program
    - Monitor and control of processes and product
    - Nonconformance control procedures
- Statement of Applicability of AAR Specification M-1002
- Qualification requirements of NDT personnel
- Inspection and test technique evaluation procedures
- Calibration and measurement of test equipment procedures
- A system for keeping maintenance, inspections, and tests records

12.3 PERSONNEL QUALIFICATIONS

Personnel involved in the maintenance of tank cars must be properly trained and certified. All personnel performing nondestructive testing (NDT) must be qualified for each inspection or test performed per AAR Specification M-1002, Appendix T (Reference 13.2.1). For example, personnel performing the pressure leak test after a service equipment replacement must be certified to at least a level I NDT standard for leak test.

12.4 PERSONNEL TRAINING

Personnel involved in the maintenance, loading, unloading and shipping of chlorine tank cars must be properly trained and tested in accordance with 49 CFR 172.704 and 179.7. These requirements include:

- General Awareness Training
- Function Specific Training
- Safety Training
- Proficiency Testing
- Record Keeping

Records of such training must be maintained while employed and for 90 days after leaving the company. These records include:

- employee name
- the most recent training date
- a description, copy or the location of the training materials used
- the name and address of the person providing the training
- a statement certifying that the employee has been trained and tested

New employees may perform these duties for up to 90 days until training has been documented, but must work under the direct supervision of a properly trained and knowledgeable employee. Recurrent training is required at least every three years.

13. REFERENCES

13.1 Institute Publications

13.1.1 Chlorine Manual, ed. 6; Pamphlet 1; The Chlorine Institute: Arlington, VA, 1997.

13.1.2 Bulk Storage of Liquid Chlorine Storage, ed. 7; Pamphlet 5; The Chlorine Institute: Arlington, VA, 2005.

13.1.3 Piping Systems for Dry Chlorine, ed. 15; Pamphlet 6; The Chlorine Institute: Arlington, VA, 2005.

13.1.4 Emergency Shut-Off Systems for Bulk Transfer of Chlorine, ed. 4; Pamphlet 57; The Chlorine Institute: Arlington, VA, 2003.

13.1.5 First Aid, Surveillance and Occupational Hygiene Monitoring Practices for Chlorine, ed. 7; Pamphlet 63; The Chlorine Institute: Arlington, VA, 2003.

13.1.6 Personal Protective Equipment for Chlor-Alkali Chemicals, ed. 4; Pamphlet 65; The Chlorine Institute: Arlington, VA, 2001.

13.1.7 Chlorine Scrubbing Systems, ed. 3; Pamphlet 89; The Chlorine Institute: Arlington, VA, 2006.

13.1.8 Gaskets for Chlorine Service, ed. 3; Pamphlet 95; The Chlorine Institute: Arlington, VA, 2003.

13.1.9 Safe Handling of Chlorine Containing Nitrogen Trichloride, ed. 2; Pamphlet 152; The Chlorine Institute: Arlington, VA, 2005.

13.1.10 Angle Valve Guidelines for Chlorine Bulk Transportation, ed. 1; Pamphlet 166; The Chlorine Institute: Arlington, VA, 2002.

13.1.11 Instruction Booklet: Chlorine Institute Emergency Kit "C" for Chlorine Tank Cars and Tank Trucks, ed. 8, R-1; Pamphlet IB/C; The Chlorine Institute: Arlington, VA, 2006.

13.1.12 Excess Flow Valve with Removable Seat - 7000 lbs/hr, Drawing; DWG 101-7; The Chlorine Institute: Arlington, VA, 1993.

13.1.13 Studs, Nuts and Gaskets for Chlorine Tank Manway Covers and Valves, Drawing; DWG 102-11; The Chlorine Institute: Arlington, VA, 2006.

13.1.14 Manway Cover for Chlorine Tank Cars and Cargo Tanks, Drawing; DWG 103-8; The Chlorine Institute: Arlington, VA, 2001.

13.1.15 Standard Chlorine Angle Valve Assembly, Drawing; DWG 104-9; The Chlorine Institute: Arlington, VA, 2002.

13.1.16 Standard Chlorine Angle Valve Parts, Drawing; DWG 105-10 (two sheets); The Chlorine Institute: Arlington, VA, 2002.

13.1.17 Typical Manway Arrangement - Chlorine Tank Car, Drawing; DWG 107-9; The Chlorine Institute: Arlington, VA, 2001.

13.1.18 Excess Flow Valve with Removable Seat - 15,000 lbs/hr, Drawing; DWG 114-6; The Chlorine Institute: Arlington, VA, 1993.

13.1.19 Chlorine Tank Car Unloading Connection, Drawing; DWG 118-4; The Chlorine Institute: Arlington, VA, 1991.

13.1.20 Typical Manway Arrangement - Chlorine Cargo Tank, Drawing; DWG 137-5; The Chlorine Institute: Arlington, VA, 1996.

13.1.21 Chlorine Tank Car Marking, Drawing; DWG 167-5; The Chlorine Institute: Arlington, VA, 2001.

13.1.22 Maximum Internal Tank Pressure for Padding Chlorine Bulk Transports, Drawing; DWG 201-3; The Chlorine Institute: Arlington, VA, 2001.

13.1.23 Pressure Relief Device for Chlorine Service - Elastomeric Seat Seal Design, Styles 1½ JQ 225 and 1½ JQ 375, Drawing; H-50155-H; Crosby Valve and Gage Company: Wrentham, MA, 1996.

13.1.24 Pressure Relief Device for Chlorine Service - Metallic Seat Design, Styles 1½ JQ 225 and 1½ JQ 375, Drawing; H-51970-F; Crosby Valve and Gage Company: Wrentham, MA, 1996.

13.1.25 The Chlorine Institute, Inc. web site: www.chlorineinstitute.org

13.2 AAR PUBLICATIONS

13.2.1 Specifications for Tank Cars; Specification M-1002; Association of American Railroads: Washington, DC, 2003.

13.2.2 Field Manual of the AAR Interchange Rules; Association of American Railroads: Washington, DC, (Re-issued in January of each year).

13.2.3 AAR Scale Handbook; Association of American Railroads: Washington, DC,

13.2.4 Specifications for Quality Assurance, Specification M-1003; Association of American Railroads: Washington, DC, 1999. (Revised 2005)

480 of 593

13.3 DOT REGULATIONS

13.3.1 Code of Federal Regulations. Title 49. Parts 100-185. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

13.3.2 North American Emergency Response Guidebook. Office of Hazardous Material Transportation (DHM-51). Research and Special Programs Administration. U.S. Department of Transportation: Washington, DC, 2000.

13.4 EPA REGULATIONS

13.4.1 Code of Federal Regulations. Title 40. Part 150. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

13.5 OSHA REGULATIONS

13.5.1 Code of Federal Regulations. Title 29. Part 1910. Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

13.5.2 "OSHA Standard Method for Determination of Respiratory Protection Program Acceptability" (available from the Chlorine Institute).

13.6 CANADIAN REGULATIONS

13.6.1 Guide to Canadian Transportation of Dangerous Goods Act and Regulations, mini version; ICC International Compliance Center Ltd: Mississauga, Ontario, 1999.

13.6.2 The Dangerous Chemicals and Noxious Liquid Substances Regulations; The Canada Communications Group: Ottawa, Ontario, 1993.

13.6.3 Construction and Maintenance of Tank Car Tanks and Selection and Use of Tank Car Tanks, Portable Tanks and Rail Cars for the Transportation of Dangerous Goods by Rail; CAN/CGSB-43.147; Canadian General Standards Board: Ottawa; 2005.

13.6.4 Chlorine Tank Car Unloading Facilities Regulations (General Order O-35), Transport Canada, Rail Safety Directorate; 1985.

For further assistance and information on items referenced, contact:

American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5000
703-741-6000 (Fax)
www.AmericanChemistry.com

Association of American Railroads (AAR)
Transportation Technology Center, Inc.
55500 DOT Road
Pueblo, CO 81001
719-584-0750
719-584-0711 (Fax)
www.aar.org
www.ttci.aar.com

Canadian Chemical Producers= Association (CCPA)
350 Sparks Street, Suite 805
Ottawa, Ontario K1R 7S8 (CANADA)
613-237-6215
613-237-4061 (Fax)
www.ccpa.ca

Canadian General Standards Board
Place du Portage III, 6B1
11 Laurier Street
Gatineau, Quebec
800-655-2472 or 819-956-0425
819-956-5644 (Fax)
www.pwgsc.gc.ca/cgsb

Canadian Government Publishing
PWGSC
Ottawa, Ontario K1A OS5 (CANADA)
800-635-7943 or 613-941-5995
613-954-5779 (Fax)
www.publications.pwgsc.gc.ca

Canadian Standards Association
5060 Spectrum Way, Suite 100
Mississauga, Ontario
L4W 5N6 CANADA
416-747-4044 (Sales)
416-747-2510 (Fax)
www.csa.ca

ICC International Compliance
205 Matheson Boulevard E
Mississauga, Ontario
L4Z 1X8 CANADA
800-554-6181
905-890-7070
www.thecompliancecenter.com

National Archives and Records Admin.
Director, Office of the Federal Register
800 North Capitol Street, NW, Suite 700
Washington, DC 20001
202-741-6000
202-741-6012 (Fax)
www.archives.gov

National Tank Truck Carriers, Inc.
2200 Mill Road
Alexandria, VA 22314-4677
703-838-1960
703-684-5753 (Fax)
www.tanktruck.org

Superintendent of Documents
Government Printing Office
732 North Capitol Street, NW
Washington, DC 20401
202-512-1800 (Sales)
www.access.gpo.gov

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APPENDIX A - CHECKLIST

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

Place a check mark in the appropriate box below:

Yes	No	N/A			
☐	☐	☐	1.	Are personnel familiar with facility and transfer site emergency plans?	{3.1}
☐	☐	☐	2.	Are Emergency Kit C and SCBA readily available at the transfer site?	{3.4,3.5}
☐	☐	☐	3.	Are personnel trained in regulatory requirements for chlorine?	{4}
☐	☐	☐	4.	Has shipper registered with EPA, and are tanks properly labeled when the chlorine is to be used in FIFRA regulated application?	{4.2, 8.8}
☐	☐	☐	5.	Do chlorine tank cars meet all governmental specifications and Chlorine Institute recommendations?	{5.1-5.3}
☐	☐	☐	6.	Is the tank car properly spotted for loading or unloading?	{6.1, 6.2}
☐	☐	☐	7.	Has the tank car been properly inspected prior to loading?	{7.2}
☐	☐	☐	8.	Does the transfer facility follow the Chlorine Institute's recommendations for emergency shut off?	{8.2, 9.3}
☐	☐	☐	9.	Are conditions during loading and padding such that tank pressure will not approach the relief device setting?	{8.5}
☐	☐	☐	10.	Is air, used for unloading and padding, free from oil and foreign matter and dried to a minimum dew point of -40EF (-40EC)	{10.2}
☐	☐	☐	11.	Have precautions been taken to ensure the tank car is not overloaded?	{8.4, 7.3.1}

Yes	No	N/A			
❐	❐	❐	12.	Is the transfer of chlorine properly monitored?	{9.8}
❐	❐	❐	13.	is an inspection checklist used for all aspects of the loading or unloading operations?	{7.1, 9.2}
❐	❐	❐	14.	Have the proper checks been made after then tank car is loaded or unloaded?	{8.8, 9.12}

REMINDER

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

APPENDIX B
Chlorine Tank Car Loading & Unloading Checklist

Date: ______________ Product: ______________ T/C No.: ______________

Quantity: ______________ Track & Spot No.: ______________

[OK or ✓] OK [X] UNSATISFACTORY [NA or -] NOT APPLICABLE...

PREPARATION: COMPLETED BY: ______________________________
(Signature)

LOAD	UNLOAD		
		1.	Tank car inspected and no suspicious material found attached or protruding?
		2.	Tank car body inspected to insure there are no major scars or dents?
		3.	All DOT information and stenciling on all sides of tank car is legible and free of graffiti?
		4.	Tank car has springs on all sets of trucks?
		5.	Tank car brake pads in place and in good condition?
		6.	Double shelf coupler on each end of the tank car is free of cracks or other damage?
		7.	The double shelf coupler pin is present and not broken?
		8.	Ladders are secured on both sides of the tank car with no welds cracked or bolts loose?
		9.	All bolts and nuts on the sill steps and grab irons are tight?
		10.	Placard holders are not bent or broken?
		11.	Air hoses are in good condition with no cracks?
		12.	Paint/jacket condition - Good ______ Fair _______ Poor ________

BEFORE LOADING/UNLOADING: COMPLETED BY ______________________________
(Signature)

LOAD	UNLOAD		
		1.	Loader/unloader has successfully completed required training?
		2.	Tank car number agrees with shipping documents? (If not, do not proceed.)
		3.	Capacity checked against amount to load/unload?
		4.	Material in facility tank approved for loading?
		5.	Loading/unloading outage calculated?
		6.	Tank car is correct for product? (Example - DOT 105J500W)
		7.	Hand brakes are set and wheels chocked?
		8.	Visually check safety appliances (ladders, handrails, grab irons) and placard holders?
		9.	Blue flags, blue lights and derails in place?
		10.	Product tags agree with product identification on shipping documents?
		11.	Security seals (if used) are intact and numbers match shipping documents?
		12.	Pressure relief device test up to date?
		13.	No tank car test/inspection dates are past due?
		14.	Grounding cables attached, if appropriate?
		15.	Fall restraint bar/system in place?
		16.	Visually check securement devices (valves, plugs, chains on plugs).

LOAD	UNLOAD	
		17. Valves, pressure plate and pressure relief device inspected for sign of leakage?
		18. OK to load on heel or residue?
		19. Has product been properly identified?
		20. Tank car vented or connected to vacuum/blowdown system?
		21. Loader knowledgeable of procedure to prevent overfilling car?
		22. Verify correct product line is attached to tank car – check line label?
		23. Confirm emergency shutdown system is operational.
		24. Tank car ready to load/unload?
		25. Loading/unloading hoses and fittings inspected for leaks upon beginning transfer?

DURING LOADING/UNLOADING: COMPLETED BY ______________________
(Signature)

LOAD	UNLOAD	
		1. Tank car fittings observed for leaks – liquid or vapor?
		2. Observe product tank scale and/or tank car scale readings to prevent overfilling.

POST LOADING/UNLOADING: COMPLETED BY ______________________
(Signature)

LOAD	UNLOAD	
		1. Tank loaded to proper weight?
		2. Product lines removed and secured (closed, capped, plugged)?
		3. Tank car tank pressure-checked for leaks?
		4. Tank car pressure checked and OK?
		5. Vent/blowdown line removed and secured (closed, capped, plugged)?
		6. All valves and plugs properly secured and tool-tight (closed and plugged) – All plugs attached to valves with chains?
		7. Protective housing dome cover closed, pinned and sealed?
		8. Four protective housing outlet covers in closed position?
		9. Product labels/tags/seals in place?
		10. Fall restraint bar/system removed?
		11. '1017' placards applied on all four sides of car?
		12. Ground wire removed?
		13. Derails, blue flags and blue lights removed?
		14. Hand brakes set and chocks left in place for removal by Railroad personnel?

RECORD SEAL NUMBERS:

______________ , ______________ , ______________ , ______________ , ______________

______________ , ______________ , ______________ , ______________ , ______________

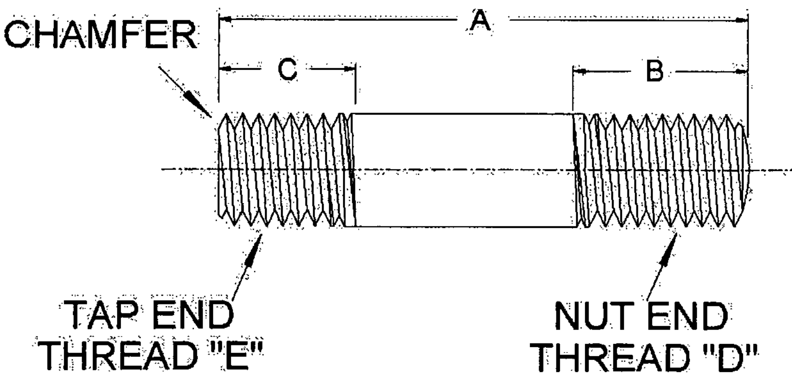
COMMENTS:

____

____

Note: The Chlorine Institute recommends a checklist be used for chlorine tank car loading and unloading operations. This sample checklist is an example of the types of information that could be included in such a checklist. Chlorine loading and unloading facilities should use this as a guide in the development of site specific checklists.

DRAWINGS



ITEM	PART	USE
1	STUD	Tank car and cargo tank pressure relief device (1 1/2 JQ)
2	STUD	Standard angle valve and tank car protective housing. (see NOTE 7)
2A	STUD	Alternate angle valve. (see NOTE 7)
3	STUD	Tank car and cargo tank manway cover.
4	GASKET	Angle valve, pressure relief device (1 1/2 JQ)
5	GASKET	Tank car and cargo tank manway cover.
6	NUT	Angle valve, pressure relief device (1 1/2 and 4JQ) tank car and cargo tank protective housing.
7	NUT	Tank car and cargo tank manway cover.
8	GASKET	Tank barge pressure relief device (4JQ)
9	STUD	Tank barge pressure relief device (4JQ)

STUDS

DIM.	ITEM 1	ITEM 2	ITEM 2A	ITEM 3	ITEM 9	CLASS OR TOL.
A	3 3/4	3	2 5/8	4 1/2	4 1/8	+1/16,-0
B	2 3/8	1 5/8	1 1/4	2 3/4	1 3/8	+0,-1/16
C	7/8	7/8	7/8	1 1/4	1	+0,-1/16
D	3/4-10 UNC	3/4-10 UNC	3/4-10 UNC	1 1/8-7 UNC	3/4-10 UNC	2A
E	3/4-10 UNC	3/4-10 UNC	3/4-10 UNC	1 1/8-7 UNC	3/4-10 UNC	3A

ITEM 6 - 3/4-10 UNC-2B (1 1/4 ACROSS FLATS)

ITEM 7 - 1 1/8-7 UNC-2B (1 13/16 ACROSS FLATS)

Material shall conform to ASTM A320 Grade L7 specifications including impact testing.

GASKETS

DIM	ITEM 4	ITEM 5	ITEM 8
OD	2 1/4	20 1/4	6 3/16
ID	1 1/2	19 1/4	5 3/16
THICK	1/8	1/8	1/8

MATERIAL: Per gasket material section in pamphlet 95

NUTS

Nuts shall be heavy series, semifinished hexagon type in conformance with ANSI B18.22 & ASTM A194.

NOTES:

1. Dimensions in inches unless noted.
2. Screw thread tolerance and gaging shall conform to ANSI B1.1.
3. Dimensions "B" and "C" include 1 to 1-1/4 imperfect threads.
4. Lock washers not permitted.
5. Cargo tank parts are identical to tank car parts.
6. Place grade mark "L7" on nut end of stud.
7. The valve supplier should be consulted for the proper stud dimensions.

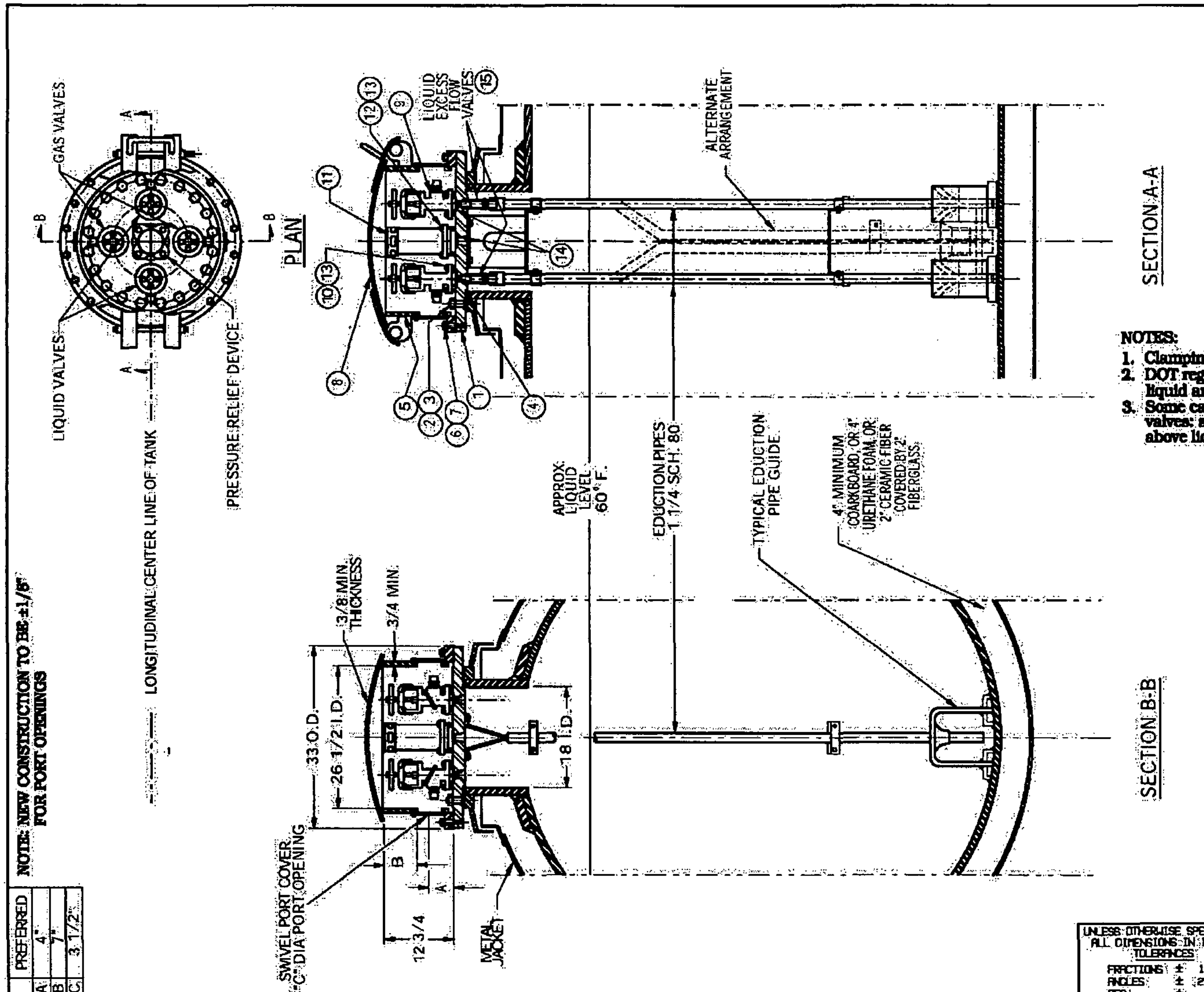
THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

ISS	DATE	REVISION	APPR
11	10/06	ADDED "2A", REVISED NOTES	
10	1/01	CLARIFIED USE & MAT. NOTES	STC
9	7/93	REDRAWN	
8	8/83	CORRECT DIM "C", ITEM 2 & 9	
7	9/82	ADD NOTE 6	STC
6		GASKET SPEC UPDATED	CCSS
5	9/76	ITEMS 1-3, DIM. A, B & C REV.	
4	11/62	4JQ STUDS, 8C GASKET ADDED	CCSS
3	5/58	GENERAL REVISIONS	CCSS
2	1/58	THREADS REVISED TO UNC	CCSS
1	2/57	ISSUED	RLM

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

STUDS, NUTS & GASKETS FOR CHLORINE TANK MANWAY COVERS & VALVES

DRAWN	A. KASS	7-93
TRACED		
CHECKED	REP	
APPROVED		
DWG. NO.	102	ISSUE 11



ITEM	NAME OF PART		QTY	DWG
1	MANWAY COVER		1	103
2	MANWAY COVER STUD		20	102
3	MANWAY COVER NUT		20	102
4	MANWAY COVER GASKET		1	102
5	PROTECTIVE HOUSING		1	
6	PROTECTIVE HOUSING STUD		20	102
7	PROTECTIVE HOUSING NUT		20	102
8	PROTECTIVE HOUSING COVER		1	
9	ANGLE VALVE - 1"		4	104
10	ANGLE VALVE STUD		16	102
11	PRESSURE RELIEF DEVICE	- SOFT SEAT - METAL SEAT	1	
12	PRESSURE RELIEF DEV STUD		4	102
13	VALVE NUT		20	102
14	VALVE GASKET		5	102
15	EXCESS FLOW VALVE		2	

NOTES:

1. Clamping arrangements for eduction pipes vary.
2. DOT regulations require excess flow valves under liquid angle valves.
3. Some cars are equipped with short nipples under gas valves; some have drop pipes extending to slightly above liquid level.

THIS DRAWING WAS DEVELOPED BY A TECHNICAL COMMITTEE OF THE INSTITUTE. THE USER SHOULD BE AWARE THAT CHANGING TECHNOLOGY OR REGULATIONS MIGHT REQUIRE REVISION OF THE DRAWING. APPROPRIATE STEPS SHOULD BE TAKEN TO INSURE THAT THE DRAWING IS CURRENT WHEN USED.

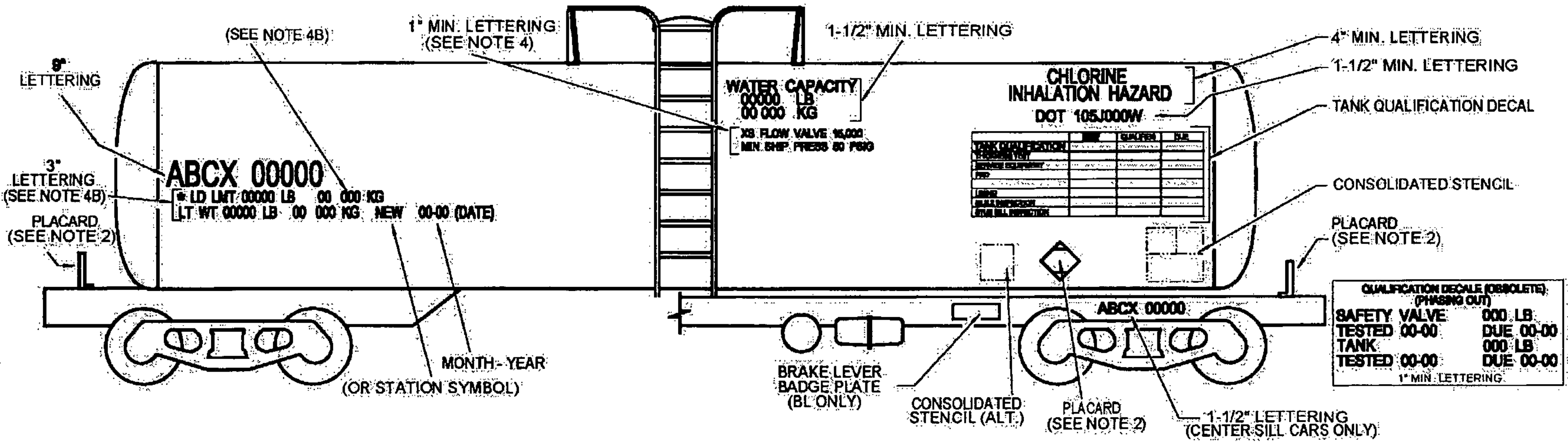
ISS	DATE	REVISION	APPR
9	1/01	Remove drawing ref's	STC
8	11/96	Adopted "PRD" nomenclature	
7	7/93	Redrawn	
6	9/82	Note 5 & insulation note rev.	STC
5	9/71	Redrawn - added dimension	CCSS
4	2/70	Redrawn	CCSS
3	1/62	Note 4 rev. & add hdg.th.	CCSS
2	6/59	Plan view corrected	CCSS
1	1/59	Initial release	CCSS

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

TYPICAL MANWAY ARRANGEMENT CHLORINE TANK CAR

DRAWN	A. KASS	7-93	
TRACED		SCALE - NONE	
CHECKED	REP		
APPROVED			
DWG. NO.	107	ISSUE	9

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± 1/16
ANGLES ± 2°
DEC. ± .005



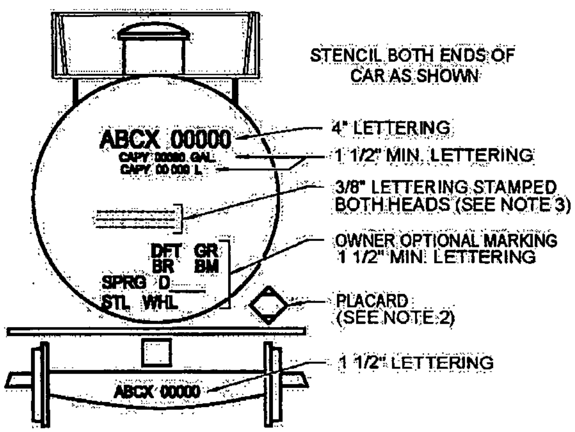
NOTES:

1. REFER TO THE CURRENT EDITION OF AAR SPECIFICATIONS FOR TANK CARS, APPENDIX C FOR AAR & DOT (T.C) REQUIREMENTS FOR MARKING OF TANK CARS INCLUDING STENCILING AND STAMPING.
2. THE CHLORINE PLACARD MUST BE INSTALLED IN METAL PLACARD HOLDERS ON BOTH SIDES AND BOTH ENDS OF CAR AS SHOWN.
3. EACH TANK MUST BE PLAINLY AND PERMANENTLY STAMPED IN LETTERS AND FIGURES AT LEAST 3/8" HIGH INTO THE METAL NEAR THE CENTER OF BOTH OUTSIDE HEADS AS FOLLOWS:

EXAMPLE OF REQUIRED STAMPING

SPECIFICATION ______________ DOT-105J500W
MATERIAL ______________ AAR T.C 128B
TANK BUILDERS INITIALS ______________ ABC
DATE OF ORIGINAL TEST ______________ 00-0000
CAR ASSEMBLER
(IF OTHER THAN TANK BUILDER) ______ DEF
WATER CAPACITY ______________ 00000 LB

4. IN ADDITION TO THAT REQUIRED BY REGULATIONS, THE INSTITUTE'S TECHNICAL COMMITTEES RECOMMEND THAT ADDITIONAL STENCILING BE APPLIED TO CHLORINE TANK CARS AS FOLLOWS:
   A) EXCESS FLOW VALVES - STENCIL AS SHOWN BOTH SIDES OF CAR TO THE RIGHT OF THE LADDER WITH THE MAXIMUM OPERATING FLOW RATE IN POUNDS OF LIQUID CHLORINE PER HOUR AND MINIMUM SHIPPING PRESSURE IN PSIG.
   B) ON A 90-TON CHLORINE CAR, THE LOAD LIMIT SHOULD BE STARRED IF THE LIGHTWEIGHT PLUS 180,000 LB EXCEEDS 263,000 LB.
   C) THE METRIC LOAD LIMIT CONVERSION FOR A 90-TON CHLORINE CAR IS TO THE NEXT LOWER KILOGRAM. THE METRIC LOAD LIMIT CONVERSION FOR CARS SMALLER THAN 90-TON IS TO THE NEAREST 50 KILOGRAMS PER AAR FIELD MANUAL RULE 70.
5. THE INHALATION HAZARD STENCIL MAY BE BELOW (PREFERRED) OR ABOVE THE CHLORINE COMMODITY STENCIL.



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ISS	DATE	REVISION	APPR
5	1/01	NEW QUALIFICATION DECAL	STC
4	7/93	REVISION NOTE "4C", ADD "4D"	STC
3	6/91	REDRAWN, ADD NEW REQ.	STC
2	8/77	UPDATE FIG C-1 REQ. & NOTES	CCSS
1	3/73	ORIGINAL ISSUE	CCSS

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

CHLORINE TANK CAR MARKING

DRAWN	A. KASS	7-93	
TRACED		SCALE = NONE	
CHECKED	REP	ISSUE 3	
APPROVED			
DWG. NO.	167	ISSUE	5

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ISS	DATE	REVISION	APPR
6			
5			
4			
3	1/01	REORIENT AXIS	STC
2	6/91	REDRAW	
1	8/62	INITIAL RELEASE	CCSS

THE CHLORINE INSTITUTE, INC.
WASHINGTON, D.C.

MAXIMUM INTERNAL TANK PRESSURE FOR PADDING CHLORINE BULK TRANSPORTS

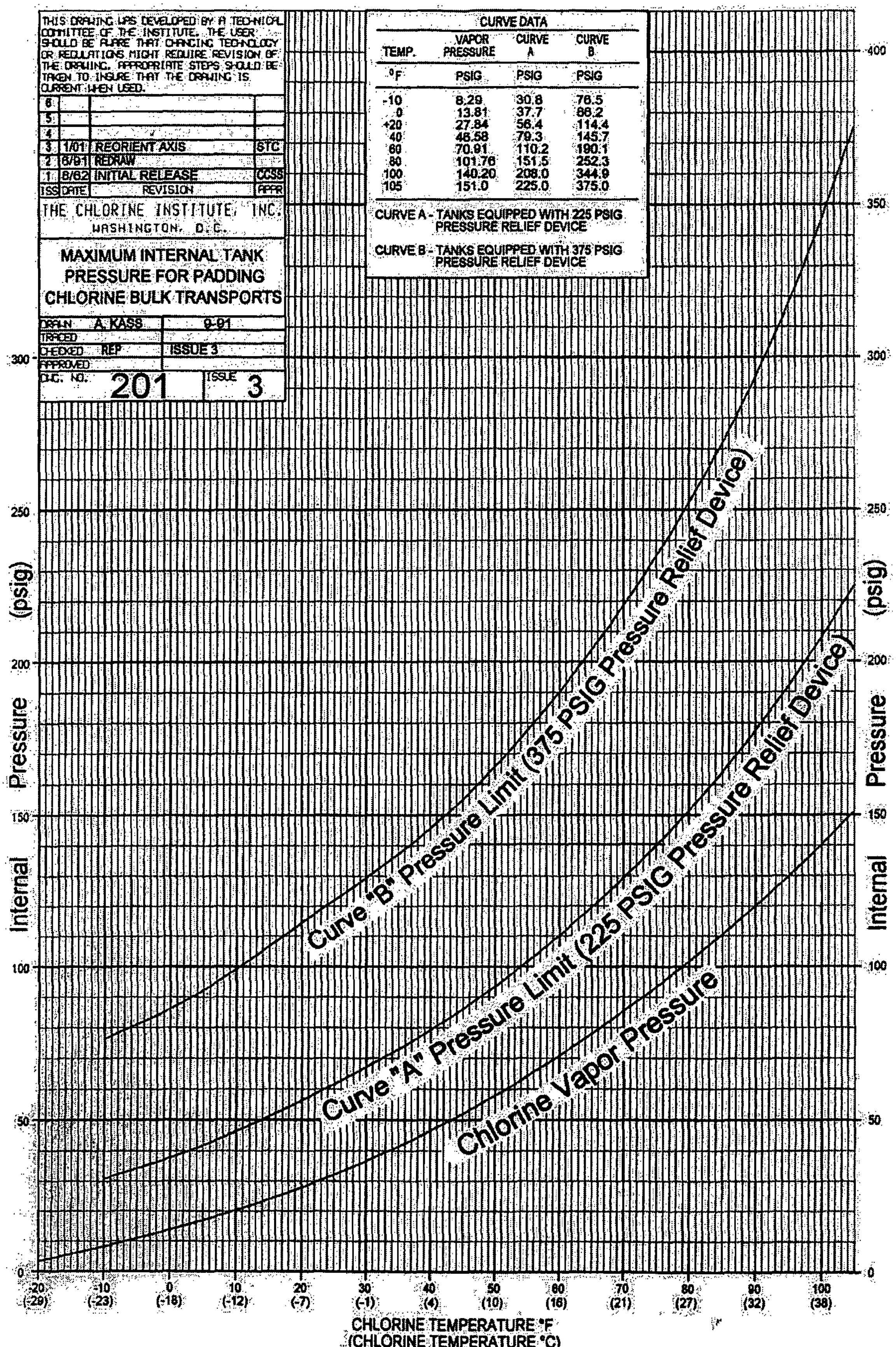
DRAWN	A. KASS	9-91
TRACED		
CHECKED	REP	ISSUE 3
APPROVED		
DWG. NO.	201	ISSUE 3

CURVE DATA

TEMP. °F	VAPOR PRESSURE PSIG	CURVE A PSIG	CURVE B PSIG
-10	8.29	30.8	76.5
0	13.81	37.7	86.2
+20	27.84	56.4	114.4
40	46.58	79.3	145.7
60	70.91	110.2	190.1
80	101.76	151.5	252.3
100	140.20	208.0	344.9
105	151.0	225.0	375.0

CURVE A - TANKS EQUIPPED WITH 225 PSIG PRESSURE RELIEF DEVICE

CURVE B - TANKS EQUIPPED WITH 375 PSIG PRESSURE RELIEF DEVICE



THE CHLORINE INSTITUTE, INC.

THE CHLORINE INSTITUTE, INC. since 1924 A LEGACY OF SAFETY STEWARDSHIP

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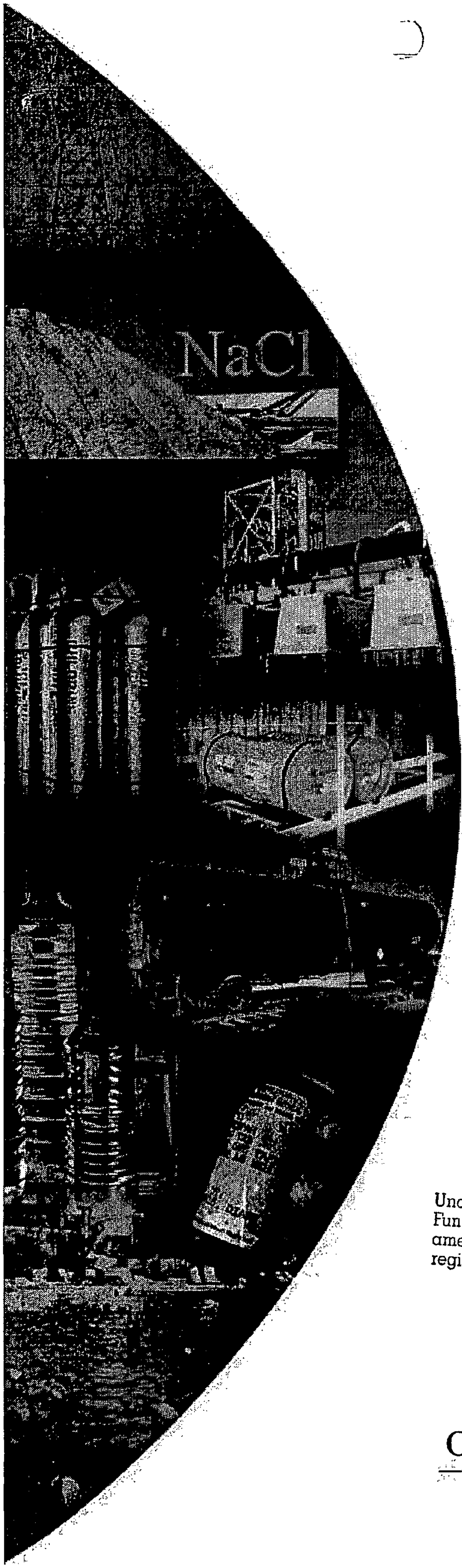

THE CHLORINE INSTITUTE, INC.

Pamphlet 82

Recommendations for Using 100 and 150 Pound Cylinders at Swimming Pools

Edition 2

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 148-707

October 2008

494 of 593

TABLE OF CONTENTS

495 of 593

1. INTRODUCTION

1.1 SCOPE

Chlorine is used extensively in a variety of industries. For example, it is utilized as a bleaching agent in paper and textile manufacturing and as a component in the production of dyes, insecticides, cleaning solvents, and medicines. Its largest use is in the manufacture of plastics. Chlorine is also the most widely used disinfectant in the world and it is often used to disinfectant swimming pools. Sodium and calcium hypochlorites are also used to chlorinate swimming pools, but this document deals only with elemental chlorine.

This pamphlet is intended to provide basic information on chlorine safety for swimming pool personnel. Throughout this text, the reader may be referred to other Chlorine Institute (CI) publications for technical topics requiring detailed explanations or for subjects of specific interest.

THIS PAMPHLET IS NOT INTENDED TO SERVE AS A COMPLETE GUIDE FOR PERSONNEL WHEN USING CHLORINE GAS AS A DISINFECTANT AT SWIMMING POOLS. EMPLOYEE TRAINING BEYOND THE SCOPE OF THIS PAMPHLET IS ABSOLUTELY ESSENTIAL FOR ANY PERSON USING CHLORINE GAS AS A SWIMMING POOL DISINFECTANT. SUCH TRAINING MUST BE ADMINISTERED BY COMPETENT PERSONS WITH SUFFICIENT KNOWLEDGE AND EXPERIENCE IN THE USE OF CHLORINE GAS AS A DISINFECTANT AT SWIMMING POOLS.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. (CI) 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 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 the CI website at www.chlorineinstitute.org.

1.3 ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental and Industrial Hygienists
AIHA	American Industrial Hygiene Association
ASTM	American Society for Testing and Materials; now known solely by the acronym

AWWA	American Water Works Association
CHEMTREC	Chemical Transportation Emergency Center
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHLOREP	Chlorine Emergency Plan – Activated Through CHEMTREC
CI	The Chlorine Institute, Inc.
CIIT	Chemical Industry Institute of Technology
DHS	Department of Homeland Security
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERP	Emergency response plan
ERPG	Emergency response planning guidelines
HAZMAT	Hazardous materials
ICC	International Code Council
IDLH	Immediately dangerous to life and health
LEPC	Local emergency planning committee
MSDS	Material safety data sheet
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limits
PPE	Personal protective equipment
PSM	Process safety management
RMP	Risk management plan
RMPR	Risk Management Program Rule

SARA	Superfund Amendments and Reauthorization Act of 1986
SCBA	Self-contained breathing apparatus
STEL	Short-term exposure limits
TWA	Time-weighted average

1.4 Disclaimer

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require changes in the recommendations contained herein. Appropriate steps should be taken to ensure that the information is current, when used. These recommendations should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.5 Approval

The Institute's Customer Stewardship Issue Team approved Edition 2 of this pamphlet on October 7, 2008.

1.6 Revisions

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

1.6.1 Significant Revisions in Current Edition

The entire document was updated to be consistent with current Chlorine Institute recommendations including, but not limited to, using 26° Baumé aqua ammonia for leak checking and using a torque wrench when opening and closing container valves.

1.7 Reproduction

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. GENERAL INFORMATION FOR POOL OPERATORS

2.1 Usage

Chlorine's primary use in pool water is as a disinfectant to destroy harmful organisms. It can also remove ammonia compounds (chloramines) through the process of break-point chlorination. This is sometimes referred to as super-chlorination or shock in the pool industry.

2.2 Physical and Chemical Properties

The chemical symbol for elemental chlorine is Cl. Chlorine exists as a molecule containing two atoms, shown chemically as Cl_2. Chlorine has an atomic weight of 35.453, a molecular weight of 70.906, and an atomic number of 17. Some of the physical properties of chlorine are given in Table 1. While it is not explosive or flammable, as a liquid or gas it can react violently with many substances. Chlorine is only slightly soluble in water (0.3 to 0.7% by weight.)

Chlorine gas has a greenish-yellow color. It has a characteristic disagreeable and pungent odor similar to chlorine-based laundry bleaches, and is detectable by smell at concentrations as low as 0.2 to 0.4 ppm. It is about two and a half times as heavy as air. Consequently, if chlorine gas escapes from a container or system, it will seek the lowest level in the building or area.

Liquid chlorine is amber in color and is about one and a half times as heavy as water. Chlorine is seldom seen as a liquid because it boils (converts to a gas) at about -29°F (-34°C) at atmospheric pressure.

The term dry chlorine does not refer to dry chlorinating chemicals such as calcium hypochlorite. It refers to liquid or gaseous elemental chlorine with very low water content (See CI Pamphlet 100). While dry chlorine reacts violently with some metals, it is not corrosive to metals such as copper or carbon steel. However, wet chlorine is highly corrosive to most metals (Section 2.3.5). Chlorine shipped in rail cars, cargo tanks, cylinders, and ton containers is dry chlorine.

Problems attributable to wet chlorine are usually due to moisture in a system and can result from poor operating practices at the water or wastewater plant.

Table 1. Physical Properties of Chlorine	
Boiling point (liquefying point) at 1 atmosphere = 14.696 psi (101.325 kPa)	-29.15°F (-33.97°C)
Melting point (freezing point) at 1 atmosphere	-149.76°F (-100.98°C)
Liquid density at 60°F (16°C)	88.76 lb/cu ft (1,422 kg/m^3)
Gas density at 34°F (1.1°C)	0.2006 lb/cu ft (3.213 kg/m^3)
Specific gravity (liquid) at 32°F (0°C)	1.468 (water = 1)
Specific gravity (gas) at 32°F (0°C)	2.485 (air = 1)
Water solubility at 70°F (21.1°C)	0.7% by weight
Vapor pressures:	
at 32°F (0°C)	53.51 psi (368.9 kPa)
at 77°F (25°C)	112.95 psi (778.8 kPa)
at 129°F (48.9°C)	191.01 psi (1,316.8kPa)

Chlorine gas reacts with water to form both hypochlorous and hydrochloric acids (Eq. 1):

$$Cl_2 + H_2O \leftrightarrow HOCl + HCl \quad \text{(Eq. 1)}$$

chlorine + water ↔ hypochlorous acid + hydrochloric acid

Hypochlorous acid dissociates in water to form the hydrogen and hypochlorite ions (Eq. 2):

$$HOCl \leftrightarrow H^+ + OCl^- \quad \text{(Eq. 2)}$$

hypochlorous acid ↔ hydrogen ion + hypochlorite ion

The degree of dissociation is dependent on the pH and temperature of the water.

Hypochlorous acid is the dominant form of chlorine in water up to pH 7.8. A significant percentage of the chlorine is still in the form of hypochlorous acid even between pH 8 and pH 9 (Table 2). Each plant must determine the dose and residual needed to achieve disinfection. Hypochlorous acid is the predominant form of chlorine for disinfection.

Table 2. Percent Hypochlorous Acid and Hypochlorite Ion at 68°F (20°C)

pH	%HOCL	$\%OCL^-$
5.0	99.7	0.3
5.5	99.2	0.8
6.0	97.5	2.5
6.5	92.4	7.6
7.0	79.3	20.7
7.5	54.8	45.2
8.0	27.7	72.3
8.5	10.8	89.2
9.0	3.7	96.3
9.5	1.2	98.8
10.0	0.4	99.6
10.5	0.1	99.9

2.3 SPECIAL CONCERNS FOR OPERATORS

2.3.1 Liquid-Gas Volume Relationship

One volume of liquid chlorine yields about 460 volumes of chlorine gas. For example, one pound or about 11 fluid ounces of liquid chlorine yields approximately 5.4 cubic feet of 100% chlorine gas when vaporized at normal temperature [70°F (21.1°C)] and atmospheric pressure. Therefore, one 150 lb cylinder would completely fill a 10 x 10 x 8-foot room with 100% chlorine gas.

2.3.2 Liquid-Gas Temperature Effect

The vaporization of liquid chlorine on skin or clothing may reduce the temperature enough to cause frostbite (even through high-quality protective clothing), cause the fogging of protective face masks, or the freezing of footgear to the ground. It is essential to wear the proper PPE during all routine operations.

2.3.3 Physiological Effects of Chlorine Exposure

Chlorine is an irritant to the eyes, skin, mucous membranes, and the respiratory system. The primary concern with exposure to chlorine is the respiratory system followed by the eyes. The impact of exposure to chlorine is both concentration and time dependent. People with respiratory conditions should inform their doctor that they work around chlorine. Extra precautions may be necessary. Table 3 summarizes exposure levels and effects on humans.

Table 3. Chlorine Exposure Levels and Effects on Humans

Exposure levels (ppm)	Effects
0.2 to 0.4	Odor threshold (varies by individual)
less than 0.5	No known acute or chronic effect
0.5	ACGIH 8-hour time weighted average
1.0	OSHA ceiling level (PEL) TLV-STEL ERPG-1
1 to 10	Irritation of the eyes and mucous membranes of the upper respiratory tract. Severity of symptoms depends on concentrations and length of exposure.
3	ERPG-2 (Emergency Response Planning Guidelines as values developed by AIHA) is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects that could impair an individual's ability to take protective action.
10	NIOSH IDLH (immediately dangerous to life and health)
20	ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

As the duration of exposure or the concentration increases, the affected individual may become apprehensive and restless, with coughing accompanied by throat irritation, sneezing, and excess salivation. At higher levels, vomiting associated with labored breathing can occur. In extreme cases, difficulty in breathing can progress to the point of death through suffocation. An exposed person with a preexisting medical or cardiovascular condition can have an exaggerated response. Anyone exhibiting these symptoms should see a qualified healthcare provider immediately as his or her condition is likely to deteriorate over the next few hours.

2.3.4 Reaction with Water

Chlorine is only slightly soluble in water, in which it forms a weak solution of hydrochloric and hypochlorous acids (Eq. 1). Chlorine hydrate, a greenish ice-like substance ($Cl_2{\bullet}8H_2O$), may form as crystals below 49.3°F (9.6°C) at atmospheric pressure.

Chlorine hydrate can also form at higher temperatures if the chlorine is at an increased pressure. These crystals can interfere with the proper operation of chlorination systems.

2.3.5 Reactions with Metals

Below 250°F (121°C) iron, copper, steel, lead, nickel, platinum, silver, and tantalum are resistant to dry chlorine (gas or liquid state). At ordinary temperatures, dry chlorine reacts (often violently) with aluminum, arsenic, gold, mercury, selenium, tellurium, tin, and titanium. Carbon steel ignites at 483°F (251°C) in a chlorine atmosphere (See CI Pamphlet 164).

Wet chlorine forms acids and is very corrosive to most common metals. Platinum, silver, and tantalum are resistant to both wet and dry chlorine. Titanium is unique because it is resistant to wet chlorine but cannot be used in contact with dry chlorine. Experts should be consulted when dealing with systems using wet chlorine.

2.3.6 Other Reactions

Chlorine should be segregated from ammonia and ammonia compounds because potentially violent reactions could result in the event of a chlorine release.

Chlorine reacts with many organic compounds. Some of these reactions can be violent or explosive, including those with oils, greases, solvents, coolants, and other hydrocarbons. The separation of these materials during storage and use is essential to safety. This is especially important when new components including piping are added to the chlorine system. Even thin layers of oils and greases can react violently (See CI Pamphlets 6 and 164).

3. CHLORINE CONTAINERS

3.1 <u>GENERAL</u>

Chlorine is shipped and stored in pressure vessels as a liquefied gas under pressure. While on-site stationary tanks are used solely for storage, chlorine is commonly transported in cylinders, ton containers, cargo tanks, and rail tank cars. Different equipment is needed to deal with emergencies involving each type of container. Chlorine Institute Emergency Kit A and cylinder recovery vessels are designed to contain most cylinder leaks.

Chlorine containers must always be handled with care and should not be dropped or struck. During transport, containers must be secured to prevent them from moving. A loading dock or a hydraulic tailgate on the truck should be used when unloading. A container valve's protective housing should be in place when the container is not in use.

3.2 CYLINDERS

Chlorine cylinders may include foot-ring, bumped-bottom, and double-bottom construction (Figure 1), with only one opening permitted. The most common sizes are 100 lb (45 kg) and 150 lb (68 kg). Table 4 lists tare weights (the weight of an empty container with valves and fusible plugs [safety relief devices] but without valve protection devices) and dimensions of 100 and 150 lb cylinder containers. A standard Chlorine Institute cylinder valve is commonly used in the United States and Canada. The CI has developed recommended criteria for alternate cylinder and ton valves. The valve outlet threads are not standard pipe threads.

Cylinder valves are equipped with a pressure relief device consisting of a fusible metal plug in the valve body, located below the valve seat. The fusible metal is designed to melt between 158°F and 170°F (70°C and 77°C) to relieve pressure and prevent rupture of the cylinder in case of exposure to high temperatures.

Cylinders should always be stored upright. They are stamped near the neck-ring area with the tare weight and the date of the last hydrostatic test. According to U.S. Department of Transportation regulations, cylinders must be hydrostatically tested every five years. DOT regulations prohibit the marring or defacing of these markings.

Table 4. Container Dimensions and Weights

Capacity		100 lb (45 kg)	150 lb (68 kg)
Volume of liquid chlorine (approximate at 60°F/15.6°C)	(gal) (L)	8.42 31.87	12.64 47.85
Tare weight	(lb) (kg)	63-115 29-52	85-140 39-64
Outside diameter	(in) (mm)	8.25-10.75 210-273	10.25-10.75 260-273
Cylinder Height	(in) (mm)	39.5-59* 1,003-1,499*	53-56* 1,346-1,422*

*Heights are to the top of the valve protection housing. The height to the center of the valve outlet is about 3.5 in. (89 mm) less.

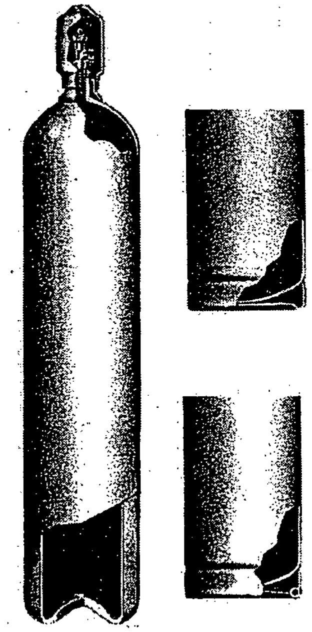

Figure 1
Chlorine Cylinder
(Left - bump-bottom; Upper right - double-bottom; Lower right - foot-ring)

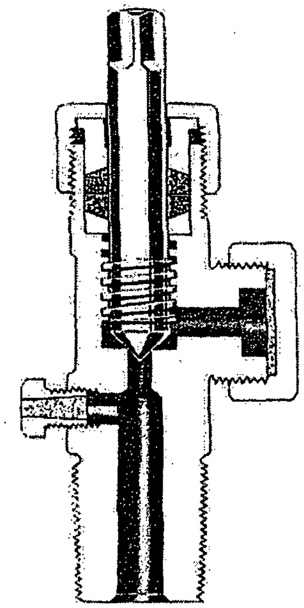

Figure 2
Typical Cylinder Valve

4. TRANSPORTATION, STORAGE, AND HANDLING OF CYLINDERS

4.1 TRANSPORTATION OF CHLORINE

The U.S. DOT regulates the transportation of hazardous materials, including chlorine. Applicable DOT regulations appear in Title 49 of the Code of Federal Regulations (49 CFR), and requires special HazMat and safety permits as of January 1, 2005. In most circumstances, it is preferable to let the chlorine supplier transport the chlorine to each use site. If this arrangement is not possible, CI Pamphlet 76 contains recommendations on how to safely transport packaged chlorine. Placards are required for the transportation of any amount of chlorine. Proper labeling of the container is essential and the correct shipping papers must be on the vehicle. These requirements, including the correct wording of the paperwork and labeling, change frequently (Contact the supplier and review 49 CFR to remain current).

In Canada, you must follow the requirements of the Transportation of Dangerous Goods Regulations by Transport Canada, covering High Consequence Dangerous Goods.

The DOT and TC have specific training requirements for all personnel involved in the transportation of hazardous materials, from those preparing the paperwork to those loading and driving the truck (See CI Pamphlet 76).

4.2 RECEIVING AND UNLOADING CHLORINE CYLINDERS

Individual cylinders should be chained or clamped to a hand truck or otherwise secured to the moving device for unloading or relocating. If secured in a storage rack, a fork lift can be used. Cylinders should not be lifted by the valve protective housing, which is not designed to carry the weight of the cylinder. The cylinders should always be secured to prevent them from falling (See CI Pamphlet 76).

4.3 LEAK DETECTION AND CORRECTION

4.3.1 Cylinder Leaks

When a leak is suspected, it is recommended that ammonia vapors be used to find the source. When ammonia vapor is directed at a leak, a white cloud will form. To produce ammonia vapor, a plastic squeeze bottle containing commercial, 26° Baumé or stronger, aqua ammonia (ammonium hydroxide solution) should be used. A weaker solution such as household ammonia may not be concentrated enough to detect minor leaks. If a wash bottle is used, the dip tube inside the bottle should be cut off so that squeezing the bottle directs only the vapor, and not liquid, from the nozzle. To prevent corrosion, liquid aqua ammonia should not come into contact with any metal parts.

4.3.2 Responding to a Leak

NOTE: Before responding to any leak, review Sections 9, 10 and 11.

Self-contained breathing apparatus and appropriate protective suits are required. (The on-site coordinator decides what level of protection is needed.) Regular training with SCBA and the use of appropriate emergency kits or cylinder containment vessels are essential. Comply with all applicable local, state, and federal regulations relating to both training and response requirements.

If chlorine is escaping as a liquid from a cylinder, align the tank so that the leaking side is up. In this position, the chlorine will escape only as a gas, greatly minimizing the leak.

If a valve is leaking through the valve outlet, install an outlet cap with gasket and open and close the valve. Sometimes this will clean the stem seat and stop the leak. After closing the valve, remove the outlet cap and check for leaks. If the leak will not stop, put the outlet cap back on and notify the chlorine supplier.

When the packing gland is the source of the leak, first close the valve and then tighten the packing nut. If it still leaks, make sure the valve is closed and retighten the packing gland. Care must be taken when tightening the packing gland. Over tightening may bind the valve or strip the threads preventing the packing gland from closing or opening. Testing for leakage must be repeated after every attempt to stop the leak. Fifty foot-pounds of torque should stop most leaks.

If the source of the leak is at the valve threads, use a crowfoot wrench from the appropriate Chlorine Institute Emergency Kit to tighten the valve into the container. Care should be taken to avoid stripping the threads. Do not tighten the valve if its integrity is in question. Application of other suitable devices from kits to cap leaks or use of a cylinder containment vessel may be necessary.

4.3.3 Piping Systems

If a leak is found in the piping system, the chlorine supply to that section of piping must be shut off, the pressure relieved, and the system purged of all chlorine before the necessary repairs are made. The system must be purged with a dry, nonreactive gas before any welding is done. Welding should comply with all applicable codes. **WARNING: Never weld on or to any chlorine container.** Refer to CI Pamphlet 6 for additional information.

4.4 GENERAL STORAGE CONSIDERATIONS

Chlorine may be stored safely indoors. If stored outdoors, shading from direct sunlight in warm climates is recommended. Containers should not be stored where they can be dropped, where heavy objects can fall on them, or where vehicles can strike them. They should not be stored near elevators, heating, ventilating, or air conditioning systems because dangerous concentrations of gas may spread rapidly if a leak occurs. Easy access to containers is important in the event of a leak. Below ground storage must be avoided because chlorine vapors are heavier than air and will not readily dissipate from low areas in the event of a leak.

The chlorine storage area must be posted properly with signs in accordance with local codes and state and federal laws and regulations. Access to storage areas by unauthorized personnel should be restricted.

4.4.1 Indoor Storage and Construction

Local fire and building codes may dictate the legal requirements for buildings used to store chlorine. Consult with the local government to determine which code is in effect in the community where the plant is located and review the code. Any building that will house chlorine containers or equipment should be designed and constructed to protect all elements of the chlorine system from fire hazards. Fire-resistant construction is recommended. Chlorine containers should be segregated from flammable and oxidizing materials and from materials such as ammonia, sulfur dioxide, hydrocarbons, certain refrigerants, and other materials that are reactive with chlorine. Chlorine cylinders should be segregated from other compressed or liquefied gases. However, if flammable materials are stored or processed in the same building, a fire wall that meets the applicable fire and building code standards should be in place.

4.4.2 Outdoor Storage

Local fire codes and building codes as well as intended use may dictate the legal requirements for the outside storage of chlorine. Consult with the local government to determine which code and code year are in effect in the community where the plant is located and review the code. An outdoor storage area should be clear of trash and debris so as not to present a fire hazard. In general, it is recommended that overhead shading from the sun be provided in warm climates. Containers must not be stored in standing water.

4.4.3 Gas Detection Equipment

Installations, manned or unmanned, where chlorine is stored or used should have gas detection equipment to monitor for chlorine releases. Chlorine detectors must be designed and adequately maintained to warn personnel or to signal a remote, manned location in case of a leak. Proper maintenance includes a written plan for a regular calibration of the monitoring equipment, including written documentation of periodic testing.

4.4.4 Storage with Other Chemicals

Chlorine containers should be segregated from flammable and oxidizing materials and from materials such as ammonia, sulfur dioxide, hydrocarbons, certain refrigerants, and other materials that are reactive with chlorine. Chlorine cylinders should be segregated from other compressed or liquefied gases.

5. PIPING/FEED SYSTEMS

5.1 BASIC SYSTEMS

All chlorine is shipped and stored in pressure vessels as a liquefied gas under pressure, resulting in the presence of both liquid and gas phases in the containers. Cylinders used at pools should always feed chlorine as a gas.

The removal of gaseous chlorine from a cylinder is usually controlled by the use of a vacuum-operated, gas feed chlorinator. A chlorinator is a piece of equipment used to feed chlorine gas into water. The vacuum is produced by a water-operated venturi that mixes the chlorine with the water and produces a high-strength chlorine solution. This solution is piped and diffused into the water or wastewater to provide the required chlorine dosage.

There are a few major areas of concern for the operation of a gas chlorinator, including the cleanliness of the chlorine supplied and the safety of the piping system. The quality of the chlorine is important because the chlorinator feeding the gas has small orifices and fine control valves that can be clogged or plugged. The operator should make every effort to ensure that the entire chlorine delivery system is as clean as possible. A chlorinator has a filter at the inlet of the unit that requires periodic inspection and replacement to maintain system integrity. The appearance of a film on the gas metering tube is usually an indication of a problem. If the film is reddish in color, the piping system from the chlorine container to the chlorinator or the container may contain ferric chloride. This substance forms when moisture reacts with chlorine inside of a steel piping system.

5.2 PIPING SYSTEMS FOR DRY CHLORINE

Most current chlorinator installations use container-mounted vacuum regulators for feeding chlorine into the system. This method is generally the safest and most trouble-free from an operating point of view. The gas chlorinator is designed to operate only with chlorine gas. The presence of any liquid chlorine, including droplets, will eventually damage the chlorinator and could cause serious safety problems. However, when the chlorine cylinders discharge into a pressure system, additional concerns arise. At installations with pressure piping, the piping must be examined to ensure that the chlorine can be maintained in the gaseous state. Note the following recommendations:

1. The container storage room and pressure piping manifold should be kept at a temperature that will allow the feed rates desired.

2. All gas piping under pressure must be protected from cold drafts (windows, doors, cellars, etc.) that can cause reliquification, because any liquid chlorine formed will be carried by the gas stream to the chlorinator.

3. Facilities may need to consider low-level heat tracing for gas pressure piping made of steel. This may be needed to maintain the temperature above the reliquification point. Do not apply heat to a liquid chlorine line.

4. The addition of drip legs at points of pipeline direction change may be required. The drip legs, equipped with small pad heaters, can aid in the removal of any liquid carryover.

5. Pressure reduction by the use of a pressure-reducing valve will help prevent reliquification in the pressure line. A vacuum regulator may be directly connected to a cylinder minimizing the number of pressurized connections. This will allow the system to be operated under a vacuum. When containers are connected to a common manifold to achieve a higher feed rate, the vacuum regulator or pressure reducing valve may be mounted on the end of the manifold.

6. Slope the gas pressure line downward from the feed equipment toward the chlorine container.

7. Examine the flexible copper connectors (pigtails) periodically. If a noise is heard when the tubing is flexed, there may be internal corrosion and the tubing should be replaced. Flexible connectors should be replaced at least annually.

8. Check for external corrosion of equipment (valves, piping, fittings, etc.), which may be an indication of internal corrosion.

This section provides basic information about dry chlorine liquid or gas piping systems. For details, consult CI Pamphlet 6.

5.2.1 Metallic Piping

Dry chlorine is either gaseous or liquefied elemental chlorine with very low water content. All chlorine commercially available in cylinders, is shipped as dry chlorine.

In general, ASTM A106 Grade B Schedule 80 seamless carbon steel piping is used when the process temperature range is -20°F to 300°F (-29°C to 149°C). Threaded or socket-welded construction can be used for pipe diameters of 1½ inches or less. Butt-welded and flanged joints can be used for all sizes of piping. Consult all applicable fire and building codes regarding the use of welded or flanged joints.

Certain metal piping materials, including titanium, aluminum, gold, and tin, MUST NOT be used with dry chlorine. Stainless steels are subject to chloride stress corrosion and should not be used in chlorine service. Even metals considered compatible with chlorine should never be heated when exposed to or containing chlorine. Many of these metals can burn in a chlorine atmosphere, releasing heat and metal chloride gases. (**NOTE**: iron and steel ignite with chlorine at about 483°F [226°C]). In addition, the corrosion rate of steel in a chlorine atmosphere increases significantly at temperatures above 250°F (121°C).

Piping systems must be thoroughly cleaned and dried before use (See CI Pamphlet 6).

Information on fittings, flanges, valves, nuts, bolts, flexible connectors, pipe dope, and other fittings used in pressure piping can be found in CI Pamphlet 6. Lead and asbestos gaskets have been used. Further information on acceptable gasket materials is in CI Pamphlet 95. Refer to CI Pamphlet 164 for materials compatibility.

5.2.2 Nonmetallic Piping Systems

Plastic piping must never be used to transport liquid chlorine at swimming pools. Plastic piping is used only under specific conditions for gaseous chlorine and chlorine/water solutions after chlorine is injected from the chlorinator, or when the possibility exists for moisture to enter a system as in a gas chlorinator operation. Swimming pools use plastic piping primarily for the vacuum piping between the vacuum regulator and the ejector (injector) or for chlorine/water solution lines from the injector to the feed point. Where structural considerations are of concern, plastic-lined steel pipe may be required. Unlined steel cannot be used in a chlorine solution line.

Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), acrylonitrile-butadiene styrene (ABS), fiberglass-reinforced polyester (FRP), and polyethylene (PE) piping can be used under certain conditions (CI Pamphlet 6). Piping made of these materials is restricted to handling gaseous chlorine under vacuum or pressures up to 6 psig (41 kPa) maximum pressure. Plastic piping can become brittle in chlorine service and has a limited service life. Periodic inspection and replacement is recommended.

Most fluorocarbon plastic piping is also suitable for use with gaseous chlorine, but it should be used only under the same conditions as for other types of plastic pipes. Suitable fluorocarbon plastics include polytetrafluoroethylene (PTFE), perfluoroalkoxy (PFA), polyvinylidene fluoride (PVDF), and ethylene chlorotrifluoroethylene.

5.3 VACUUM SYSTEMS

Vacuum chlorinator systems operate under a vacuum that is created by water passing through a venturi. Many of the chlorinators that mount directly to cylinder valves are designed to close and stop the release of chlorine if vacuum is lost. This design can be a significant safety feature since any loss of vacuum, including a piping leak, will shut off the gas flow.

5.4 TESTING CHLORINE FEED SYSTEMS

Chlorine systems require an extensive initial test before being placed in service, as well as periodic pressure testing throughout their service life. Vaporizers and chlorinators should be tested according to their manufacturers' recommendations. Piping systems should be tested according to the recommendations in CI Pamphlet 6. Flexible hoses, connectors, or pigtails should be visually inspected, pressure tested, and replaced according to the manufacturers' recommendations. Periodic inspection should be part of a preventive plant maintenance program. Replacement of flexible connectors is recommended annually as a minimum.

5.5 AUTOMATIC CONTAINER SHUT-OFF

The use of automatic shut-off devices should be considered. These include actuators that close the container valves as well as separate valves adjacent to or near the container valves. They can be operated both remotely and by the use of pressure-sensing switches or chlorine detectors. Such devices exist for all types of North American containers.

5.6 ROLE OF THE CHLORINE SUPPLIER

The supplier of chlorine should help with understanding the safe operation, service, and maintenance of chlorine cylinders and valves. The equipment supplier or the chemical supplier may often be a pool operator's first contact when assistance is needed.

6. CONNECTING AND FEEDING CHLORINE TO THE SYSTEM

6.1 TYPES OF CONNECTIONS

Cylinders discharge gas when upright. When connected to the feed system, the cylinder must be secured to prevent movement or falling. The use of load cells or scales is recommended to monitor the contents of the container when feeding chlorine.

The container outlet valve is supplied with a valve cap. When the valve cap is removed, plant personnel should inspect the outlet and remove any foreign material before placing it in service.

A yoke and adaptor for use with CGA Connection 820 or 820C (either open or closed yoke) is the standard connection to the cylinder valve outlet (See Figure 3). A gasket on the face of the valve is part of the connection, and a new gasket must be used each time a connection is made. The CGA Connection 660, which utilizes a threaded union that threads to the valve outlet, is not recommended for connecting to the cylinder valve.

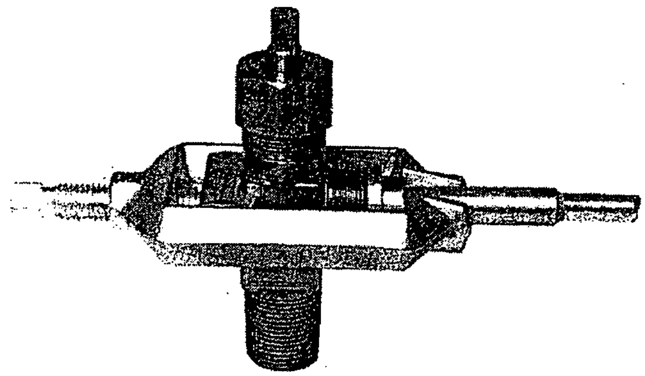

Figure 3
Yoke & Adapter-Type Connection

Valve outlet threads are not standard tapered pipe threads and, therefore, are not suitable for use with standard pipe fittings.

A flexible connection should be used between the cylinder and piping system. Annealed copper tubing suitable for brazing is recommended. ASTM Specification B-88 is recommended provided the material furnished is of the proper dimensions. As an alternative, certain types of nonmetallic and metallic hoses are acceptable. The connection should be regularly inspected and replaced when deterioration is evident. It is very important to follow the recommendations on flexible hoses found in CI Pamphlet 6.

6.2 CONNECTING AND FEEDING CHLORINE FROM CHLORINE CYLINDERS

For vacuum regulators mounted to the cylinders, follow the manufacturer's procedures for connecting and disconnecting to the system. Otherwise, proceed according to the following:

6.2.1 Cylinders Feeding Gaseous Chlorine

The cylinder must be secured properly. When connecting to the cylinder valve, the following precautions should be taken:

- Wear or equip yourself with the proper personal protective equipment (Section 9.2).
- Remove the valve hood.
- Make certain that the packing nut is at least hand tight; if it is not, contact your supplier for advice.

- Make certain that the valve is closed before removing the outlet cap.
- Remove the valve outlet cap.
- Make certain the valve face is clean and smooth.
- Use a new appropriate ring gasket to connect the yoke and the yoke adaptor to the valve. **Never reuse gaskets**.
- Tighten the yoke to make a seal, but do not over tighten.

6.2.2 Valve Operation/Feeding Chlorine

- Using a wrench (50 foot-pounds maximum torque) no longer than 8 inches, open the container valve to briefly introduce chlorine into the system and then close the valve. **Never use an extension (cheater) bar on the wrench**.
- Using only vapor from a 26° Baumé or greater, aqua ammonia (ammonium hydroxide) solution (Section 4.3.1), test the yoke adaptor interface and the packing gland area for leaks. If any leaks are found, they must be remedied before proceeding (Section 4.3.2). Repeat this step if a leak was found.
- Using a wrench no longer than 8 inches, open the valve one complete turn. This is all that is required to achieve maximum continuous gas flow rates.
- Open the appropriate valves in the piping system.
- Check again for leaks using only the vapors from an ammonia solution.

6.2.3 Disconnecting Cylinders

Extreme caution must be exercised when disconnecting cylinders that are not empty (If systems are equipped with automatic switch-over vacuum regulators, consult the manufacturer's literature for connection and disconnection procedures). This is especially critical in systems feeding liquid chlorine. Proceed with care as follows:

- Wear or equip yourself with the proper personal protection equipment (Section 9.2).
- Using a torque wrench, close the cylinder valve to a torque of 25 to 30 foot-pounds.
- Let the pressure in the system drop to zero psig by using the gas feed equipment to consume any residual chlorine, and apply a vacuum as appropriate for your systems design. When gauges indicate zero psig or a vacuum, the appropriate piping system valve can be closed.
- If any leaks exist (the pressure increases in the line by the cylinder), increase the torque to 40 foot-pounds and retest for leaks. If the leak persists, use a maximum of 50 foot-pounds of torque on the stem and repeat the above procedure.
- If the valve still leaks at 50 foot-pounds, contact your supplier for advice.
- If the pressure in the line connected to the cylinder remains constant at or below zero psig, the yoke can be loosened and disconnected.

- Verify that an outlet gasket is in place and replace the valve outlet cap.
- Protect the yoke adaptor and chlorine line from the intrusion of moisture and moist air.
- Place a valve hood on the cylinder as appropriate and mark as empty.
- Place the cylinder in an appropriate location for empty containers.

6.3 VAPOR PRESSURE/TEMPERATURE RELATIONSHIP

The vapor pressure of chlorine increases significantly as the temperature rises. Consequently, chlorine flow rates also can vary greatly depending on the temperature of the liquid chlorine.

It is possible that at very low temperatures a pressure gauge might read zero psig and indicate that a chlorine vessel is empty when, in fact, the chlorine vapor pressure is low due to the low temperature of the residual liquid chlorine in the container. A similar situation can occur if chlorine gas is withdrawn too quickly from cylinders.

The remaining liquid chlorine can be cooled by the evaporating gas and result in reduced vapor pressure.

6.4 CYLINDER FEED RATES

Chlorinator manufacturers use the approximation that cylinders of chlorine can be unloaded as a gas to a vacuum system at a continuous rate of 1 to 1.5 lb/day/°F of ambient temperature. For example, a vacuum system at 70°F (21°C) ambient temperature can achieve a feed rate of 70 to 105 lb (32 to 48 Kg) per 24 hours.

Higher rates can be achieved for short periods of time, but the rate decreases as the vaporization cools the remaining liquid chlorine.

7. BUILDING/STRUCTURE CONCERNS

7.1 DESIGN AND CONSTRUCTION

Local fire and building codes may dictate the legal requirements for buildings or other structures used to store or feed chlorine. Consultation with local government officials to determine what code and code year applies is essential. Buildings in which chlorine is stored should be made of noncombustible materials and should be free of flammable materials. Any building housing chlorine equipment or containers should be designed and constructed to protect all elements of the chlorine system from fire hazards. If flammable materials are stored or processed in the same building, a fire wall should be erected to separate the chlorine from the flammables. Fire-resistant construction is recommended.

7.2 ELECTRICAL SYSTEMS

Chlorine is not classified as a flammable gas; therefore, no special code requirements exist with regard to electrical systems. However, chlorine gas is extremely corrosive and, in the event of a leak, the electrical system at a chlorine use site could be damaged by corrosion.

7.3 VENTILATION AND AIR OPENINGS

7.3.1 Ventilation

The Institute recommends that ventilation requirements be determined on a site-specific basis. Fire or building codes may dictate the minimum acceptable ventilation rate.

Safeguards should be in place to ensure that personnel without the appropriate personal protective equipment do not enter or remain in buildings where chlorine is present due to a leak or equipment failures (See CI Pamphlet 65).

7.3.2 Air Openings

Chlorine gas is heavier than air and will collect at floor level. The exhaust air intake should be located at or near floor level. The exhaust air discharge should be at a safe location. An elevated fresh-air inlet must be provided and should be positioned for adequate cross ventilation. Multiple fresh-air inlets and fans may be necessary to facilitate adequate ventilation. Fans, if used, should be operable from a safe remote location.

7.4 HEATING

Rooms in which chlorine cylinders are stored should be maintained at a normal indoor temperature of 60° to 70°F (15° to 20°C) to facilitate gas discharge rates from the containers. The chlorination equipment should be housed in a room at the same or higher temperature. However, the temperature in chlorine use and storage areas must never exceed 130°F (54°C). Never apply heat directly to a chlorine cylinder.

7.5 ABSORPTION AND AUTOMATIC SHUT-OFF SYSTEMS

Local fire and building codes should be consulted to determine if scrubber systems are required. Scrubbers are devices that remove chlorine from the air, and they are effective for controlling chlorine releases. However, CI Emergency Kit A or cylinder containment vessels and trained responders to stop or contain chlorine leaks are adequate for most locations (Sections 3, 4.3, and 10). Any requirements for scrubbers should be based on a risk assessment that considers the quantity of chlorine on site and the proximity to and potential impact on nearby populations and facilities.

Automatic actuators or valves can be located on or next to the cylinder valve and can be activated by a chlorine detector or even by a remote switch. There also are automatic closure devices that fit over the actual cylinder valves to close them if activated by a chlorine detector or a remotely located switch. Automatic closure devices are now cited in ICC and NFPA Fire and Building Codes.

7.6 SPRINKLER SYSTEMS

The Chlorine Institute does not recommend sprinklers for chlorine storage or use areas that are constructed of noncombustible materials and that are always free of flammable materials. However, some fire and building codes may still require them. If sprinklers are installed, they should be used only to suppress fires or to cool containers threatened by fire. Sprinklers are not effective in mitigating a chlorine leak or in serving as scrubbers. The presence of water (moisture) and chlorine can cause corrosion and exacerbate a leak.

7.7 EXITS AND WINDOWS

Exits should be clearly marked. All exit doors should open outward to the outdoors and should be equipped with anti-panic hardware that allows for easy opening. Internal exit doors are not recommended. The room should contain at least one window so the interior can be viewed without entering the building. All windows should be made of fire-resistant, non-shattering material. Local fire and building codes also should be reviewed.

7.8 GAS DETECTION

Installations using or storing chlorine should have gas detection equipment in place to monitor for chlorine releases. Such equipment is particularly important when the pool site is not staffed twenty-four hours a day. Chlorine detectors must be designed and adequately maintained to warn on-site personnel or to alert responders at a remote location of a release.

If the monitors are being used for leak detection as opposed to monitoring for OSHA exposure limits (CI Pamphlets 1 or 65), different alarm settings may be required. Pertinent information should be available from the manufacturer of the detection equipment (See CI Pamphlet 73).

8. SECURITY

Chlorine facilities should be protected against accidental or unauthorized entry. The vulnerability of each facility must be evaluated to determine the amount of security needed. The decision on the type of security will depend on factors such as location, proximity to other buildings, local codes, and so on. Buildings or areas should be surrounded by a fence, warning signs should be posted, and gates and doors should be locked. Access should be completely restricted and only personnel involved with the handling of the chlorine should be able to enter this area (See CI Security Management Plan for the Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks, August 15, 2003).

Chemical security regulations are currently under development; check with the Department of Homeland Security and other federal, state, or local agencies for applicability to your facility.

9. EMPLOYEE TRAINING, SAFETY, AND PERSONAL PROTECTION EQUIPMENT

9.1 TRAINING

9.1.1 General

To a great extent, safety in handling chlorine depends on the effectiveness of employee training, proper safety instructions, and the use of suitable equipment. It is the responsibility of the employer to train employees, to document such training as appropriate and to ensure such training and documentation is in compliance with the regulations (See CI Pamphlet 85).

It is the responsibility of employees to carry out correct operating procedures safely and to properly use the safety equipment provided. The Chlorine Institute maintains numerous publications and other materials to aid end users in the development of meaningful training programs. See the Chlorine Institute Catalog for a complete listing.

OSHA regulations define the training requirements for emergency response personnel. The regulation identifies several training levels according to the emergency response task, each having minimum training requirements (See 29 CFR 1910.120, and Section 10.3.3).

In addition to the OSHA training, at a minimum, employee training should include the following subjects:

- Chlorine properties (Sections 2.2 and 2.3);
- Health hazards (Section 2.3.3);
- Chlorine containers (Section 3);
- Basics of transporting, storing, and handling of chlorine containers (Section 4);
- Connecting, disconnecting, and feeding from chlorine containers (Section 6);
- Chlorine leaks (Section 4.3); and
- First aid (Section 12).

9.1.2 Supplier Support

Suppliers of both chemicals and equipment can be valuable sources of information. They frequently have handling guides, training programs, and a selection of safety videos available for their customers to use. Consult the individual manufacturer or distributor. Similar information is available through various associations and national organizations (See Section 17).

9.1.3 Material Safety Data Sheets and Other Literature

Suppliers are responsible for providing material safety data sheets (MSDS) that contain a detailed assessment of chemical characteristics, hazards, and other information relative to health, safety, and the environment. These sheets provide the following information:

- Identification of chemical composition, Chemical Abstract Service number, formula, molecular weight, and synonyms;
- Physical data on boiling, freezing, and melting points, specific gravity, solubility, and vapor pressure;
- Reactivity information such as incompatibility, decomposition products, and polymerization potential;
- Health hazard data on effects of exposure (acute and chronic), permissible exposure limits, and warning signals;
- Environmental impact potential, such as effects on the environment, and pertinent federal regulations including those involving shipping;
- Exposure control methods, such as personal protective measures and engineering and administrative controls;
- Work practices, such as handling and storage procedures, normal cleanup, and waste disposal methods; and
- Emergency procedures for handling spills, fires, and explosions, as well as first-aid procedures.

Such basic vital information must be readily accessible to all employees as a reference source.

9.1.4 Emergency Assistance

Some chlorine suppliers have technical expertise and equipment that can be made available to a customer during an emergency. The availability of such emergency assistance should be ascertained during your initial planning.

9.1.5 Other Training Information Sources

The Chlorine Institute maintains training materials and other publications that may be found in the Chlorine Institute Catalog (See Section 13).

9.2 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY

9.2.1 General Recommendations

Employees with respiratory diseases or reduced respiratory capacity should avoid working in situations where chlorine exposure is possible. Chlorine users should adopt a medical surveillance program suitable to their needs (See CI Pamphlet 63).

9.2.2 Clothing

In the general areas of a pool site or in buildings where chlorine is stored or used, no specialized clothing is required for workers performing routine operations. However, long pants, shirts with sleeves, safety glasses with side shields or goggles approved for use with hazardous chemicals, hard hats, and safety shoes should be worn or be available as dictated by the site's practice. They should be free of oil and grease (See CI Pamphlet 65).

9.2.3 Respiratory Protection

All personnel entering areas where chlorine is stored or handled should carry or have immediately available an escape-type respirator. Chemical cartridge or full-face canister gas masks offer adequate temporary protection provided the oxygen content in the air is greater than 19.5% and the chlorine concentration does not exceed the rated capacity of the respirator. The need to protect the eyes from chlorine should be part of the evaluation of appropriate respiratory equipment, since some types of respirators also protect the eyes and additional protection is not needed if these are used.

Self-contained breathing apparatus (SCBA), with full face piece, is required for performing tasks when chlorine may be present unless air sampling verifies the chlorine concentration is such that a lower level of respiratory protection is adequate. Emergency responders must have regularly scheduled and documented training to assure competency with SCBA. This SCBA apparatus should be located on site or at acceptable locations. If arrangements have been made to use an approved outside emergency response group, then the responders and apparatus may be located off site.

Fit testing and regular maintenance programs for respirator equipment are required and must be documented (29 CFR 1910.134(f) and Appendix A, (h) and (m)) (See CI Pamphlet 65).

9.2.4 Specific Recommendations

This section addresses only the need for PPE in connection with initial line breaks and the routine operations of connecting, feeding, and disconnecting containers performed by swimming pool personnel. Emergency response operations are covered in Section 10.

These recommendations should supplement the pool sites:

- Written operating and maintenance procedures;
- Emergency response plan; and
- Established programs for training employees.

It is also assumed that the pool site has performed a detailed job safety analysis of the specific task being performed. If such an analysis concludes that a lower level of PPE is required for the employee(s) performing the operations, such lower-level PPE must be fully compatible with these recommendations.

9.2.5 Initial Line Break

A line break is defined as the opening of a line, section of a line, a vessel, or other equipment that contains or previously contained chlorine and includes equipment that was returned to chlorine service and is reopened to the atmosphere. An initial line break is considered a maintenance activity and does not include the act of connecting or disconnecting containers for loading and/or unloading purposes or material sampling activities.

For line breaks that have been routinely performed in the past, and have demonstrated that the evacuation techniques and maintenance procedures utilized do not result in chlorine concentrations that exceed either the OSHA ceiling limit or the safety rating of the respirator, then use a full-face air purifying respirator (See CI Pamphlet 65).

9.2.6 Feeding Chlorine

The following recommendations assume that the pool site has a system for purging and evacuating the pipeline and hoses used for feeding chlorine. If your connecting, feeding and disconnecting procedure has been undertaken periodically in the past and industrial hygiene sampling results indicate that the techniques being used will result in chlorine concentrations not exceeding the TWA level of 0.5 ppm and the STEL ceiling limit of 1 ppm, no specialized PPE is needed.

If your connecting, feeding and disconnecting procedures have been found to result in chlorine concentrations exceeding the TWA level of 0.5 ppm or the STEL ceiling limit of 1 ppm but not more than the capability of the respirator being used, the use of a full-face air purifying respirator is recommended.

If testing or evaluation work has not been undertaken, or if such testing was done and indicated that chlorine levels exceeded the rated capacity of air purifying respirators, the use of SCBA or a full-face air line respirator is recommended.

9.3 OTHER SAFETY EQUIPMENT

An emergency eyewash and a deluge shower should be located near the potential exposure site but not so close as to be unusable in an emergency. The path to the unit must remain clear of all obstructions. There are OSHA standards that define eyewash/safety shower parameters, i.e., flow rates and temperature along with other considerations such as protection against freezing (29 CFR 1910.151(c)).

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10. HANDLING EMERGENCIES

10.1 PLANNING

The presence and use of chlorine can be a potential hazard to both pool site employees and the surrounding community. In recognition of this potential, federal law and many state laws require that written emergency plans be developed to prevent and mitigate a chlorine release and to guide response. There are at least two planning efforts required for each pool site: one that addresses protecting the community from a chlorine release and one for protecting employees.

Before an emergency plan is written, a risk assessment for the pool site is recommended. Risk assessment is the process of collecting and analyzing information in order to determine what chemical hazards and process risks are present at a pool site that could impact employees or the public. Sites with more than 1,500 lb of chlorine in a single process are required to do a risk assessment under PSM regulations issued by OSHA in Section 1910.119 of 29 CFR. The EPA requires an RMP for sites where chlorine exceeds 2,500 lb in a single process, as given in 40 CFR 68.

At the time this document was published, there were two generic RMPs involving chlorine that could provide information useful in preparing plans suited to specific facilities. One, designed for treatment plants, was prepared by the EPA and the research foundation of the AWWA. The other, available from the Chlorine Institute (CI Pamphlet 162), applies to chlorine packaging plants and sodium hypochlorite manufacturers.

RMP planning must include consideration for monitoring, detection, and alarm equipment. Selection of the appropriate emergency personnel, assignment of responsibilities, quantity release estimate, mutual assistance (supplier, hazardous materials [HAZMAT] teams, fire departments, etc.), necessary notification requirements (on- site and off site), decision making, first-aid needs, and containment should be covered in a set of procedures included in the written plan.

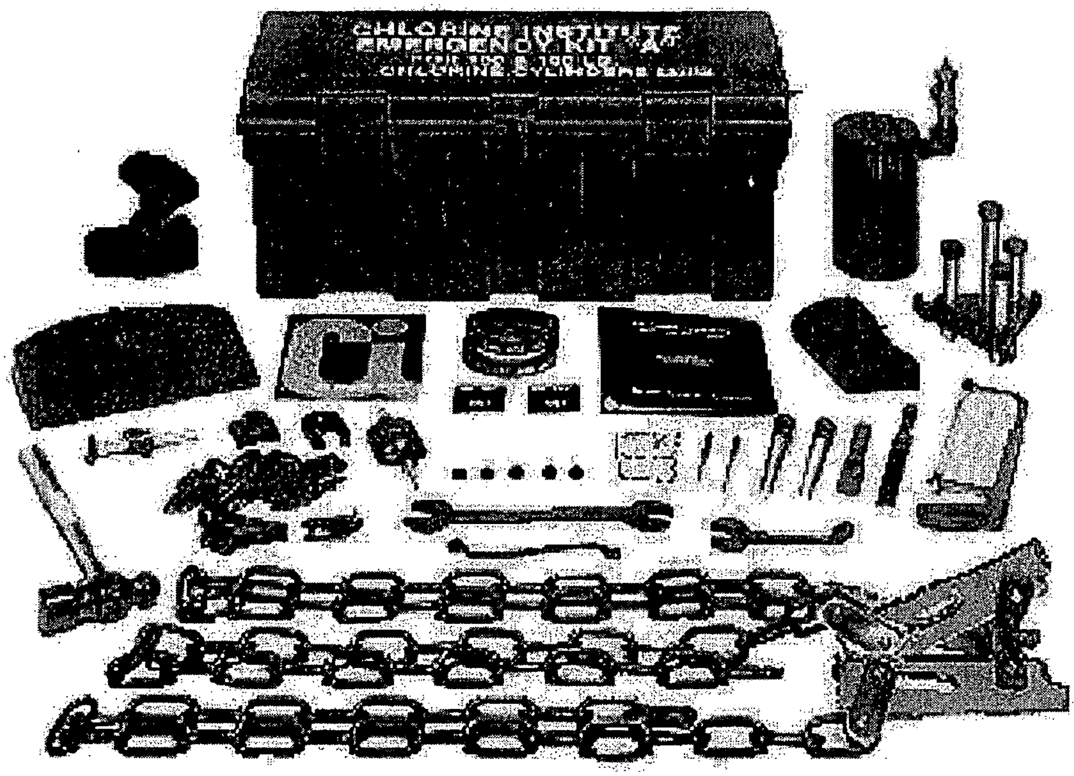

Figure 4
Chlorine Institute Emergency Kit "A" for Chlorine Cylinders

Additional planning considerations should include the technical expertise, scientific instrumentation, and transportation vehicles that may be needed during an emergency. An inventory of locally available items should be accessible to responders. Likewise, the locations of emergency kits or containment vessels for cylinders should be known. The availability of emergency breathing apparatus, showers, and eye-wash stations and their locations should also be known.

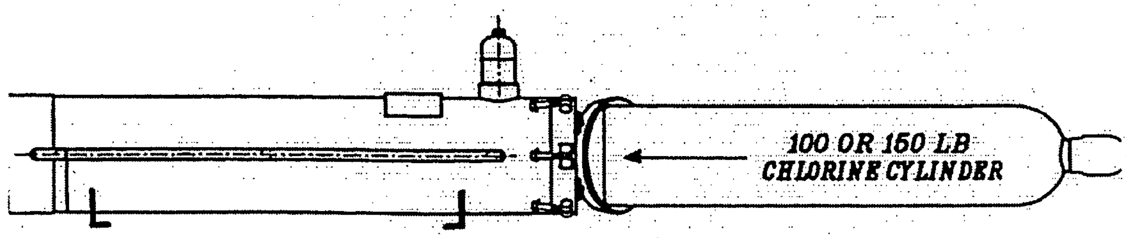

Figure 5
Cylinder Recovery Vessel

10.2 ESTABLISHING PROCEDURES

Emergency response procedures are concerned with the efforts of employees from outside the immediate release area or by other designated responders in dealing with an occurrence that 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 the employees in the immediate release area or by maintenance personnel are not considered to be emergency responses (29 CFR 1910.120).

The procedures established should outline the proper coordination and communication between swimming pool personnel, pool management, and outside agencies. Community response personnel must include fire department, police department, emergency medical personnel, and HAZMAT teams at the least. State or local regulations may have additional requirements.

Each pool site should develop its own emergency action checklist, which should be readily available for the pool site's personnel to aid in response. Table 5 lists typical key actions that are to be taken in the event of a chlorine emergency. It should be considered as a guide to aid the pool operator. More detailed assistance is available from OSHA, EPA, and state regulatory agencies.

Assistance and information during the planning process is available from your chlorine suppliers and from CI Pamphlet 64. In an emergency situation, responders should be called in the order dictated in your ERP. These may include the fire service, your chlorine supplier, or another local emergency response team. If you cannot obtain assistance during an emergency, you can contact CHEMTREC by calling the toll-free number on your shipping papers. CHEMTREC is designed to assist in transportation emergencies and should be used only as a last resort for assistance.

Table 5. Typical Steps for an Emergency Action Checklist

Action
(Where appropriate, responsible personnel should be assigned these steps in advance.)

Alert key personnel.

Activate emergency response team if on site.

Determine seriousness of situation.

Ensure that employees and guests are located in a safe area and protected, and that all are accounted for.

Alert appropriate off-site authorities.

Ensure that anyone who may have been exposed receive medical surveillance and treatment if necessary.

Attempt to stop or control release.

Obtain outside assistance:
Local Emergency Response Team
Supplier or CHLOREP via CHEMTREC Continental U.S.: 1- 800-424-9300
Alaska, Hawaii, D.C.: 1- 703-527-3887
Canada: Call collect - 1- 613-996-6666

Bring the incident under control.

Determine when normal operations can resume.

Provide close-out report of incident.

10.3 TRAINING

10.3.1 Materials and Sources

Training programs and materials are available from a variety of sources, including chlorine suppliers, state and local government agencies, and organizations such as the CI, AWWA, WEF, and NFPA. The best starting point for identifying training resources is the LEPC for your area (contact your state Emergency Response Commission for LEPC information) as well as your supplier.

10.3.2 Pool Site Personnel

Pool employees should be trained in the emergency response plan, in safety procedures for the handling and use of chlorine gas, and in the use of self-contained breathing apparatus and other applicable equipment. The training requirements depend on the specific employee's roles and responsibilities. Each pool site should have a training program customized to its specific needs depending on the type of facility, type and number of chlorine containers, and number of employees. The site should keep written documentation of all training.

10.3.3 Emergency Responders

Emergency responder training requirements are based on the response level and type of job responsibility assigned to each responder. It is beyond the scope of this pamphlet to provide the details of a training program for emergency responders. Actual training requirements for each level of responder are given in 29 CFR 1910.120. Because these regulations change, you should review 29 CFR periodically.

10.4 AUDITS AND EXERCISES

An effective way to determine the adequacy of an emergency plan is to have periodic audits and exercises. Audits should be performed with various response personnel to test their knowledge of duties and equipment, along with periodic auditing on actual use of the equipment. Exercises should be conducted to test the participants' reactions and effectiveness in implementing the emergency plan as well as to test the actual mechanics of the plan.

There are basically three types of exercises: the full-scale exercise, the on-site exercise, and the table-top exercise. Consideration should be given to conducting full-scale exercises utilizing responders from the community at least once a year. Periodic on-site exercises should use different simulated events and involve as many of the various personnel as possible. These exercises should be conducted similarly to full-scale exercises but would not involve outside emergency personnel. Table-top exercises should be conducted periodically to check the ability of the emergency response crews to analyze an event, communicate effectively to outside emergency response personnel, and respond to unfolding events. This type of exercise is usually conducted with just the supervisors of key emergency response personnel, both on-site and from outside agencies.

Following any of the exercises, a critique should be made to assess the effectiveness of the plan and to pinpoint any weaknesses in it or in the training and knowledge level of the personnel involved. A written report of the exercise should be available for review and the pool site's emergency plan should be modified as needed.

11. MEDICAL ASPECTS

11.1 HAZARDS TO HEALTH

11.1.1 General

Chlorine gas is primarily a respiratory irritant. At low concentrations chlorine gas has an odor similar to household bleach. As the concentrations increase from the level of detection by smell, so do the symptoms in the exposed individual. At chlorine concentrations above 5 ppm 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. If the symptoms persist for more than a few hours, the effects of exposure to chlorine may become more severe for several days after the incident. In such cases, observation of exposed individuals should be a part of the medical response program. See CI Pamphlet 63 for more detailed information.

The following list is a compilation of chlorine exposure thresholds and reported responses in humans (with considerable variation among subjects):

Table 6. Chlorine Exposure Thresholds and Reported Responses

0.2 – 0.4	Odor threshold (decrease in odor perception occurs over time)
1 – 3 ppm	Mild mucous membrane irritation, tolerated up to 1 hour
5 – 15 ppm	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
30 ppm	Immediate chest pain, vomiting, dyspnea, cough
40 – 60 ppm	Toxic pneumonitis and pulmonary edema
430 ppm	Lethal over 30 minutes
1000 ppm	Fatal within a few minutes.

11.2 ACUTE TOXICITY

11.2.1 Respiratory/Cardiovascular

The toxic effects of chlorine are due to its corrosive properties. Chlorine is water soluble and primarily removed by the upper airways. As indicated above, exposure to low concentrations of chlorine gas may cause nasal irritation as well as irritation of the mucous membranes of the respiratory tract. As concentrations increase, there is an increase in the irritating effect on the upper and lower respiratory tract manifested as coughing with eventual difficulty in breathing. Inhalation of chlorine gas (>15 ppm) may lead to respiratory distress associated with airway constriction and accumulation of fluid in the lungs (pulmonary edema).

As the duration of exposure and/or the concentration increase, the affected individual may develop the immediate onset of rapid breathing, wheezing, rales, or hemoptysis. In extreme cases difficulty in breathing can progress to the point of death through cardiovascular collapse from respiratory failure. An exposed person with a pre-existing respiratory condition can have an exaggerated response. Cases of Reactive Airways Dysfunction Syndrome (RADS), a chemical irritant-induced type of asthma, have been reported.

11.2.2 Dermal

Liquid chlorine in contact with the skin will cause local chemical or thermal (frostbite) burns. Gaseous chlorine in contact with the skin can dissolve in body moisture (i.e., perspiration) to form hypochlorous and hydrochloric 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.

11.2.3 Eyes

Low concentrations of chlorine in the air can result in eye irritation, associated burning discomfort, spasmodic blinking, redness, conjunctivitis and tearing. Exposure to higher concentrations of gaseous chlorine may result in more serious injuries. Liquid chlorine in contact with the eyes will result in serious thermal and/or chemical burns.

11.3 CHRONIC TOXICITY

Most studies indicate no significant connection between adverse health effects and chronic exposure to low concentrations of chlorine.

11.4 CI HEALTH VIDEO

A health video, outlining the short term health effects is available from The Chlorine Institute (See H-VIDEO or H-DVD).

12. FIRST AID

First aid is the immediate temporary treatment given to an exposed individual. Prompt action is essential. Reassurance to the individual will help to alleviate anxiety. When indicated, medical assistance must be obtained as soon as possible. Never give anything by mouth to an unconscious or convulsing person. If chlorine has saturated an exposed individual's clothes and/or skin, decontamination should be done by removing affected clothing and showering as appropriate (See CI Pamphlet 63 for more detailed information).

Responders should take the necessary precautions to protect themselves from any exposure to chlorine while administering first aid and should move the victim from any contaminated area as quickly as possible.

12.1 INHALATION

An individual with chlorine exposure should be evaluated for adequate airway, breathing and circulation after the inhalation. If breathing has apparently ceased, the victim should be given cardiopulmonary resuscitation (CPR) immediately. If breathing has not ceased, the exposed individual should be placed in a comfortable position. The person should sit in an upright position with the head and trunk elevated to a 45-60 degree position (unless there is a medical contraindication). Slow, deep breathing should be encouraged. Vital signs (respiratory rate, pulse, and blood pressure) and oxygen saturation should be obtained if trained personnel and equipment are available.

Suitable equipment for the administration of oxygen should be available either on site or at a nearby facility. Such equipment should be periodically tested.

Historically, oxygen therapy, specifically humidified oxygen, has been considered the primary treatment for chlorine inhalations. Humidified oxygen is preferred since the humidity soothes the irritation to the mucous membranes caused by the chlorine. Oxygen without the humidity can have a drying effect, thus potentially aggravating the irritant symptoms. However, if humidified oxygen is not available, oxygen without the humidity should not be withheld if oxygen therapy is indicated. With the advance in technology, equipment (pulse oximeter) is now available which can quickly measure the oxygen saturation in an individual. This measurement may be helpful in deciding whether supplemental oxygen is needed after a chlorine inhalation.

Oxygen therapy may not be necessary for all cases of chlorine inhalation. However, in any case in which an individual with a chlorine inhalation continues to be symptomatic after leaving the area of exposure, oxygen therapy is recommended unless it can be determined that it is not needed. **The circumstances in which oxygen therapy is not needed should be defined in advance by a physician, based on the clinical findings and a case by case determination made by first aid providers specifically trained in this area.**

12.1.1 Administration of Oxygen

Oxygen should be administered by first aid providers trained in the use of the specific oxygen equipment under the guidance of a licensed health care professional.

If a pulse oximeter is not available, oxygen therapy is recommended for any individual who has inhaled chlorine and continues to be symptomatic after leaving the area of exposure.

If a pulse oximeter is available, the following findings comprise a base list of situations in which oxygen therapy is generally indicated to be given by first aid providers after a chlorine inhalation. Other criteria may be added to this list if specifically recommended by a physician:

- Sustained pulse-oximetry readings <92%; or
- The individual is in obvious respiratory distress (including, but not limited to rapid respirations, difficulty breathing, using accessory muscles for respiration, continuous uncontrollable coughing, wheezing); or
- The exposed individual is having "symptoms of concern", such as significant chest pain/tightness, extreme weakness, altered/declining mental status, or the individual is diaphoretic (clammy/pale/sweating not due to environmental conditions) etc., especially if these or other significant symptoms occur with an individual with a past history of cardiac problems or asthma; (**NOTE**: "symptoms of concern" generally do not include the typical upper respiratory tract irritation symptoms which occur with mild chlorine gas inhalations such as mild/moderate coughing, initial difficulty "catching one's breath", mild/moderate shortness of breath, irritated throat, runny nose, congestion, headache, and/or mild nausea)

NOTE: It is recommended that a physician be consulted regarding any individual meeting one or more of the above criteria in order to determine whether further evaluation and or treatment is indicated.

If oxygen therapy is indicated, it should be administered until the symptoms resolve. Whenever oxygen is discontinued after symptoms resolve, the individual should then be observed for 30-60 minutes while breathing room air. If significant symptoms do not resolve within 60 minutes of oxygen therapy, or symptoms return/worsen and/or the oxygen saturation (when pulse oximetry is available) falls below 92%, it is recommended that oxygen therapy be restarted (if it had been discontinued) and further evaluation by a physician be provided.

12.1.2 Administration of Humidified Breathing Air

Not all individuals who have inhaled chlorine require oxygen therapy. It is recommended that the circumstances in which oxygen therapy is not needed should be defined in advance by a physician and a case by case determination made by first aid providers specifically trained in this area.

In situations where it has been determined that oxygen therapy is not needed, but the individual with an inhalation exposure has irritant symptoms, humidified air may be provided for symptomatic care. While breathing humidified air, the individual should be closely monitored for 30-60 minutes. If the individual continues to show no signs or symptoms for which oxygen would be indicated, the humidified air can be stopped.

Observation should continue for an additional 30 minutes while the individual is breathing room air so as to insure that there is no deterioration of the individual's condition. Oxygen therapy should be started at any time during the above process if symptoms worsen to the point that oxygen is indicated. Further evaluation by a physician should be provided in any case in which oxygen therapy is provided.

12.1.3 Symptomatic care

Other symptomatic care measures, such as cool compresses to the face and over-the-counter medications, may help to minimize symptoms. Over-the-counter medications which may be helpful include:

- Irritated/sore throat – throat lozenges
- Dry cough – dextromethorphan, guaifenesin
- Headaches – acetaminophen, aspirin, ibuprofen
- Upset stomach – antacids

12.2 <u>CONTACT WITH SKIN</u>

If liquid chlorine has contaminated the skin or clothing, an emergency shower should be used immediately and contaminated clothing should be removed under the shower. Flush contaminated skin with copious amounts of tepid water for 15 minutes or longer. Thermal burns, due to the cold temperature of liquid chlorine, may be more damaging than any chemical reaction of chlorine and the skin. Exposure to gaseous chlorine can irritate the skin. Do not attempt chemical neutralization or apply any salves or ointments to damaged skin. Refer to a qualified health care provider if irritation persists after irrigation or if skin is broken or blistered.

12.3 <u>CONTACT WITH THE EYES</u>

If the eyes have been irritated due to exposure to chlorine, they should be flushed immediately with copious quantities of tepid water for at least 15 minutes.

▸ Never attempt to neutralize with chemicals.

The eyelids should be held apart during this period to ensure contact of water with all accessible tissue of the eyes and lids. Medical assistance must be obtained as soon as possible. If such assistance is not immediately available, eye irrigation should be continued for a second 15-minute period. Nothing but water should be applied unless ordered by a qualified heath care provider.

13. CHLORINE INSTITUTE PUBLICATIONS OF RELATED INTEREST

13.1 PAMPHLETS AND INSTRUCTIONAL BOOKLETS

The reader should refer to the current CI Catalog for a complete list of pamphlets.

Pamphlet #	**Title**
1	Chlorine Basics
6	Piping Systems for Dry Chlorine
17	Packaging Plant Safety and Operational Guidelines
63	First Aid, Medical Management/Surveillance and Occupational Hygiene Monitoring Practices for Chlorine
64	Emergency Response Plans for Chlor-Alkali, Sodium Hypochlorite, and Hydrogen Chloride Facilities
65	Personal Protective Equipment for Chlor-Alkali Chemicals
72	Properties of Chlorine in SI Units
73	Atmospheric Monitoring Equipment for Chlorine
74	Guidance on Complying with EPA Requirements under the Clean Air Act Estimating the Area Affected by a Chlorine Release
76	Guidelines for the Safe Motor Vehicular Transportation of Chlorine Cylinders and Ton Containers
89	Chlorine Scrubbing Systems
95	Gaskets for Chlorine Service
100	Dry Chlorine: Definitions and Analytical Issues
155	Water and Wastewater Operators Chlorine Handbook
164	Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials
IB/A	Instruction Booklet: Chlorine Institute Emergency Kit "A" for 100 and 150 lb Chlorine Cylinders

Free Publications: A number of CI Publications are offered as downloads free of charge. Please refer to the CI website (www.chlorineinstitute.org) for a complete listing.

13.2 DRAWINGS

The reader should refer to the current CI Catalog for a complete list of drawings.

13.3 AUDIO/VISUAL MATERIALS

These materials are available in both English and Spanish (except H-VIDEO) and in both video and DVD format.

Video	**Title**
A-VIDEO	How to Use the Chlorine Institute Emergency Kit "A" for 100 lb and 150 lb Chlorine Cylinders
H-VIDEO	Health Effects from Short-Term Chlorine Exposure
W-VIDEO	Chlorine Safety for Water & Wastewater Operators

14. SARA TITLE III REPORTING REQUIREMENTS

The EPCRA is also known as Title III of SARA of 1986 (42 CFR). Five sections of this act apply to the use of 100 and 150 lb chlorine cylinders at swimming pools. They are summarized as follows:

- Section 302 requires that any facility having on its premises more than 100 lb of chlorine must report this fact to the State Emergency Response Commission. This is a one-time reporting requirement. Other extremely hazardous substances not typically found at pools must also be reported.
- Section 303 requires that any facility that has reported in accordance with section 302 must provide to the local emergency planning committee (LEPC) the name of its facility emergency coordinator who will participate with the LEPC in the emergency planning process. The facility must also provide to the LEPC any information requested for plan development and implementation.
- Section 304 requires that any facility that releases 10 lb or more of chlorine into the environment must immediately report the release to the community emergency coordinator, the state, and the National Response Center. The initial contact of this notification must be followed-up by a written notification to the same parties. The contents of the notification are also stipulated in this section. **Failure to report to the National Response Center (800-424-8802) in a timely manner can result in criminal and civil penalties.**
- Section 311 requires that any facility having 100 lb of chlorine on its premises at any one time must submit an MSDS for chlorine, or a list of the hazardous chemicals, including chlorine, that are on its premises, to the local fire department, the local emergency planning committee, and the State Emergency Response Commission. If an MSDS is submitted, it must be resubmitted whenever there is a significant change in it.
- Section 312 requires that any facility having 100 lb of chlorine on its premises at any one time during a calendar year must prepare and submit, before March 1 of the following year, an Emergency and Hazardous Chemical Inventory Form (either

Tier I or Tier II) to the State Emergency Response Commission, the emergency planning committee, and the local fire department. This is an annual requirement.

For further information on the EPCRA law, contact your local emergency planning committee of the State Emergency Response Commission.

15. RISK MANAGEMENT PROGRAM

You are covered by the RMPR if you operate a stationary source and have more than 2,500 lb of chlorine in a process.

The EPA defines stationary sources as buildings, structures, equipment, installations, or substances emitting stationary activities that belong to the same industrial group, which are located on one or more contiguous properties, which are under the control of the same person (or persons under common control) and from which an accidental release may occur (40 CFR). The term stationary source does not apply to transportation including storage incident to transportation of any regulated substance, but it does include transportation containers used for storage not incident to transportation and transportation containers connected to equipment at a stationary source for loading or unloading.

This issue is not fully resolved because there is some confusion among several government agencies over regulating and enforcement authority. However, it is the intent of the EPA to apply the RMPR to chlorine tank cars and tank trucks unloading or feeding a process at a facility. In addition, the amount of chlorine in transportation vehicles is an important factor in determining worst-case and alternate scenarios and complying with other parts of the Rule.

The EPA defines process to mean any activity involving a regulated substance, including any use, storage, manufacturing, handling, or on-site movement of such substances, or any combination of these activities. Any group of vessels that are interconnected, or separate vessels that are located in such a way that a regulated substance could be involved in a potential release, is considered a single process. The EPA also says that the owner or operator of a facility must make a reasonable determination as to whether two or more vessels may be involved in the same accident, or whether a release from one vessel may be likely to lead to a release from another.

To our knowledge, neither the Occupational Safety and Health Administration (OSHA) nor the EPA has issued guidelines further refining this definition of process. Each individual site must use the guidelines that are given to determine the number of processes it has. Since the two agencies will not issue additional guidelines, the Chlorine Institute cannot do so either.

If the RMPR applies to your facility, then you will be required to develop a formal risk management program and to register and submit a risk management plan (RMP). The regulations apply to 77 toxic substances (including chlorine, anhydrous ammonia, and sulfur dioxide) and 63 substances that are flammable when certain threshold amounts are met or exceeded in a process. Many of the requirements are similar to Process Safety Management (PSM) rules developed by OSHA (Appendix C), but there are important additional requirements.

The EPA regulations go beyond the PSM rules and require facilities to determine the effect potential workplace chemical accidents may have in the surrounding community. Also, the EPA rules require facilities to register and submit certain data about your risk management program to government agencies and local emergency planning committees (LEPCs), as well as make it available to the general public.

NOTE: In addition, the list of chemicals covered and the threshold amounts are different for the PSM and RMP. It is technically possible to be covered by the PSM but not by the RMP except under the **general duty clause**.

Compliance with both the OSHA standard and the EPA's RMP is required by the Clean Air Act Amendments. Operators who incorporate the stipulations of both sets of requirements will be better equipped to meet full compliance while enhancing their relationship with the local community.

The deadline for completing all of the elements in the Risk Management Program and for registering and submitting the RMP is the day you first have a quantity over the threshold in a process.

16. OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REGULATIONS

The following sections of Title 29 of the Code of Federal Regulations (29 CFR) are pertinent to the operation of facilities utilizing chlorine as part of the process.

16.1 29 CFR 1910.120: HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

Any pool site having an extremely hazardous substance, such as chlorine, on its premises must develop an emergency response plan and train its employees in the implementation of that plan.

Each employer shall develop an emergency response plan that shall address, at a minimum, the following elements:

- Pre-emergency planning and coordination with outside parties. Personnel roles, lines of authority, training, and communication. Emergency recognition and prevention;
- Safe distances and place of refuge;
- Site security and control;
- Evacuation route and procedures;
- Decontamination;
- Emergency medical treatment and first aid;
- Emergency alerting and response procedures;

- Critique of response and follow-up; and
- Personal PROTECTIVE equipment (PPE) and emergency equipment.

16.2 29 CFR 1910.1200: HAZARD COMMUNICATIONS

Employers shall provide employee training on the chemical hazards that may be encountered on the job. The training program must contain the following items:

- Guidance on how to read and understand the MSDS;
- Information on the location of the pool site's emergency response plan and what the employees' responsibilities would be during an emergency;
- Education as to the physical and health hazards of chlorine gas and any other hazardous material that may be present in the employees' work place;
- Procedures that employees can take to protect themselves from health hazards; and
- Information regarding actions taken by the employer to provide protection, such as emergency procedures and personal protective equipment, and so on.

16.3 29 CFR 1175.1: GENERAL REQUIREMENTS

Compressed gases shall be stored, handled, and used in accordance with generally accepted standards.

Cylinders, pressure vessels, or containers shall be identified as to the gas contained therein.

Compressed gas cylinders in storage or in service shall be secured to prevent falling or being upset, and shall be protected against tampering by unauthorized persons.

Storage tanks and cylinders located in areas subjected to traffic shall be protected against vehicle damage.

Compressed gas cylinders when not being used shall have their protective caps in place over the valve assembly.

In addition to these sections from 29 CFR, you should review the following concerning the specific topics indicated:

Section 1910.132-139 on personal protective equipment

Section 1910.38(a) on employer emergency plans and fire prevention plans

For further information on OSHA regulations as they apply to government-owned or government-operated facilities, contact the state department of labor, public employees safety, and health, or a similar organization in your state.

17. DIRECTORY OF ORGANIZATIONS

American Conference of Governmental Industrial Hygienists
1330 Kemper Meadow Drive
Cincinnati, OH 45240
513-742-2020
www.acgih.org

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235
303-794-7711
www.awwa.org

American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5000
www.americanchemistry.com

The Chlorine Institute Inc.
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5760
www.chlorineinstitute.org

Compressed Gas Association
4221 Walney Road, 5th Floor
Chantilly, VA 20151
703-788-2700
www.cganet.com

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
617-770-3000
www.nfpa.org

United States Department of Transportation Pipeline and Hazardous Materials Safety Administration
1200 New Jersey Avenue, S.E.
Washington, DC 20590
202-366-4433
www.phmsa.dot.gov

United States Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460
202-564-3750 (Office of Ground Water and Drinking Water)
800-424-8802 (National Response Center – to report chemical spills/emergencies)
www.epa.gov

Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
703-684-2400
www.wef.org

Chemical Industry Institute of Technology
P.O. Box 12137
Research Triangle Park, NC 27709
919-558-1200
http://www.thehamner.org/institutes/ciit/

Association of Pool & Spa Professionals
2111 Eisenhower Avenue
Alexandria, VA 22314-4695
703-838-0083
www.apsp.org

Department of Homeland Security
U.S. Department of Homeland Security
Washington, DC 20528
202-282-8000
www.dhs.gov

For information on the local emergency commission in your region, contact your State Emergency Response Commission.

18. CHECKLIST

This checklist is designed to emphasize major topics and safety knowledge for someone who has already read and understood the pamphlet. Taking recommendations from this list without understanding the appropriate sections in the pamphlet is unsafe.

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

Yes	No	N/A	
❐	❐	❐	1. Has everyone involved with pool chemicals been trained on the physical and chemical properties of chlorine gas including the temperature / vapor pressure relationship with a liquefied gas?
❐	❐	❐	2. Have all pool supervisors, life-guards and other pool staff personnel been trained about the hazards of chlorine and are they familiar with its odor?
❐	❐	❐	3. Have all appropriate employees been trained about the basic features of chlorine cylinders, cylinder valves, and the injection system?
❐	❐	❐	4. Is the staff trained and rehearsed in the use of the Emergency Response Plan/Evacuation Plan?
❐	❐	❐	5. Have drills been conducted at your facility to ensure that everyone is aware of their responsibilities in the site's Emergency Response Plan?
❐	❐	❐	6. Are copies of the Emergency Response Plan readily available to all employees?
❐	❐	❐	7. Has the Emergency Response Plan been reviewed with local authorities?
❐	❐	❐	8. Do the chlorine storage and feed areas meet local fire and building code requirements, as well as the Chlorine Institute recommendations in this pamphlet?
❐	❐	❐	9. Do you have a hand truck equipped with chains or straps for moving the cylinders on site?
❐	❐	❐	10. Does your piping system follow the recommendation of the Chlorine Institute as found in this document or in Chlorine Institute Pamphlet 6?
❐	❐	❐	11. Do all operators understand the meaning of wet and dry chlorine?
❐	❐	❐	12. Do all operators understand how wet chlorine can corrode and damage metal piping systems?
❐	❐	❐	13. Are cylinders, both full and empty, secured to prevent them from falling over when not in use?

Yes	No	N/A	
☐	☐	☐	14. Are cylinders secured and in a protected location when in use?
☐	☐	☐	15. Are the appropriate employees aware that cylinder valves must be closed immediately when not in use and that lines should be evacuated?
☐	☐	☐	16. Are all appropriate employees trained in first aid for chlorine exposures?
☐	☐	☐	17. Do employees understand that OSHA has strict regulations and training requirements for emergency responders that must be satisfied before they can respond to a leak?
☐	☐	☐	18. Are all employees aware that anyone exhibiting symptoms after a chlorine exposure will likely get worse over the next few hours and that they should seek medical attention immediately?
☐	☐	☐	19. Has your pool met the requirements of SARA Title III for any site with 100 pounds or more of chlorine on site? (See Section 14)
☐	☐	☐	20. Have all your employees been trained in OSHA requirements (29 CFR)? (See Section 16)
☐	☐	☐	21. Have you reviewed the RMP General Duty Clause to determine its applicability to your operation? (See Section 15)

REMINDER:

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

THE CHLORINE INSTITUTE, INC.

A LEGACY OF SAFETY STEWARDSHIP

THE CHLORINE INSTITUTE, INC. *since* 1924

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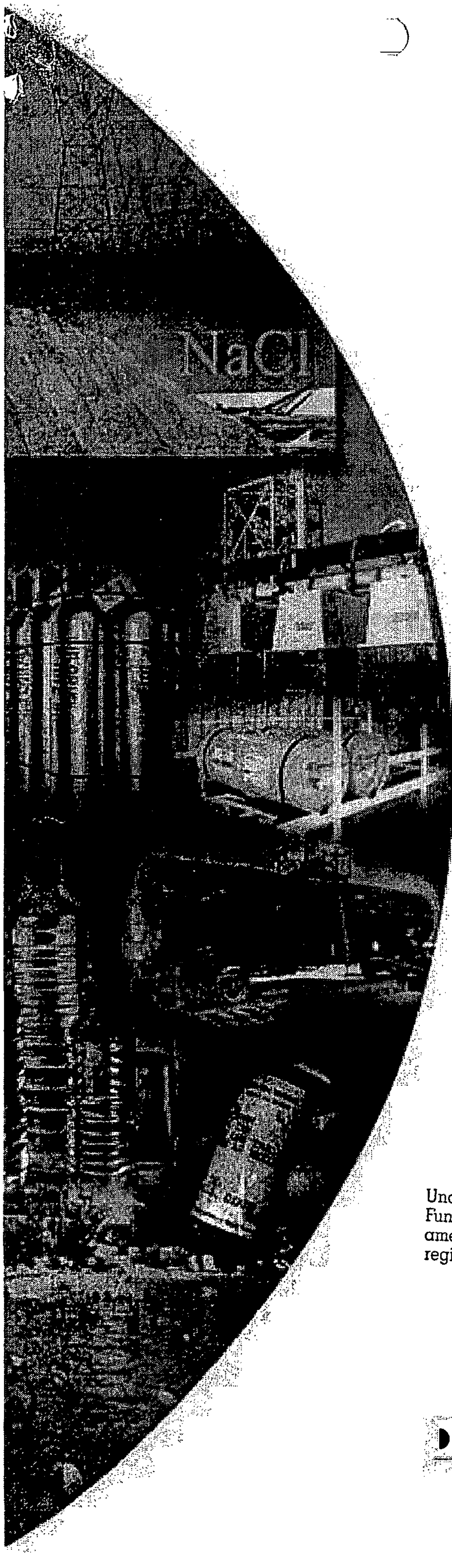

THE CHLORINE INSTITUTE, INC.

Pamphlet 155

Water and Wastewater Operators Chlorine Handbook

Edition 2

A LEGACY OF SAFETY STEWARDSHIP since 1924

ACCEPTED
with COMMENTS
in EPA Letter Dated:
JUL 19 2010
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide, registered under EPA Reg. No. 1148-707

January 2008

Table of Contents

1. INTRODUCTION

1.1 SCOPE

Chlorine is the most widely used disinfectant in water and wastewater treatment plants in the world. Although sodium and calcium hypochlorites are also used in water and wastewater treatment, this document deals only with elemental chlorine.

This manual is intended to provide basic information on chlorine safety for treatment plant personnel. Throughout this text, the reader is referred to other Chlorine Institute (CI) publications for technical topics requiring detailed explanations of the subject matter or for subjects of specific interest.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. (CI) 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 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 the CI website at www.chlorineinstitute.org.

1.3 ABBREVIATIONS AND ACRONYMS

ACC	American Chemistry Council
ACGIH	American Conference of Governmental and Industrial Hygienists
AIHA	American Industrial Hygiene Association
ASTM	American Society for Testing and Materials; now known solely by the acronym
AWWA	American Water Works Association
CAS	Chemical Abstracts Service
CHEMTREC	Chemical Transportation Emergency Center
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHLOREP	Chlorine Emergency Plan – Activated Through CHEMTREC
CI	The Chlorine Institute, Inc.
CIIT	Chemical Industry Institute of Technology
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency

EPCRA	Emergency Planning and Community Right-to-Know Act
ERP	Emergency response plan
ERPG	Emergency response planning guidelines
HAZMAT	Hazardous materials
ICC	International Code Council
IDLH	Immediately dangerous to life and health
LEPC	Local emergency planning committee
MSDS	Material safety data sheet
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limits
PPE	Personal protective equipment
PSM	Process safety management
RMP	Risk management plan
RMPR	Risk Management Program Rule
SARA	Superfund Amendments and Reauthorization Act of 1986
SCBA	Self-contained breathing apparatus
STEL	Short-term exposure limits
TLV	Threshold limit value
TWA	Time-weighted average
WEF	Water Environment Federation

1.4 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The 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 or regulations may require changes in the recommendations contained herein. Appropriate steps should be taken to ensure that the information is current, when used. These recommendations should not be confused with federal, state, provincial, municipal, or insurance requirements, or with national safety codes.

1.5 APPROVAL

The Institute's Customer Stewardship Issue Team approved Edition 2 of this pamphlet on January 3, 2008.

1.6 REVISIONS

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

1.7 REPRODUCTION

The contents of this pamphlet are not to be copied for publication, in whole or in part, without prior Institute permission.

2. GENERAL INFORMATION FOR WATER AND WASTEWATER TREATMENT

2.1 USAGE

Chlorine's primary use in potable water treatment is as a disinfectant to destroy harmful organisms. It can also remove color and ammonia compounds, eliminate hydrogen sulfide, oxidize iron and manganese to insoluble forms, and reduce undesirable taste and odors.

Chlorine's primary use in wastewater treatment is to disinfect the effluent to protect the receiving waters. Other wastewater uses include the destruction of hydrogen sulfide, control of odors, removal of ammonia and ammonia compounds, control of filamentous biomass, oxidation of organics, and control of filter flies.

2.2 PHYSICAL AND CHEMICAL PROPERTIES

The chemical symbol for elemental chlorine is Cl. Chlorine exists as a molecule containing two atoms, shown chemically as Cl_2. Chlorine has an atomic weight of 35.453, a molecular weight of 70.906, and an atomic number of 17. Some of the physical properties of chlorine are given in Table 1. While it is not explosive or flammable, as a liquid or gas it can react violently with many substances. Chlorine is only slightly soluble in water (0.3 to 0.7% by weight.)

Chlorine gas has a greenish-yellow color. It has a characteristic disagreeable and pungent odor, similar to chlorine-based laundry bleaches, and is detectable by smell at concentrations as low as 0.2 to 0.4 ppm. It is about two and a half times as heavy as air. Consequently, if chlorine gas escapes from a container or system, it will seek the lowest level in the building or area.

Liquid chlorine is amber in color and is about one and a half times as heavy as water. Chlorine is seldom seen as a liquid because it boils (converts to a gas) at about -29°F (-34°C) at atmospheric pressure.

The term dry chlorine does not refer to dry chlorinating chemicals such as calcium hypochlorite. It refers to liquid or gaseous elemental chlorine with a very low water content (see CI Pamphlet 100). While dry chlorine reacts violently with some metals, it is not corrosive to metals such as copper or carbon steel. However, wet chlorine is highly corrosive to most metals (Section 2.3.5). Chlorine shipped in rail cars, cargo tanks, cylinders, and ton containers is dry chlorine.

Problems attributable to wet chlorine are usually due to moisture in a system and can result from poor operating practices at the water or wastewater plant.

Table 1. Physical Properties of Chlorine

Boiling point (liquefying point) at 1 atmosphere = 14.696 psi (101.325 kPa)	-29.15°F (-33.97°C)
Melting point (freezing point) at 1 atmosphere	-149.76°F (-100.98°C)
Liquid density at 60°F (16°C)	88.76 lb/cu ft (1,422 kg/m3)
Gas density at 34°F (1.1°C)	0.2006 lb/cu ft (3.213 kg/m3)
Specific gravity (liquid) at 32°F (0°C)	1.468 (water = 1)
Specific gravity (gas) at 32°F (0°C)	2.485 (air = 1)
Water solubility at 70°F (21.1°C)	0.7% by weight
Vapor pressures:	
at 32°F (0°C)	53.51 psi (368.9 kPa)
at 77°F (25°C)	112.95 psi (778.8 kPa)
at 129°F (48.9°C)	191.01 psi (1,316.8kPa)

Chlorine gas reacts with water to form both hypochlorous and hydrochloric acids (Eq. 1):

$$\underset{\text{(chlorine)}}{Cl_2} + \underset{\text{(water)}}{H_2O} \leftrightarrow \underset{\text{(hypochlorous acid)}}{HOCl} + \underset{\text{(hydrochloric acid)}}{HCl} \qquad \text{(Eq. 1)}$$

Hypochlorous acid dissociates in water to form the hydrogen and hypochlorite ions (Eq. 2):

$$\underset{\text{(hypochlorous acid)}}{HOCl} \leftrightarrow \underset{\text{(hydrogen ion)}}{H+} + \underset{\text{(hypochlorite ion)}}{OCl^-} \qquad \text{(Eq. 2)}$$

The degree of dissociation is dependent on the pH and temperature of the water.

Hypochlorous acid is the dominant form of chlorine in water up to pH 7.8. A significant percentage of the chlorine is still in the form of hypochlorous acid even between pH 8 and pH 9 (Table 2). Each plant must determine the dose and residual needed to achieve disinfection. Hypochlorous acid is the predominant form of chlorine for disinfection.

Table 2. Percent Hypochlorous Acid and Hypochlorite Ion at 68°F

pH	%HOCL	%OCL$^-$
5.0	99.7	0.3
5.5	99.2	0.8
6.0	97.5	2.5
6.5	92.4	7.6
7.0	79.3	20.7
7.5	54.8	45.2
8.0	27.7	72.3
8.5	10.8	89.2
9.0	3.7	96.3
9.5	1.2	98.8
10.0	0.4	99.6
10.5	0.1	99.9

2.3 SPECIAL CONCERNS FOR OPERATORS

2.3.1 Liquid-Gas Volume Relationship

One volume of liquid chlorine yields about 460 volumes of chlorine gas. For example, 1 pound or about 11 fluid ounces of liquid chlorine yields approximately 5.4 cubic feet of 100% chlorine gas when vaporized at normal temperature [70°F (21.1°C)] and atmospheric pressure. Therefore, one 150-lb cylinder would completely fill a 10 x 10 x 8-foot room with 100% chlorine gas.

2.3.2 Liquid-Gas Temperature Effect

The vaporization of liquid chlorine on skin or clothing may reduce the temperature enough to cause frostbite (even through high-quality protective clothing), cause the fogging of protective face masks, or the freezing of footgear to the ground. It is essential to wear the proper PPE during all routine operations.

2.3.3 Physiological Effects of Chlorine Exposure

Chlorine is an irritant to the eyes, skin, mucous membranes, and the respiratory system. The primary concern with exposure to chlorine is the respiratory system followed by the eyes. The impact of exposure to chlorine is both concentration and time dependent. People with respiratory conditions should inform their doctor that they work around chlorine. Extra precautions may be necessary. Table 3 summarizes exposure levels and effects on humans.

Table 3. Chlorine Exposure Levels and Effects on Humans

Exposure levels (ppm)	Effects
0.2 to 0.4	Odor threshold (varies by individual)
less than 0.5	No known acute or chronic effect
0.5	ACGIH 8-hour time weighted average
1.0	OSHA ceiling level (PEL) TLV-STEL ERPG-1
1 to 10	Irritation of the eyes and mucous membranes of the upper respiratory tract. Severity of symptoms depends on concentrations and length of exposure.
3	ERPG-2 (Emergency Response Planning Guidelines as values developed by AIHA) is 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 that could impair an individual's ability to take protective action
10	NIOSH IDLH (immediately dangerous to life and health)
20	ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

As the duration of exposure or the concentration increases, the affected individual may become apprehensive and restless, with coughing accompanied by throat irritation, sneezing, and excess salivation. At higher levels, vomiting associated with labored breathing can occur. In extreme cases, difficulty in breathing can progress to the point of death through suffocation. An exposed person with a preexisting medical or cardiovascular condition can have an exaggerated response. **Anyone exhibiting these symptoms should see a qualified healthcare provider immediately as his or her condition is likely to deteriorate over the next few hours.**

2.3.4 Reaction with Water

Chlorine is only slightly soluble in water, in which it forms a weak solution of hydrochloric and hypochlorous acids (Eq. 1). Chlorine hydrate, a greenish ice-like substance ($Cl_2 \cdot 8H_2O$), may form as crystals below 49.3°F (9.6°C) at atmospheric pressure.

Chlorine hydrate can also form at higher temperatures if the chlorine is at an increased pressure. These crystals can interfere with the proper operation of chlorination systems.

Reactions with Metals

Below 250°F (121°C) iron, copper, steel, lead, nickel, platinum, silver, and tantalum are resistant to dry chlorine (gas or liquid state). At ordinary temperatures dry chlorine reacts (often violently) with aluminum, arsenic, gold, mercury, selenium, tellurium, tin, and titanium. Carbon steel ignites at 483°F (251°C) in a chlorine atmosphere (See CI Pamphlet 164).

Wet chlorine forms acids and is very corrosive to most common metals. Platinum, silver, and tantalum are resistant to both wet and dry chlorine. Titanium is unique because it is resistant to wet chlorine but cannot be used in contact with dry chlorine. Experts should be consulted when dealing with systems using wet chlorine.

2.3.5 Other Reactions

Chlorine should be segregated from ammonia and ammonia compounds because potentially violent reactions could result in the event of a chlorine release.

Chlorine reacts with many organic compounds. Some of these reactions can be violent or explosive, including those with oils, greases, solvents, coolants, and other hydrocarbons. The separation of these materials during storage and use is essential to safety. This is especially important when new components including piping are added to the chlorine system. Even thin layers of oils and greases can react violently (See CI Pamphlets 6 and 164).

3. CHLORINE CONTAINERS

3.1 GENERAL

Chlorine is shipped and stored in pressure vessels as a liquefied gas under pressure. While on-site stationary tanks are used solely for storage, chlorine is commonly transported in cylinders, ton containers, cargo tanks, and rail tank cars. Cylinders and ton containers have many handling similarities, but different equipment is needed to deal with emergencies involving each type of container. Chlorine Institute Emergency Kit and cylinder recovery vessels are designed to contain most container leaks. These include:

Kit A: for 100- and 150-lb cylinders
Kit B: for ton containers
Kit C: for tank cars and cargo tanks (tank trucks), and
Cylinder Containment Vessels for 100 and 150-lb cylinders

Confusion can be avoided if the term "ton containers" is used and *not* "ton cylinders".

Chlorine ton containers and cylinders must always be handled with care and should not be dropped or struck. During transport, containers must be secured to prevent them from moving. A loading dock or a hydraulic tailgate on the truck should be used when unloading. A container valve's protective housing and valve outlet cap should be in place when the container is not in use.

3.2 CYLINDERS

Chlorine cylinders may include foot-ring, bumped-bottom, and double-bottom construction (Figure 1), with only one opening permitted. The most common sizes are 100 lb (45 kg) and 150 lb (68 kg). Table 4 lists tare weights [the weight of an empty container with valves and fusible plugs (safety relief devices) but without valve protection devices] and dimensions of 100-lb and 150-lb cylinders. The CI has developed recommended criteria for cylinder valves. This can be found in an appendix to CI Pamphlet 17. The valve outlet threads are *not* standard pipe threads.

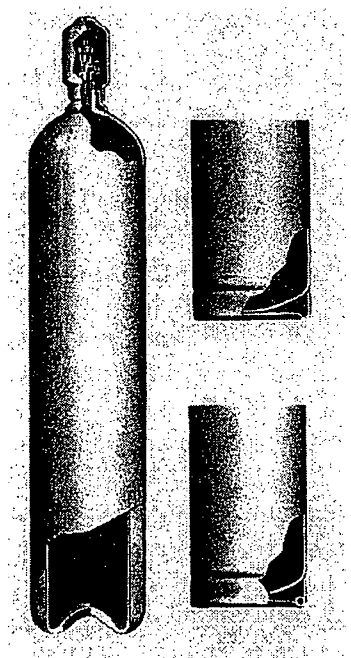

Figure 1 - Chlorine Cylinder
(Left - bump-bottom; Upper right - double-bottom; Lower right - foot-ring)

Cylinder valves are equipped with a pressure relief device consisting of a fusible metal plug in the valve body, located below the valve seat. The fusible metal is designed to melt between 158°F and 165°F (70°C and 74°C) to relieve pressure and prevent rupture of the cylinder in case of exposure to high temperatures.

Cylinders should always be stored upright. They are stamped near the neck ring area with the tare weight and the date of the last hydrostatic test. According to U.S. Department of Transportation [DOT] or Canadian Transportation of Dangerous Goods Regulations, cylinders must be hydrostatically tested every five years. DOT regulations prohibit the marring or defacing of these markings. Cylinders must be designed for use with CI Chlorine Emergency Kit A for Cylinders.

Table 4. Container Dimensions and Weights

Capacity		100 lb (45 kg)	150 lb (68 kg)	2,000 lb (907 kg)
Volume of liquid chlorine (approximate at 60°F/15.6°C)	(gal) (L)	8.42 31.87	12.64 47.85	168.5 637.8
Tare weight	(lb) (kg)	63-115 29-52	85-140 39-64	1,300-1,650 590-748
Outside diameter	(in) (mm)	8.25-10.75 210-273	10.25-10.75 260-273	30 762
Cylinder Height	(in) (mm)	39.5-59* 1,003-1,499*	53-56* 1,346-1,422*	
Ton Container Length	(in) (mm)			79.75-82.5 2,026-2,096

*Heights are to the top of the valve protection housing. The height to the center of the valve outlet is about 3.5 in. (89 mm) less.

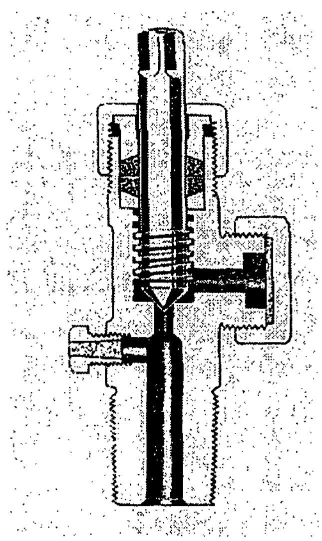

Figure 2 - One Typical Style of a Cylinder Valve (Other Designs May Also be in Use)

3.3 TON CONTAINERS

Ton containers (Figure 3) are welded steel tanks with a chlorine capacity of 2,000 lb (907 kg) and a loaded weight of as much as 3,650 lb (1,659 kg). They are stamped with a serial number, the tare weight, and the date of the most recent hydrostatic test. Refer to Table 4 for dimensions and weights.

The heads are either concave or convex and welded to the barrels. The chimes (the steel wall that extends beyond each head) provide a substantial grip for lifting beams. The container valves are protected by a removable steel valve protective housing. Ton containers have two valves and can supply either liquid or gas. When the valves are properly aligned in a vertical position, the upper valve feeds chlorine gas while the lower valve feeds liquid chlorine. The container has three fusible plugs in each end that are designed to melt between 158°F and 165°F (70°C and 74°C) to relieve internal pressure.

The CI has developed recommended criteria for ton container valves. This can be found in an appendix to CI Pamphlet 17. The valve outlet threads are not standard pipe threads. All ton containers must be able to accommodate the use of the devices in CI Emergency Kit B.

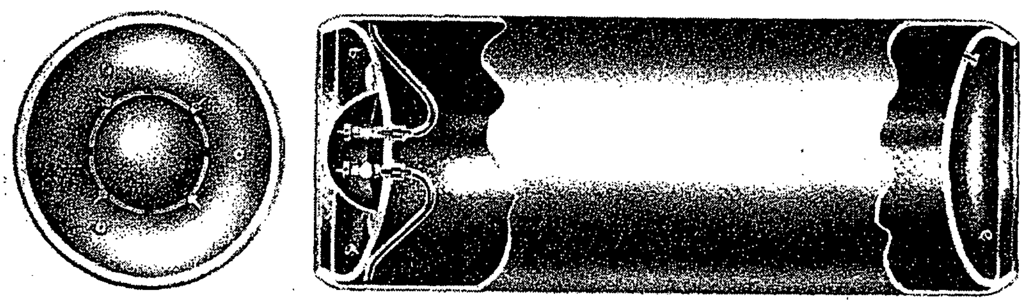

Figure 3 - Chlorine Ton Container

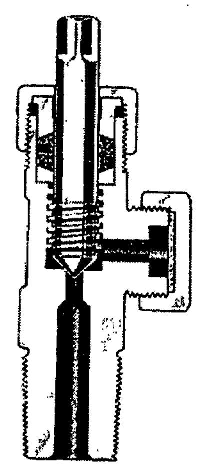

Figure 4 - One Style of a Chlorine Ton Container Valve (Other Designs May Also be in Use)

3.4 CARGO TANKS (TRAILERS)

Cargo tanks are used to transport chlorine over roads and highways. They have a capacity of 15-22 tons (13,600 kg-20,000 kg.) Cargo tanks use the same man way and valve arrangements as rail tank cars (Section 3.5) and are required to have excess flow check valves under both the liquid and gas angle valves (CI Pamphlet 49).

All chlorine cargo tanks have four angle valves. They also have one safety relief valve designed to release excess pressure buildup within the tank. They are designed to relieve pressure at 225 psi (1,551 kPA.) Two of the angle valves are located on the longitudinal center of the tank. These valves are connected to eduction pipes that run to the bottom of the tank and are used to unload liquid chlorine. Two angle valves are located on a line perpendicular to the tank's length and are connected to the vapor phase. These valves should never be used for gas withdrawal, but can be used to pressurize the car when needed to increase the rate of liquid withdrawal. All four valves are equipped with excess flow valves designed to close at a flow rate of 7,000 lb/hr (3,200 kg/hr).

CI Emergency Kit C is designed for stopping leaks on chlorine cargo tanks and tank cars (CI Pamphlet 49).

3.5 TANK CARS (RAIL)

Tank cars for transporting chlorine via railroad have capacities of 55, 85, or 90 tons, and they may not be loaded in excess of these nominal loading weights. The only opening into tank cars is through a manway on top, where the valves are enclosed with a steel cover.

All chlorine tank cars have four angle valves. They also have one safety relief valve designed to release excess pressure buildup within the tank. Two of the angle valves are located on the longitudinal center of the car. These valves are connected to eduction pipes that run to the bottom of the tank and are used to unload liquid chlorine. Two angle valves are located on a line perpendicular to the car's length and are connected to the vapor phase. These valves should never be used for gas withdrawal, but can be used to pressurize the car when needed to increase the rate of liquid withdrawal. The liquid valves are equipped with excess flow valves designed to close at flow rates of 7,000, 15,000 or 32,000 lb per hour. The flow rate is usually stenciled on the side of the car. Unstenciled cars have 7,000-lb-per-hour valves.

CI Emergency Kit C is designed for stopping leaks on chlorine tank cars and cargo tanks. For additional recommendations, see CI Pamphlet 66.

For additional guidelines, recommended practices, and other useful information concerning chlorine tank cars, refer to CI Pamphlets 1, 4, 24 and 66.

3.6 STATIONARY STORAGE TANKS

Stationary chlorine storage tanks may be found at large capacity treatment facilities. Such tanks should be designed in accordance with CI Pamphlet 5, which includes a standard tank car dome assembly (Section 3.5). Local codes should also be consulted.

4. TRANSPORTATION, STORAGE, AND HANDLING OF CONTAINERS

4.1 TRANSPORTATION OF CHLORINE

The U.S. DOT regulates the transportation of hazardous materials, including chlorine. Applicable DOT regulations appear in Title 49 of the *Code of Federal Regulations* (49 *CFR*), and requires special HazMat and safety permits as of January 1, 2005. In most circumstances it is preferable to let the chlorine supplier transport the chlorine to each use site. If this arrangement is not possible, CI Pamphlet 76 contains recommendations on how to safely transport packaged chlorine. Placards are required for the transportation of any amount of chlorine. Proper labeling of the container is essential and the correct shipping papers must be on the vehicle. These requirements, including the correct wording of the paperwork and labeling, change frequently (Contact the supplier and review 49 *CFR* to remain current).

In Canada, you must follow the requirements of the Transportation of Dangerous Goods Regulations by Transport Canada, covering High Consequence Dangerous Goods.

The DOT and CTDG have specific training requirements for all personnel involved in the transportation of hazardous materials, from those preparing the paperwork to those loading and driving the truck (See CI Pamphlet 76).

4.2 RECEIVING AND UNLOADING CHLORINE CONTAINERS

4.2.1 Cylinders

Individual cylinders should be chained or clamped to a hand truck or otherwise secured to the moving device for unloading or relocating. If secured in a storage rack, a forklift can be used. Cylinders should not be lifted by the valve protective housing, which is not designed to carry the weight of the cylinder. The cylinders should always be secured to prevent them from falling (See CI Pamphlet 76).

4.2.2 Ton Containers

Ton containers may be lifted by using a hoist of sufficient capacity for the load in conjunction with a ton container lifting beam (Figure 5). A forklift of sufficient capacity can also be used. Whether full or empty, ton containers must always be secured to prevent them from rolling. **Warning**: An empty ton container may weigh as much as 1,650 lb and can cause severe injury if not secured (See CI Pamphlet 76).

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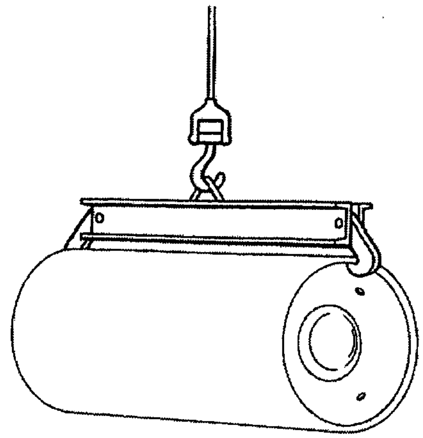


Figure 5 - Lifting Beam For Handling Chlorine Ton Containers

4.2.3 Cargo Tanks

The chlorine in cargo tanks can either be unloaded into a permanent storage tank or fed directly into the process. The storage tank must be on a scale or load cell to make certain that it can accommodate the entire shipment. A trained driver or operator should make the connections and monitor the unloading process (See CI Pamphlets 5, 49, and 57).

4.2.4 Tank Cars (Rail)

Tank cars should be inspected to make certain they are properly placarded and stenciled with UN 1017. The tank car number and arrival dates should be noted in records kept at the receiving facility. Cars should be used in the order received. They should not be connected to a system until unloading time.

Specific DOT rules and CTDG Regulations must be met for placing warning signs, derails, chocks, and bumpers, as well as for monitoring the unloading. Tank car suppliers should provide the latest DOT requirements in addition to periodic training on connecting, unloading, and disconnecting chlorine cars. Extensive training is needed by employees who work with chlorine tank cars. Automatic or remotely activated valves located on both sides of the flexible hose or copper loop should be considered to allow operators to quickly shut off the flow of chlorine in case of a leak (See CI Pamphlets 57 and 66).

4.3 <u>LEAK DETECTION AND CORRECTION</u>

4.3.1 Cylinder and Ton Container Leaks

When a leak is suspected, it is recommended that ammonia vapors be used to find the source. When ammonia vapor is directed at a leak, a white cloud will form. To produce ammonia vapor, a plastic squeeze bottle containing commercial, 26 degree Baume or stronger, aqua ammonia (ammonium hydroxide solution) should be used. A weaker solution such as household ammonia may not be concentrated enough to detect minor leaks. If a wash bottle is used, the dip tube inside the bottle should be cut off so that squeezing the bottle directs only the vapor, and not liquid, from the nozzle. To prevent corrosion, liquid aqua ammonia should not come into contact with any metal parts.

4.3.1.1 Responding to a Leak

Before responding to any leak, review Sections 8, 9 and 10 of this document.

Self-contained breathing apparatus (SCBA) and appropriate protective suits are required (the on-site coordinator decides what level of protection is needed). If chlorine is escaping as a liquid from a cylinder or a ton container, align the tank so that the leaking side is up. In this position the chlorine will escape only as a gas, greatly minimizing the leak.

If a chlorine valve is leaking through the valve outlet, install an outlet cap with gasket and open and close the valve. Sometimes this will clean the stem seat and stop the leak. After closing the valve, remove the outlet cap and check for leaks. If the leak will not stop, put the outlet cap back on and notify the chlorine supplier.

When the packing gland is the source of the leak, first close the valve and then tighten the packing nut. If it still leaks, make sure the valve is closed and retighten the packing gland. Care must be taken when tightening the packing gland. Over tightening may bind the valve or strip the threads and it will not close or open. Testing for leakage must be repeated after every attempt to stop the leak. Fifty foot-pounds of torque on the packing nut should stop most leaks.

If the source of the leak is at the valve threads, use a crowfoot wrench from the appropriate Chlorine Emergency Kit to tighten the valve into the container. Care should be taken to avoid stripping the threads. Do not tighten the valve if its integrity is in question. Application of other suitable devices from Chlorine Institute Emergency Kits to cap leaks or use of a cylinder containment vessel may be necessary.

Regular training with an SCBA and the use of appropriate Emergency Kits or cylinder containment vessels is essential. Comply with all applicable local, state, and federal regulations relating to both training and response requirements.

4.3.2 Cargo Tanks and Tank Cars

Responding to leaks involving tank cars and cargo tanks requires more extensive training than that needed for cylinder and ton container leaks. Personnel dealing with tank car and cargo tank leaks must be highly trained and familiar with the various features of these containers as well as with CI Pamphlets 49 and 66 and the Emergency Kit C. Coverage of the specific training required is beyond the scope of this pamphlet.

CI publishes a pamphlet and a video dedicated to Emergency C Kits.

4.3.3 Piping Systems

If a leak is found in the pressurized piping system, the chlorine supply to that section of piping must be shut off, the pressure relieved, and the system purged of all chlorine before the necessary repairs are made. The system must be purged with a dry, non-reactive gas before any welding is done. Welding should comply with all applicable codes. **Never weld on or to any chlorine container** (See CI Pamphlet 6).

4.4 GENERAL STORAGE CONSIDERATIONS

Chlorine may be stored safely indoors. If stored outdoors, shading from direct sunlight in warm climates is recommended. Containers should not be stored where they can be dropped, where heavy objects can fall on them, or where vehicles can strike them. They should not be stored near elevators, heating, ventilating, or air conditioning systems because dangerous concentrations of gas may spread rapidly if a leak occurs. Easy access to containers is important in the event of a leak. Below ground storage must be avoided because chlorine vapors are heavier than air and will not readily dissipate from low areas in the event of a leak.

The chlorine storage area must be posted properly with signs in accordance with local codes and state and federal laws and regulations. Access to storage areas by unauthorized personnel should be restricted.

4.4.1 Indoor Storage and Construction

Local fire and building codes may dictate the legal requirements for buildings used to store chlorine. Consult with the local government to determine which code is in effect in the community where the plant is located and review the code. Any building that will house chlorine containers or equipment should be designed and constructed to protect all elements of the chlorine system from fire hazards. Fire-resistant construction is recommended. Chlorine containers should be segregated from flammable and oxidizing materials and from materials such as ammonia, sulfur dioxide, hydrocarbons, certain refrigerants and other materials that are reactive with chlorine. Chlorine cylinders should be segregated from other compressed or liquefied gases. However, if flammable materials are stored or processed in the same building, a fire wall that meets the applicable fire and building code standards should be in place.

4.4.2 Outdoor Storage

Local fire codes and building codes as well as intended use may dictate the legal requirements for the outside storage of chlorine. Consult with the local government to determine which code and code year are in effect in the community where the plant is located and review the code. An outdoor storage area should be clear of trash and debris so as not to present a fire hazard. In general, it is recommended that overhead shading from the sun be provided in warm climates. Containers must not be stored in standing water.

4.4.3 Gas Detection Equipment

Installations, manned or unmanned, where chlorine is stored or used should have gas detection equipment to monitor for chlorine releases. Chlorine detectors must be designed and adequately maintained to warn personnel or to signal a remote, manned location in case of a leak. Proper maintenance includes a written plan for a regular calibration of the monitoring equipment, including written documentation of periodic testing.

4.4.4 Storage with Other Chemicals

Chlorine containers should be segregated from flammable and oxidizing materials and from materials such as ammonia, sulfur dioxide, hydrocarbons, certain refrigerants and other materials that are reactive with chlorine. Chlorine cylinders should be segregated from other compressed or liquefied gases.

5. PIPING/FEED SYSTEMS

5.1 Basic Systems

All chlorine is shipped and stored in pressure vessels as a liquefied gas under pressure, resulting in the presence of both liquid and gas phases in the containers. Cylinders are nearly always used to feed chlorine as a gas. Ton containers have two valves and can supply either liquid or gas. When the valves are properly aligned in a vertical position, the upper valve feeds chlorine gas while the lower valve feeds chlorine as a liquid (Figure 6). Cargo tanks and tank cars should only be used to feed liquid chlorine.

In water and wastewater treatment operations, the removal of gaseous chlorine from a cylinder or ton container is usually controlled by the use of a vacuum-operated, gas feed chlorinator. A chlorinator is a piece of equipment used to feed chlorine gas into water. The vacuum is produced by a water-operated venturi that mixes the chlorine with the water and produces a high-strength chlorine solution. This solution is piped and diffused into the water or wastewater to provide the required chlorine dosage.

If liquid chlorine is being withdrawn from a ton container, the liquid chlorine must be converted to a gas by passing through a vaporizer and the resulting gas is fed into the chlorination system. Chlorinators are designed to handle gaseous chlorine. Liquid chlorine may damage gas chlorinators.

There are a few major areas of concern for the operation of a gas chlorinator, including the cleanliness of the chlorine supplied and the safety of the piping system. The quality of the chlorine is important because the chlorinator feeding the gas has small orifices and fine control valves that can be clogged or plugged. The operator should make every effort to ensure that the entire chlorine delivery system is as clean as possible. A chlorinator has a filter at the inlet of the unit that requires periodic inspection and replacement to maintain system integrity. The appearance of a film on the gas metering tube is usually an indication of a problem. If the film is reddish in color, the piping system from the chlorine container to the chlorinator or the container may contain ferric chloride. This substance forms when moisture reacts with chlorine inside of a steel piping system.

The container outlet valve is supplied with a valve cap. When the valve cap is removed, plant personnel should inspect the outlet and remove any foreign material before placing it in service.

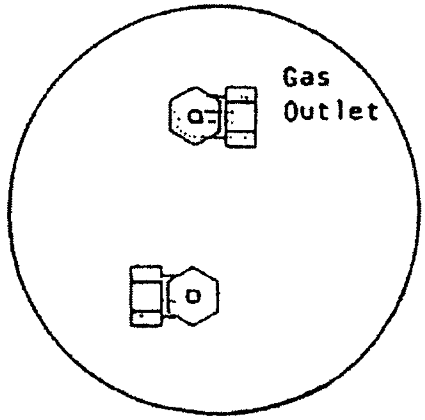


Figure 6 - Ton Container Valve Configuration

5.2 Piping Systems for Dry Chlorine

The gas chlorinator is designed to operate only with chlorine gas. Most current gas chlorinator installations mount directly on the container valve to feed gas from the container. When installed in this fashion, there is minimal chance of liquid carryover from the container to the gas chlorinator.

When chlorine containers discharge into a pressure manifold, the gas chlorinator is connected to the manifold and additional concerns arise. The pressure piping must be installed so that no liquid chlorine or chlorine liquid droplets can enter the gas chlorinator. Any liquid chlorine, including droplets, will eventually damage the chlorinator and could cause serious safety problems. The following are recommendations that will help prevent this from happening:

1. The container storage room and pressure piping manifold should be kept at a temperature that will allow the feed rates desired.

2. All gas piping under pressure must be protected from cold drafts (windows, doors, cellars, etc.) that can cause reliquification, because any liquid chlorine formed will be carried by the gas stream to the chlorinator.

3. Facilities may need to consider low-level heat tracing for gas pressure piping made of steel. This may be needed to maintain the temperature above the reliquification point (See Figure 7). Do not apply other sources of heat to chlorine lines. This procedure should be reviewed with a person trained in designing or operating chlorine systems.

4. The addition of drip legs at points of pipeline direction change may be required. The drip legs, equipped with small pad heaters, can aid in the removal of any liquid carryover.

5. Pressure reduction by the use of a pressure-reducing valve will help prevent reliquification in the pressure line. A vacuum regulator may be directly connected to a cylinder or ton container minimizing the number of pressurized connections. This will allow the system to be operated under a vacuum. When containers are manifolded to achieve a higher feed rate, the vacuum regulator or pressure reducing valve may be mounted on the end of the manifold.

6. Slope the gas pressure line downward from the feed equipment toward the chlorine container.

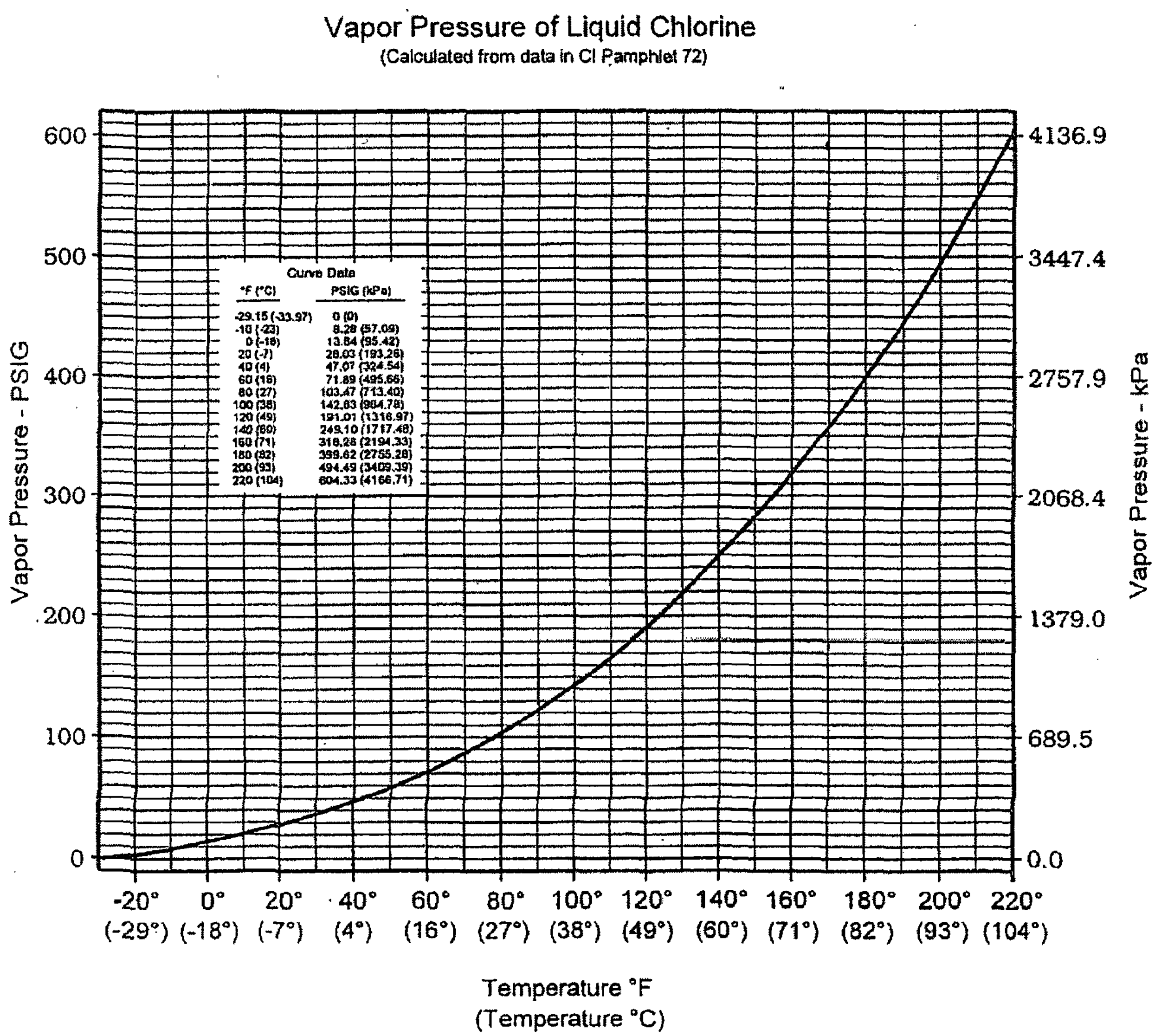
7. Examine the flexible copper connectors (pigtails) periodically. If a noise is heard when the tubing is flexed there may be internal corrosion and the tubing should be replaced. Flexible connectors should be replaced at least annually.

8. Check for external corrosion of equipment (valves, piping, fittings, etc.), which may be an indication of internal corrosion.

This section provides basic information about dry chlorine liquid or gas piping systems. (See CI Pamphlet 6.)

561 of 593

Figure 7 - Vapor Pressure of Liquid Chlorine



5.2.1 Metallic Piping

Dry chlorine is either gaseous or liquefied elemental chlorine with a very low water content. All chlorine commercially available in cylinders, ton containers, cargo tanks, and railroad tank cars is shipped as dry chlorine.

In general, ASTM A106 Grade B Schedule 80 seamless carbon steel piping is used when the process temperature range is -20°F to 300°F (-29°C to 149°C). Threaded or socket-welded construction can be used for pipe diameters of 1½ inches or less. Butt-welded and flanged joints can be used for all sizes of piping. Consult all applicable fire and building codes regarding the use of welded or flanged joints.

Certain metal piping materials, including titanium, aluminum, gold, and tin, **MUST NOT** be used with dry chlorine. Stainless steels are subject to chloride stress corrosion and should not be used in chlorine service. Even metals considered compatible with chlorine should never be heated when exposed to or containing chlorine. Many of these metals can burn in a chlorine atmosphere, releasing heat and metal chloride gases. (Note: iron and steel ignite with chlorine at about 483°F [226°C]). In addition, the corrosion rate of steel in a chlorine atmosphere increases significantly at temperatures above 250°F (121°C).

Piping systems must be thoroughly cleaned and dried before use (See CI Pamphlet 6).

Information on fittings, flanges, valves, nuts, bolts, flexible connectors, pipe dope and other fittings used in pressure piping can be found in Pamphlet 6. Lead and asbestos gaskets have been used. Further information on acceptable gasket materials is in Pamphlet 95. Refer to Pamphlet 164 for materials compatibility.

5.2.2 Nonmetallic Piping Systems

Plastic piping must never be used to transport liquid chlorine at treatment plants. Plastic piping is used only under specific conditions for gaseous chlorine and chlorine/water solutions after chlorine is injected from the chlorinator, or when the possibility exists for moisture to enter a system as in a gas chlorinator operation. Treatment plants use plastic piping primarily for the vacuum piping between the vacuum regulator and the ejector (injector) or for chlorine/water solution lines from the injector to the feed point. Where structural considerations are of concern, plastic-lined steel pipe may be required. Unlined steel cannot be used in a chlorine solution line.

Polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), acrylonitrile-butadiene styrene (ABS), fiberglass-reinforced polyester (FRP), and polyethylene (PE) piping can be used under certain conditions (CI Pamphlet 6). Piping made of these materials is restricted to handling gaseous chlorine under vacuum or pressures up to 6 psig (41 kPa) maximum pressure. Plastic piping can become brittle in chlorine service and has a limited service life. Periodic inspection and replacement is recommended.

Most fluorocarbon plastic piping is also suitable for use with gaseous chlorine, but it should be used only under the same conditions as for other types of plastic pipes. Suitable fluorocarbon plastics include polytetrafluoroethylene (PTFE), perfluoroalkoxy (PFA), polyvinylidene fluoride (PVDF), and ethylene chlorotrifluoroethylene.

5.3 VACUUM SYSTEMS

Vacuum chlorinator systems operate under a vacuum that is created by water passing through a venturi. Many of the chlorinators that mount directly to cylinder and ton container valves are designed to close and stop the release of chlorine if vacuum is lost. This design can be a significant safety feature since any loss of vacuum, including a piping leak, will shut off the gas flow.

5.4 VAPORIZERS (EVAPORATORS)

Vaporizers (evaporators) are designed to convert liquid elemental chlorine into chlorine gas. Steam or hot water jackets are used to provide the heat needed for vaporization. Temperature control is critical. Pressure relief through the use of a safety valve with a rupture disk is required for vaporizers. Periodic cleaning is necessary and the manufacturer's recommendations should be followed (See CI Pamphlet 9).

5.5 TESTING CHLORINE FEED SYSTEMS

Chlorine systems require an extensive initial test before being placed in service, as well as periodic pressure testing throughout their service life. Vaporizers and chlorinators should be tested according to their manufacturers' recommendations. Piping systems should be tested according to the recommendations in CI Pamphlet 6. Flexible hoses, connectors, or pigtails should be visually inspected, pressure tested, and replaced according to the manufacturers' recommendations. Periodic inspection should be part of a preventive plant maintenance program. Replacement of flexible connectors is recommended annually as a minimum.

5.6 MANIFOLDING CYLINDERS AND TON CONTAINERS

Cylinders can be manifolded to withdraw gaseous chlorine. Ton containers can be manifolded to withdraw gaseous or liquid chlorine. Any manifolded cylinders or ton containers used for gas withdrawal should have the same liquid chlorine temperature. Liquid manifolding requires special procedures to prevent the possibility of transferring liquid chlorine from one manifolded container to another in the same manifold. The ton containers should be manifolded together via the vapor (upper) valves and separately manifolded via the liquid (lower) valves. After leak testing both manifolds, all of the vapor (upper) valves can be opened to equalize the internal pressures in the containers. The manifolded liquid (bottom) valves can then be opened to feed liquid chlorine to the vaporizer. CI Drawing 183, "Manifolding Containers for Liquid Chlorine Withdrawal," depicts the system needed if two or more ton containers are connected together for liquid withdrawal.

5.7 AUTOMATIC CONTAINER SHUT-OFF

The use of automatic shut-off devices should be considered. These include actuators that close the container valves as well as separate valves adjacent to or near the container valves. They can be operated both remotely and by the use of pressure-sensing switches or chlorine detectors. Such devices exist for all types of North American containers.

5.8 ROLE OF THE CHLORINE SUPPLIER

The supplier of chlorine and/or the supplier of your chlorination equipment can often help with understanding the safe operation, service, and maintenance of chlorine gas feed equipment (chlorinator) at water and wastewater treatment plants. The chemical supplier may often be a plant operator's first contact when assistance is needed.

6. CONNECTING AND UNLOADING TO THE SYSTEM

6.1 TYPES OF CONNECTIONS

6.1.1 Cylinders

Cylinders discharge gas when upright. When connected to the unloading system, the cylinder must be secured to prevent movement or falling. The use of load cells or scales is recommended to monitor the contents of the container during unloading.

A yoke and adaptor for use with CGA Connection 820 or 820C (either open or closed yoke) is the standard connection to the cylinder valve outlet. (See Figure 8) A gasket on the face of the valve is part of the connection, and a new gasket must be used each time a connection is made. The CGA Connection 660, which utilizes a threaded union that threads to the valve outlet, is not recommended for connecting to the cylinder valve.

Valve outlet threads are not standard tapered pipe threads and, therefore, are not suitable for use with standard pipe fittings.

A flexible connection should be used between the cylinder and piping system. Annealed copper tubing suitable for brazing is recommended. ASTM Specification B-88 is recommended provided the material furnished is of the proper dimensions. As an alternative, certain types of nonmetallic and metallic hoses are acceptable. The connection should be regularly inspected and replaced when deterioration is evident. It is very important to follow the recommendations on flexible hoses found in CI Pamphlet 6.

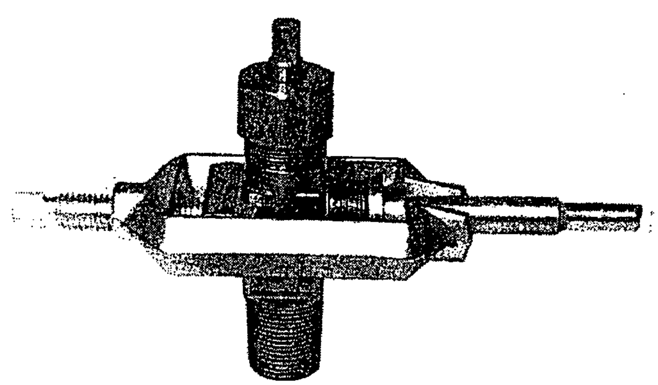


Figure 8 - Open Yoke Adapter - Type Connector

6.1.2 Ton Containers

Chlorine may be discharged as a liquid or a gas from ton containers. Ton containers are unloaded from a horizontal position, with the two discharge valves aligned vertically. The upper valve discharges gas and the lower valve discharges liquid chlorine. Containers should be held in a cradle or firmly secured to prevent rolling. A cradle with rollers makes it easy to rotate the container so that the two discharge valves are aligned vertically.

Ton containers use a valve similar to the cylinder valve. The major difference is the lack of a fusible plug in the valve body. The Institute recommends the use of the yoke and adaptor (CGA Connection 820 or 820C) as the standard connection to the container valve outlet. A gasket on the face of the valve is part of the connection, and a new gasket must be used each time a connection is made. The union threaded connection (CGA Connection 660) is not recommended for connecting to the unloading valve. Valve outlet threads are not standard tapered pipe threads. A flexible connection must be used between the ton container and piping system (Section 6.1.1).

6.1.3 Connecting/Disconnecting and Unloading Chlorine Containers

For vacuum regulators mounted to cylinders or ton containers, follow the manufacturer's procedures for connecting and disconnecting to the system. Otherwise, proceed according to the following subsection:

6.1.3.1 Cylinders and Ton Containers Unloading Gaseous or Liquid Chlorine

The cylinder or ton container must be secured properly. When connecting to the cylinder or ton container valve, the following precautions should be taken:

- Wear or equip yourself with the proper personal protective equipment (Section 8.2).
- Remove the valve hood or valve protection bonnet.
- Make certain that the packing nut is at least hand tight; if it is not, contact your supplier for advice.
- Make certain that the valve is closed before removing the outlet cap.
- Remove the valve outlet cap. Note that for ton containers with valves vertically aligned, the upper valves dispense gas and the lower valves dispense liquid.
- Make certain the valve face is clean and smooth.
- Use a new appropriate ring gasket to connect the yoke and the yoke adaptor to the valve. **Never reuse gaskets**.
- Tighten the yoke to make a seal, but do not over tighten.

6.1.3.2 Valve Operation/Unloading

- Using a wrench (50 ft/lbs maximum torque)/no longer than 8 inches, open the container valve to briefly introduce chlorine into the system and then close the valve. **Never use an extension (cheater) bar on the wrench.**
- Using only vapor from a 26 degree Baume or greater, aqua ammonia (ammonium hydroxide) solution (Section 4.3.1), test the yoke adaptor interface and the packing gland area for leaks. If any leaks are found, they must be remedied before proceeding (Subsection 4.3.1.1). Repeat this step if a leak was found.
- Using a wrench no longer than 8 inches, open the valve one complete turn. This is all that is required to achieve maximum gas flow rates.

- Open the appropriate valves in the piping system.
- Check again for leaks using only the vapors from an ammonia solution.

6.1.3.3 Disconnecting Cylinders and Ton Containers

Extreme caution must be exercised when disconnecting cylinders or ton containers that are not empty (If systems are equipped with automatic switch-over vacuum regulators, consult the manufacturer's literature for connection and disconnection procedures). This is especially critical in systems feeding liquid chlorine. Proceed with care as follows:

- Wear or equip yourself with the proper personal protection equipment (Section 9.2).
- Using a torque wrench, close the cylinder or ton container valve to a torque of 25 to 30 foot pounds.
- Let the pressure in the system drop to 0 psig by using the gas feed equipment to consume any residual chlorine, and apply a vacuum as appropriate for your systems design. When gauges indicate 0 psig or a vacuum, the appropriate piping system valve can be closed.
- If any leaks exist (the pressure increases in the line by the container), increase the torque to 40 foot pounds and retest for leaks. If the leak persists, use a maximum of 50 foot pounds of torque on the stem and repeat the above procedure.
- If the valve still leaks at 50 foot pounds, contact your supplier for advice.
- If the pressure in the line connected to the cylinder or ton valve remains constant at or below 0 psig, the yoke can be loosened and disconnected.
- Verify that an outlet gasket is in place and replace the valve outlet cap.
- Protect the yoke adaptor and chlorine line from the intrusion of moisture and moist air.
- Place a valve hood or bonnet on the cylinder or ton container as appropriate and mark as empty.
- Place the cylinder or ton container in an appropriate location for empty containers.

6.1.4 Tank Cars and Cargo Tanks

Chlorine tank cars must never be connected or unloaded by anyone not thoroughly trained about chlorine, the design of the car, and the unloading system. Each organization should have its own training program that covers these items. Pertinent details are beyond the scope of this document. See CI pamphlets 49 and 66. The chlorine supplier also can provide help with the training of personnel responsible for connecting to and unloading chlorine from a tank car or a cargo tank.

Opening the angle valve too quickly or allowing unusually high flow rates will cause the excess-flow valve to close. If this occurs, the angle valve should be closed and left closed until the metal ball in the excess-flow valve drops back into place with an audible click. If the ball does not fall into place, contact your chlorine supplier for advice. When unloading chlorine, the angle valve should be completely open and **never** used to control flow rate.

Automatic shut-off systems should be considered and may be required by local codes and regulations (CI Pamphlet 57).

6.2 Vapor Pressure/Temperature Relationship

A graph that shows the relationship between the chlorine vapor pressure and the temperature of the liquid chlorine is illustrated in Figure 7. From this figure it can be seen that the vapor pressure increases significantly as the chlorine temperature rises. Consequently, chlorine flow rates also can vary greatly depending on the temperature of the liquid chlorine.

It is possible that at very low temperatures a pressure gauge might read zero PSIG and indicate that a chlorine vessel is empty when, in fact, the chlorine vapor pressure is low due to the low temperature of the residual liquid chlorine in the container. A similar situation can occur if chlorine gas is withdrawn too quickly from cylinders and ton containers.

The remaining liquid chlorine can be cooled by the evaporating gas and result in reduced vapor pressure.

Tank cars and cargo tanks may need to be padded (CI Pamphlets 49 or 66) with oil-free dry air or nitrogen with -40°F (-40°C) dew point or lower to maintain acceptable unloading rates. If a tank car is padded and the liquid is piped to a vaporizer (evaporator), care should be taken in the vaporizing operation. This false high pressure will require more heat to raise the liquid temperature to the boiling (vaporizing) point. Liquid carryover could result. **Warning: Air padding is not an acceptable practice for unloading cylinders and ton containers.**

6.3 Unloading/Feed Rates

6.3.1 Cylinder Feed Rates

Chlorinator manufacturers use the approximation that cylinders of chlorine can be unloaded as a gas to a vacuum system at a continuous rate of 1 to 1.5 lb/day/°F of ambient temperature. For example, a vacuum system at 70°F (21°C) ambient temperature can achieve a feed a rate of 70 to 105 lb (32 to 48 Kg) per 24 hours. Higher rates can be achieved for short periods of time, but the rate decreases as the vaporization cools the remaining liquid chlorine.

6.3.2 Ton Container Feed Rates

For discharging chlorine gas, a dependable continuous discharge rate is 6 to 8 lb/day/°F into a line with a pressure less than 35 psi gauge (241 kPa). At 70°F (21°C), a discharge rate of 420 to 560 lb/day (191 to 255 Kg/day) can be achieved, and this rate may be greatly exceeded for short periods of time. A feed rate of 528 lb/day (240 Kg/day) is achievable when discharging into a vacuum chlorination system.

The dependable continuous discharge rate of liquid chlorine is at least 400 lb/hr (181 kg/hr) at 70°F (21°C) and against a discharge line pressure of 35 psi gauge (241 kPa).

Ton containers should never be padded with air or nitrogen.

6.3.3 Cargo Tanks and Tank Car Unloading Rates

The maximum flow for unloading cargo tanks and tank cars is determined by the rating of the excess flow valves. Cargo tanks are equipped with excess flow valves under all four angle valves. The liquid excess flow valves are rated at 7,000 lb/hr (3,200 kg/hr). Any instantaneous rate exceeding this value will seat the excess flow valve and stop the flow. (CI Pamphlet 49).

Tank cars are equipped with excess flow valves under the two liquid angle valves located on the longitudinal center of the car. They can be rated at either 7,000 lb/hr (3,200 kg/hr) or 15,000 lb/hr (6,800 kg/hr). While large-scale users may need to connect to both liquid valves for unloading, it is unlikely that a treatment plant would need to do this (CI Pamphlet 66).

7. BUILDING/STRUCTURE CONCERNS

7.1 Design and Construction

Local fire and building codes may dictate the legal requirements for buildings or other structures used to store or feed chlorine. Consultation with local government officials to determine what code and code year applies is essential. Buildings in which chlorine is stored should be made of noncombustible materials and should be free of flammable materials. Any building housing chlorine equipment or containers should be designed and constructed to protect all elements of the chlorine system from fire hazards.

If flammable materials are stored or processed in the same building, a fire wall should be erected to separate the chlorine from the flammables. Fire-resistant construction is recommended.

7.2 Electrical Systems

Chlorine is not classified as a flammable gas; therefore, no special code requirements exist with regard to electrical systems. However, chlorine gas is extremely corrosive and, in the event of a leak, the electrical system at a chlorine facility could be damaged by corrosion.

7.3 Ventilation and Air Openings

7.3.1 Ventilation

The Institute recommends that ventilation requirements be determined on a site-specific basis. Fire or building codes may dictate the minimum acceptable ventilation rate (See CI Pamphlet 65).

Safeguards should be in place to ensure that personnel without the appropriate personal protective equipment do not enter or remain in buildings where chlorine is present due to the potential of a leak or equipment failures.

7.3.2 Air Openings

Chlorine gas is heavier than air and will collect at floor level. The exhaust air intake should be located at or near floor level. The exhaust air discharge should be at a safe location. An elevated fresh-air inlet must be provided and should be positioned for adequate cross ventilation. Multiple fresh-air inlets and fans may be necessary to facilitate adequate ventilation. Fans, if used, should be operable from a safe remote location.

7.4 Heating

Rooms in which chlorine containers are stored should be maintained at a normal indoor temperature of 60° to 70°F (15° to 20°C) to facilitate gas discharge rates from the containers. The chlorination equipment should be housed in a room at the same or higher temperature. However, the temperature in chlorine use and storage areas must never exceed 130°F (54°C).

7.5 Absorption and Automatic Shut-Off Systems

Local fire and building codes should be consulted to determine if scrubber systems are required. Scrubbers are devices that remove chlorine from the air, and they are effective for containing chlorine releases.

CI Emergency Kits or cylinder containment vessels and trained responders to stop or contain chlorine leaks are adequate for most locations (Sections 3, 4.3, and 9). Any requirements for scrubbers should be based on a risk assessment that considers the quantity of chlorine on site and the proximity to and potential impact on nearby populations and facilities.

Automatic actuators or valves can be located on or next to the cylinder or ton container valve. They can be activated by a chlorine detector, fire alarm, seismic detector, or by a remote switch. Automatic closure devices are now cited in I.C.C. and NFPA Fire and Building Codes.

7.6 Sprinkler Systems

The Chlorine Institute does not recommend sprinklers for chlorine storage or use areas that are constructed of noncombustible materials and that are always free of flammable materials; however, some fire and building codes may still require them. If sprinklers are installed, they should be used only to suppress fires or to cool containers threatened by fire. Sprinklers are not effective in mitigating a chlorine leak or in serving as scrubbers. The presence of water (moisture) and chlorine can cause corrosion and exacerbate a leak.

7.7 Exits and Windows

Exits should be clearly marked. All exit doors should open outward to the outdoors and should be equipped with anti-panic hardware that allows for easy opening. Internal exit doors are not recommended. Each room should contain at least one window so the interior can be viewed without entering the building. All windows should be made of fire-resistant, non-shattering material. Local fire and building codes also should be reviewed.

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7.8 Gas Detection

Installations using or storing chlorine should have gas detection equipment in place to monitor for chlorine releases. Such equipment is particularly important when the facility is not staffed twenty-four hours a day. Chlorine detectors must be designed and adequately maintained to warn on-site personnel or to alert responders at a remote location of a release.

If the monitors are being used for leak detection as opposed to monitoring for Occupational Safety and Health Administration (OSHA) exposure limits (CI Pamphlets 1 or 65), different alarm settings may be required. Pertinent information should be available from the manufacturer of the detection equipment (CI Pamphlet 73).

8. SECURITY

Chlorine facilities should be protected against accidental or unauthorized entry. The vulnerability of each facility must be evaluated to determine the amount of security needed. The decision on the type of security will depend on factors such as location, proximity to other buildings, local codes, and so on. Buildings or areas should be surrounded by a fence, warning signs should be posted, and gates and doors should be locked. Access should be completely restricted and only personnel involved with the handling of the chlorine should be able to enter this area. (See CI Security Management Plan for the Transportation and On-Site Storage and Use of Chlorine Cylinders, Ton Containers and Cargo Tanks, August 15, 2003.)

9. EMPLOYEE TRAINING, SAFETY, AND PERSONAL PROTECTION EQUIPMENT

9.1 Plant Employee Training

9.1.1 General

To a great extent, safety in handling chlorine depends on the effectiveness of employee training, proper safety instructions, and the use of suitable equipment. It is the responsibility of the employer to train employees, to document such training as appropriate and to ensure such training and documentation is in compliance with the regulations (See CI Pamphlet 85).

It is the responsibility of employees to carry out correct operating procedures safely and to properly use the safety equipment provided. The Chlorine Institute maintains numerous publications and other materials to aid end users in the development of meaningful training programs. See the Chlorine Institute Catalog for a complete listing.

OSHA regulations define the training requirements for emergency response personnel. The regulation identifies several training levels according to the emergency response task, each having minimum training requirements (See 29 *CFR*, 1910.120).

In addition to the OSHA training, at a minimum, chlorine employee training should include the following subjects:

- Chlorine properties (Sections 2.2 and 2.3)
- Health hazards (Section 2.3.3)
- Chlorine containers (Section 3)
- Transporting, storing, and handling of chlorine containers (Section 4)
- Connecting, disconnecting, and unloading chlorine containers (Section 6)
- Chlorine leaks (Section 4.3)
- First aid (Section 11)

9.1.2 Supplier Support

Equipment and chemical suppliers can be valuable sources of information. These companies frequently have safety and handling guides, pamphlets, videos, and other training materials for customer use. Similar information is available through various associations and national organizations (Sections 9.1 and 9.3, and Section 13.2.)

9.1.2.1 Material Safety Data Sheets and Other Literature

Suppliers are responsible for providing material safety data sheets (MSDS) that contain a detailed assessment of chemical characteristics, hazards, and other information relative to health, safety, and the environment. These sheets provide the following information:

- Identification of chemical composition, Chemical Abstract Service (CAS) number, formula, molecular weight, and synonyms.

- Physical data on boiling, freezing, and melting points, specific gravity, solubility, and vapor pressure.

- Reactivity information such as incompatibility, decomposition products, and polymerization potential.

- Health hazard data on effects of exposure (acute and chronic), permissible exposure limits, and warning signals.

- Environmental impact potential, such as effects on the environment, and shipping and other pertinent federal regulations.

- Exposure control methods, such as personal protective measures and engineering and administrative controls.

- Work practices, such as handling and storage procedures, normal cleanup, and waste disposal methods.

- Emergency procedures for handling spills, fires, and explosions, as well as first-aid procedures.

Such basic vital information must be readily accessible to all employees as a reference source.

9.1.2.2 Emergency Assistance

Some chlorine suppliers have technical expertise and equipment that can be made available to a customer during an emergency. The availability of such emergency assistance should be ascertained before you begin handling chlorine. If additional help is needed contact Chemtrec at 1-800-424-9300 (see Table 5 for Canada, Alaska and Hawaii.) Chemtrec will activate CHLOREP if needed.

9.1.3 Other Training Information Sources

The Chlorine Institute maintains training materials and other publications that may be found in the Chlorine Institute Catalog, which organizes subjects into industry specific sub-categories such as the Water and Wastewater industry (See Section 13.1.).

Table 5. Typical Emergency Action Checklist

Action	Performed by	Date/Time
Alert key plant personnel.	discoverer of the problem	
Activate emergency response team if on site.	plant operator	
Determine seriousness of situation.	plant operator	
Ensure that employees are located in a safe area, are properly equipped and protected, and that all are accounted for.	plant operator	
Alert appropriate off-site authorities.	plant operator	
Ensure that employees who may have been exposed receive medical surveillance and treatment if necessary.	plant operator	
Attempt to stop or control release.	response team	
Obtain outside assistance: Supplier or CHLOREP via CHEMTREC Continental U.S.: 1- 800-424-9300 Alaska, Hawaii, D.C.: 1- 703-527-3887 Canada: Call collect - 1- 613-996-6666	team	
Bring the incident under control.	on-site coordinator	
Determine when normal operations can resume.	on-site coordinator	
Provide close-out report of incident.	on-site coordinator	

9.2 PERSONAL PROTECTION EQUIPMENT AND SAFETY

9.2.1 General Recommendations

Employees with respiratory diseases or reduced respiratory capacity should avoid working in situations where chlorine exposure is possible. Chlorine users should adopt a medical surveillance program suitable to their needs (See CI Pamphlet 63).

9.2.1.1 Clothing

In the general areas of a facility or in buildings where chlorine is stored or used, no specialized clothing is required for workers performing routine plant operations. However, long pants, shirts with sleeves, safety glasses with side shields or *goggles approved for use with hazardous chemicals*, hard hats, and safety shoes should be worn or be available as dictated by plant practice. They should be free of oil and grease (See CI Pamphlet 65).

9.2.1.2 Respiratory Protection

All personnel entering areas where chlorine is stored or handled should carry or have immediately available an escape-type respirator. Chemical cartridge or full-face canister gas masks offer adequate temporary protection provided the oxygen content in the air is greater than 19.5% and the chlorine concentration does not exceed the rated capacity of the respirator. The need to protect the eyes from chlorine should be part of the evaluation of appropriate respiratory equipment.

Pressure-demand self-contained breathing apparatus (SCBA), with full face piece, is required for performing tasks when chlorine may be present unless air sampling verifies the chlorine concentration is such that a lower level of respiratory protection is adequate. Emergency responders must have regularly scheduled and documented training to assure competency with SCBA. This SCBA apparatus should be located on site or at acceptable locations. If arrangements have been made to use an approved outside emergency response group, then the responders and apparatus may be located off site.

Fit testing and regular maintenance programs for respirator equipment are required and must be documented (29 *CFR* 1910.134(f) and Appendix A, (h) and (m)) (See CI Pamphlet 65).

9.2.2 Specific Recommendations

This section addresses only the need for personal protective equipment (PPE) in connection with initial line breaks and the routine operations of unloading containers performed by treatment plant personnel. Emergency response operations are covered in Section 9.

These recommendations should supplement the facility's:

- written operating and maintenance procedures
- emergency response plan (ERP)
- established programs for training employees

It is assumed that the facility has performed a detailed job safety analysis of the specific task being performed. If an analysis concludes that a lower level of PPE is adequate for the employee(s) performing the operations, such lower level PPE must be fully compatible with these recommendations.

9.2.2.1 Line Break

A line break is defined as the opening of a line, section of a line, a vessel, or other equipment that contains or previously contained chlorine and includes equipment that was returned to chlorine service and is reopened to the atmosphere. An initial line break is considered a maintenance activity and does not include the act of connecting or disconnecting containers for loading and/or unloading purposes or material sampling activities.

For line breaks that have been routinely performed in the past, and have demonstrated that the evacuation techniques and maintenance procedures utilized do not result in chlorine concentrations that exceed either the OSHA ceiling limit or the safety rating of the respirator, then the following PPE recommendations apply (See CI Pamphlet 65):

- For chlorine gas, use a full-face air purifying respirator
- For chlorine liquid, use a full-face air purifying respirator and gloves that provide thermal protection.

9.2.2.2 Unloading Chlorine

For a facility that meets the following:

- Is experienced in the unloading of chlorine;
- Is equipped with a system for purging and evacuating piping, hoses and other unloading equipment;
- Has had an industrial hygiene sampling performed which supports that the techniques in place result in a chlorine concentration below the time-weighted average (TWA) and the short term exposure ceiling (STEL);
- Has written operating and maintenance procedures;
- And has trained their employees.
- For chlorine gas, no specialized PPE is needed
- For chlorine liquid, no specialized PPE is needed

If loading/unloading procedures result in a chlorine concentration that exceeds the TWA level or the STEL ceiling, but does not exceed the safety rating of the respirator, then the following recommendations apply (See CI Pamphlet 65):

- For chlorine gas, use a full-face air purifying respirator
- For chlorine liquid, use a full-face air purifying respirator and gloves that provide thermal protection

If testing or evaluation work has not been performed, or if performed with results that show chlorine levels exceeded the safety rating of the respirator, then these recommendations apply (See CI Pamphlet 65):

- For chlorine gas, use an air supply respirator
- For chlorine liquid, use an air supply respirator and gloves that provide thermal protection

9.3 OTHER SAFETY EQUIPMENT

An emergency eyewash and a deluge shower should be located near the potential exposure site but not so close as to be unusable in an emergency. The path to the unit must remain clear of all obstructions. There are OSHA standards that define eyewash/safety shower parameters, i.e., flow rates and temperature along with other considerations such as protection against freezing (29 *CFR* 1910.151(c)).

10. HANDLING EMERGENCIES

10.1 PLANNING

The presence and use of chlorine can be a potential hazard to both facility employees and the surrounding community. In recognition of this potential, federal law and many state laws require that written emergency plans be developed to prevent, mitigate, and guide response to a chlorine release. There are at least two planning efforts required for each water or wastewater treatment facility: one that addresses protecting the community from a chlorine release and one for protecting employees.

Before an emergency plan is written, a risk assessment for the facility is recommended. A risk assessment is the process of collecting and analyzing information in order to determine what chemical hazards and process risks are present at a facility that could impact employees or the public. Sites with more than 1,500 lb of chlorine in a single process are required to do a risk assessment under the Process Safety Management (PSM) regulations stipulated by OSHA in Section 1910.119 of 29 *CFR* (Appendix C). The Environmental Protection Agency (EPA) requires a risk management plan (RMP) for sites where chlorine exceeds 2,500 lb in a single process, as given in 40 *CFR* 68 (Appendix D).

At the time this document was published, there were two generic RMPs involving chlorine that could provide information useful in preparing plans suited to specific facilities. One, designed for treatment plants, was prepared by the EPA and the Research Foundation of the American Water Works Association (AWWA), The Risk Assessment Methodology for Water Utilities (2003). The other, available from the Chlorine Institute (CI Pamphlet 162), applies to chlorine packaging plants and sodium hypochlorite manufacturers. These plans can assist in preparing RMP plans for treatment plants.

RMP planning must include consideration for monitoring, detection, and alarm equipment. Selection of the appropriate emergency personnel, assignment of responsibilities, quantity release estimate, mutual assistance (supplier, hazardous materials [HAZMAT] teams, fire departments, etc.), necessary notification requirements (facility and off site), decision making, first-aid needs, and containment should be covered in a set of procedures included in the written plan.

Additional planning considerations should include the technical expertise, scientific instrumentation, heavy equipment, and transportation vehicles that may be needed during an emergency. An inventory of locally available items should be accessible to responders. Likewise, the locations of emergency kits for cylinders, ton containers, cargo tanks, and rail cars should be known. The availability of emergency breathing apparatus, showers, and eye-wash stations and their locations should be known.

10.2 ESTABLISHING PROCEDURES

Emergency response procedures are concerned with the efforts of employees from outside the immediate release area or by other designated responders in dealing with an occurrence that 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 the employees in the immediate release area or by maintenance personnel are not considered to be emergency responses (29 *CFR* 1910.120).

The procedures established should outline the proper coordination and communication between plant personnel, their plant management, and outside agencies. Community response personnel must include fire department, police department, emergency medical personnel, and HAZMAT teams at the least. State or local regulations may have additional requirements.

Each treatment plant should develop its own emergency action checklist, which should be readily available for facility personnel to aid in response. Table 5 lists typical key actions that are to be taken in the event of a chlorine emergency. It should be considered as a guide to aid the treatment plant operator. More detailed assistance is available from OSHA, EPA, and state regulatory agencies.

Assistance and information during the planning process is available from your chlorine suppliers and CI Pamphlet 64. In an emergency situation, responders should be called in the order dictated in your emergency response plan (ERP). These may include the fire service, your chlorine supplier, or another local emergency response team. If you cannot obtain assistance during an emergency, you can contact Chemtrec by calling the toll-free number on your shipping papers (see Table 5). Chemtrec is primarily designed to assist in transportation emergencies and should be used in other situations only as a last resort.

10.3 TRAINING

10.3.1 Materials and Sources

Training programs and materials are available from a variety of sources, including chlorine suppliers, state and local government agencies, and organizations such as the CI, AWWA, WEF, and NFPA. The best starting point for identifying training resources is the local emergency planning committee (LEPC) for your area (Contact your State Emergency Response Commission for LEPC information) as well as your supplier. (See CI W-Video.)

10.3.2 Facility Personnel

Treatment plant employees should be trained in the emergency response plan, in safety procedures for the handling and use of chlorine, and in the use of self-contained breathing apparatus and other applicable equipment. The training requirements depend on the specific employee's roles and responsibilities. Each plant should have a training program customized to its specific needs depending on the type of facility, type and number of chlorine containers, and number of employees. The site should keep written documentation of all training.

10.3.3 Emergency Responders

Emergency responder training requirements are based on the response level (Table 6) and type of job responsibility assigned to each responder. The following list includes the various response levels of those who may be present at the site of an emergency, and brief descriptions of their responsibilities:

- **First Responder, Awareness Level**: Persons who, in the course of their normal duties, may be first on the scene of an emergency involving a hazardous substance. They are expected to notify the proper authorities as indicated in the plant's emergency response plan and take no further action.

- **First Responder, Operations Level**: Persons involved in the initial response to a release or potential release of hazardous substances for the purpose of protecting nearby persons, the environment, or property from the effects of the release. They are trained to respond defensively without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures.

- **Hazardous Materials Technician**: Persons who respond to a release or potential release for the purpose of stopping the release. They assume a more aggressive role than first responders at the operations level do in that they will approach the point of release and attempt to plug, patch, or otherwise stop the release.

- **Hazardous Materials Specialist**: Persons who respond with and provide support to hazardous materials technicians. Their duties parallel those of the technicians but require a more specific knowledge of the various substances they may be called on to contain. The specialist also may act as the site liaison with federal, state, local, and other government authorities regarding site activities.

- **On-Scene Incident Commander**: The person who is responsible for directing and coordinating all aspects of a hazardous incident.

- **Skilled Support Personnel**: Persons who are skilled in operating certain equipment (e.g., backhoe or crane) and are needed temporarily to perform immediate emergency support work.

- **Specialist Employees**: Persons who, in the course of their regular job duties, work with and train in the hazards of specific hazardous substances, and who may be called on to provide technical advice or assistance.

It is beyond the scope of this pamphlet to provide the details of a training program for emergency responders; however, a summary of the training requirements is given in Table 6. Actual training requirements for each level of responder are given in 29 *CFR* 1910.120. Because these regulations change, you should review 29 *CFR* periodically.

Table 6. Summary of HAZMAT Responders Training Requirements

Response Level	Minimum Training Requirement
Awareness level	Understanding of hazardous materials, including their risks, and of how to secure the site and notify others in case of an emergency
First responder, operations level	8 hours of training, including awareness-level topics
Hazardous materials technician	24 hours of training, including operations-level topics
Hazardous materials specialist	24 hours of training equal to technician-level competency
On-scene incident commander	24 hours of training equal to operational level plus competency in commanding incidents and implementing emergency response plans
Skilled support personnel	Initial pre-entry briefing
Specialist employees	Annual training and competency in area of specialization

10.4 AUDITS AND EXERCISES

An effective way to determine the adequacy of a treatment plant emergency plan is to have periodic audits and exercises. Audits should be performed with various facility response personnel to test their knowledge of duties and equipment, along with periodic auditing on actual use of the equipment. Exercises should be conducted to test the participants' reactions and effectiveness in implementing the emergency plan as well as to test the actual mechanics of the plan.

There are basically three types of exercises: the full-scale exercise, the in-plant exercise, and the table-top exercise. Consideration should be given to conducting full-scale exercises utilizing responders from the community at least once a year. Periodic in-plant exercises should use different simulated events and involve as many of the various personnel as possible. These exercises should be conducted similarly to full-scale exercises but would not involve outside emergency personnel.

Table-top exercises should be conducted periodically to check the ability of the emergency response crews to analyze an event, communicate effectively to outside emergency response personnel, and respond to unfolding events. This type of exercise is usually conducted with just the supervisors of key emergency response personnel, both in-plant and from outside agencies.

Following any of the exercises, a critique should be made to assess the effectiveness of the plan and to pinpoint any weaknesses in it or in the training and knowledge level of the personnel involved. A written report of the exercise should be available for review and the facility's emergency plan should be modified as needed.

11. MEDICAL ASPECTS

11.1 HAZARDS TO HEALTH

11.1.1 General

Chlorine gas is primarily a respiratory irritant. At low concentrations chlorine gas has an odor similar to household beach. As the concentrations increase from the level of detection by smell, so does symptomatology in the exposed individual. At chlorine concentrations above 5 ppm 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. If the symptoms persist for more than a few hours, the effects of exposure to chlorine may become more severe for several days after the incident. In such cases, observation of exposed individuals should be a part of the medical response program (See CI Pamphlet 63 for more detailed information).

The following list is a compilation of chlorine exposure thresholds and reported responses in humans (with considerable variation among subjects):

Table 7. Chlorine Exposure Thresholds and Reported Responses

0.2 – 0.4	Odor threshold (decrease in odor perception occurs over time)
1 – 3 ppm	Mild mucous membrane irritation, tolerated up to 1 hour
5 – 15 ppm	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
30 ppm	Immediate chest pain, vomiting, dyspnea, cough
40 – 60 ppm	Toxic pneumonitis and pulmonary edema
430 ppm	Lethal over 30 minutes
1000 ppm	Fatal within a few minutes.

11.2 ACUTE TOXICITY

11.2.1 Respiratory/Cardiovascular

The toxic effects of chlorine are due to its corrosive properties. Chlorine is water soluble and primarily removed by the upper airways. As indicated above, exposure to low concentrations of chlorine gas may cause nasal irritation as well as irritation of the mucous membranes of the respiratory tract. As concentrations increase, there is an increase in the irritating effect on the upper and lower respiratory tract manifested as coughing with eventual difficulty in breathing. Inhalation of chlorine gas (>15 ppm) may lead to respiratory distress associated with airway constriction and accumulation of fluid in the lungs (pulmonary edema).

As the duration of exposure and/or the concentration increase, the affected individual may develop the immediate onset of rapid breathing, wheezing, rales, or hemoptysis.In extreme cases difficulty in breathing can progress to the point of death through cardiovascular collapse from respiratory failure. An exposed person with a pre-existing respiratory condition can have an exaggerated response. Cases of Reactive Airways Dysfunction Syndrome (RADS), a chemical irritant-induced type of asthma, have been reported.

11.2.2 Dermal

Liquid chlorine in contact with the skin will cause local chemical or thermal (frostbite) burns. Gaseous chlorine in contact with the skin can dissolve in body moisture (i.e., perspiration) to form hypochlorous and hydrochloric 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.

11.2.3 Eyes

Low concentrations of chlorine in the air can result in eye irritation, associated burning discomfort, spasmodic blinking, redness, conjunctivitis and tearing. Exposure to higher concentrations of gaseous chlorine may result in more serious injuries. Liquid chlorine in contact with the eyes will result in serious thermal and/or chemical burns.

11.3 CHRONIC TOXICITY

Most studies indicate no significant connection between adverse health effects and chronic exposure to low concentrations of chlorine.

11.4 CI HEALTH VIDEO

A health video, outlining the short term health effects is available from The Chlorine Institute. (See H-VIDEO or H-DVD.)

12. FIRST AID

First aid is the immediate temporary treatment given to an exposed individual. Prompt action is essential. Reassurance to the individual will help to alleviate anxiety. When indicated, medical assistance must be obtained as soon as possible. Never give anything by mouth to an unconscious or convulsing person. If chlorine has saturated an exposed individual's clothes and/or skin, decontamination should be done by removing affected clothing and showering as appropriate. (See CI Pamphlet 63 for more detailed information.)

Responders should take the necessary precautions to protect themselves from any exposure to chlorine while administering first aid and should move the victim from any contaminated area as quickly as possible.

12.1 INHALATION

An individual with chlorine exposure should be evaluated for adequate airway, breathing and circulation after the inhalation. If breathing has apparently ceased, the victim should be given cardiopulmonary resuscitation (CPR) immediately. If breathing has not ceased, the exposed individual should be placed in a comfortable position. The person should sit in an upright position with the head and trunk elevated to a 45-60 degree position (unless there is a medical contraindication). Slow, deep breathing should be encouraged. Vital signs (respiratory rate, pulse, and blood pressure) and oxygen saturation should be obtained if trained personnel and equipment are available.

Suitable equipment for the administration of oxygen should be available either on site or at a nearby facility. Such equipment should be periodically tested.

Historically, oxygen therapy, specifically humidified oxygen, has been considered the primary treatment for chlorine inhalations. Humidified oxygen is preferred since the humidity soothes the irritation to the mucous membranes caused by the chlorine. Oxygen without the humidity can have a drying effect, thus potentially aggravating the irritant symptoms. However, if humidified oxygen is not available, oxygen without the humidity should not be withheld if oxygen therapy is indicated. With the advance in technology, equipment (pulse oximeter) is now available which can quickly measure the oxygen saturation in an individual. This measurement may be helpful in deciding whether supplemental oxygen is needed after a chlorine inhalation.

Oxygen therapy may not be necessary for all cases of chlorine inhalation. However, in any case in which an individual with a chlorine inhalation continues to be symptomatic after leaving the area of exposure, oxygen therapy is recommended unless it can be determined that it is not needed. **The circumstances in which oxygen therapy is not needed should be defined in advance by a physician, based on the clinical findings and a case by case determination made by first aid providers specifically trained in this area.**

12.1.1 Administration of Oxygen

Oxygen should be administered by first aid providers trained in the use of the specific oxygen equipment under the guidance of a licensed health care professional.

If a pulse oximeter is not available, oxygen therapy is recommended for any individual who has inhaled chlorine and continues to be symptomatic after leaving the area of exposure.

583 of 593

If a pulse oximeter is available, the following findings comprise a base list of situations in which oxygen therapy is generally indicated to be given by first aid providers after a chlorine inhalation. Other criteria may be added to this list if specifically recommended by a physician:

- Sustained pulse-oximetry readings <92%; or
- The individual is in obvious respiratory distress (including, but not limited to rapid respirations, difficulty breathing, using accessory muscles for respiration, continuous uncontrollable coughing, wheezing); or
- The exposed individual is having "symptoms of concern", such as significant chest pain/tightness, extreme weakness, altered/declining mental status, or the individual is diaphoretic (clammy/pale/sweating not due to environmental conditions) etc., especially if these or other significant symptoms occur with an individual with a past history of cardiac problems or asthma ; (Note: "symptoms of concern" generally do not include the typical upper respiratory tract irritation symptoms which occur with mild chlorine gas inhalations such as mild/moderate coughing, initial difficulty "catching one's breath", mild/moderate shortness of breath, irritated throat, runny nose, congestion, headache, and/or mild nausea)

Note: It is recommended that a physician be consulted regarding any individual meeting one or more of the above criteria in order to determine whether further evaluation and or treatment is indicated.

If oxygen therapy is indicated, it should be administered until the symptoms resolve. Whenever oxygen is discontinued after symptoms resolve, the individual should then be observed for 30-60 minutes while breathing room air. If significant symptoms do not resolve within 60 minutes of oxygen therapy, or symptoms return/worsen and/or the oxygen saturation (when pulse oximetry is available) falls below 92%, it is recommended that oxygen therapy be restarted (if it had been discontinued) and further evaluation by a physician be provided.

12.1.2 Administration of Humidified Breathing Air

Not all individuals who have inhaled chlorine require oxygen therapy. It is recommended that the circumstances in which oxygen therapy is not needed should be defined in advance by a physician and a case by case determination made by first aid providers specifically trained in this area.

In situations where it has been determined that oxygen therapy is not needed, but the individual with an inhalation exposure has irritant symptoms, humidified air may be provided for symptomatic care. While breathing humidified air, the individual should be closely monitored for 30 - 60 minutes. If the individual continues to show no signs or symptoms for which oxygen would be indicated, the humidified air can be stopped. Observation should continue for an additional 30 minutes while the individual is breathing room air so as to insure that there is no deterioration of the individual's condition. Oxygen therapy should be started at any time during the above process if symptoms worsen to the point that oxygen is indicated. Further evaluation by a physician should be provided in any case in which oxygen therapy is provided.

12.1.3 Symptomatic care

Other symptomatic care measures, such as cool compresses to the face and over-the-counter medications, may help to minimize symptoms. Over-the-counter medications which may be helpful include:

- Irritated/sore throat – throat lozenges
- Dry cough – dextromethorphan, guaifenesin
- Headaches – acetaminophen, aspirin, ibuprofen
- Upset stomach – antacids

12.2 CONTACT WITH SKIN

If liquid chlorine has contaminated the skin or clothing, an emergency shower should be used immediately and contaminated clothing should be removed under the shower. Flush contaminated skin with copious amounts of tepid water for 15 minutes or longer. Thermal burns, due to the cold temperature of liquid chlorine, may be more damaging than any chemical reaction of chlorine and the skin. Exposure to gaseous chlorine can irritate the skin. Do not attempt chemical neutralization or apply any salves or ointments to damaged skin. Refer to a qualified health care provider if irritation persists after irrigation or if skin is broken or blistered.

12.3 CONTACT WITH THE EYES

If the eyes have been irritated due to exposure to chlorine, they should be flushed immediately with copious quantities of tepid water for at least 15 minutes.

▸ Never attempt to neutralize with chemicals.

The eyelids should be held apart during this period to ensure contact of water with all accessible tissue of the eyes and lids. Medical assistance must be obtained as soon as possible. If such assistance is not immediately available, eye irrigation should be continued for a second 15-minute period. Nothing but water should be applied unless ordered by a qualified heath care provider.

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*** A Free Publication: These publications may be downloaded free from CI's website: www.chlorineinstitute.org.**

13.2 Directory of Organizations

American Conference of Governmental Industrial Hygienists
1330 Kemper Meadow Drive
Cincinnati, OH 45240
513-742-2020
www.acgih.org

American Chemistry Council
1300 Wilson Boulevard
Arlington, VA 22209
703-887-1272
www.americanchemistry.com

Compressed Gas Association
1725 Jefferson Davis Highway
Crystal Square 2, Suite 1004
Arlington, VA 22202-4102
703-412-0900
www.cganet.com

Chemical Industry Institute of Toxicology
P.O. Box 12137
Research Triangle Park, NC 27709
919-558-1200
www.thehamner.org

Water Environment Federation
601 Wythe Street
Alexandria, VA 22314
1-800-666-0206
www.wef.org

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235
303-794-7711
www.awwa.org

The Chlorine Institute Inc.
1300 Wilson Boulevard
Arlington, VA 22209
703-741-5760
www.chlorineinstitute.org

International Code Council
500 New Jersey Avenue, NW/6th Floor
Washington, DC 20001
1-888-422-3233
www.iccsafe.org

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471
617-770-3000
www.nfpa.org

United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460
202-564-5700 (Office of Water)
202-564-8600 (Office of Emergency Management)
www.epa.gov

APPENDIX A

SARA TITLE III REPORTING REQUIREMENTS

The Emergency Planning and Community Right-to-Know Act (EPCRA) is also known as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (42 *CFR*). Five sections of this act apply to water and wastewater treatment facilities. They are summarized as follows:

- Section 302 requires that any facility having on its premises more than 100 lb of chlorine must report this fact to the State Emergency Response Commission. This is a one-time reporting requirement. Other extremely hazardous substances not typically found at treatment facilities must also be reported.

- Section 303 requires that any facility that has reported in accordance with section 302 must provide to the local emergency planning committee (LEPC) the name of its facility emergency coordinator who will participate with the LEPC in the emergency planning process. The facility must also provide to the LEPC any information requested for plan development and implementation.

- Section 304 requires that any facility that releases 10 lb or more of chlorine into the environment must immediately report the release to the community emergency coordinator, the state, and the National Response Center. The initial contact of this notification must be followed-up by a written notification to the same parties. The contents of the notification are also stipulated in this section. The routine release of chlorine into water and wastewater for treatment purposes does not have to be reported. Failure to report to the National Response Center (800-424-8802) in a timely manner (as soon as an RQ is believed to be exceeded and absolutely within a 24-hour time frame) can result in criminal and civil penalties. (See CI Pamphlet 64.)

- Section 311 requires that any facility having 100 lb of chlorine on its premises at any one time must submit a material safety data sheet (MSDS) for chlorine, or a list of the hazardous chemicals, including chlorine, that are on its premises, to the local fire department, the local emergency planning committee, and the State Emergency Response Commission. If an MSDS is submitted, it must be resubmitted whenever there is a significant change in it.

- Section 312 requires that any facility having 100 lb of chlorine on its premises at any one time during a calendar year must prepare and submit, before March 1 of the following year, an Emergency and Hazardous Chemical Inventory Form (either Tier I or Tier II) to the State Emergency Response Commission, the emergency planning committee, and the local fire department. This is an annual requirement.

For further information on the EPCRA law, contact your local emergency planning committee of the State Emergency Response Commission.

APPENDIX B

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REGULATIONS

The following sections of Title 29 of the *Code of Federal Regulations* (29 *CFR*) are pertinent to the operation of facilities utilizing chlorine as part of the process.

29 *CFR* 1910.120: Hazardous Waste Operations and Emergency Response

Any facility having an extremely hazardous substance, such as chlorine, on its premises must develop an emergency response plan and train its employees in the implementation of that plan.

Each employer shall develop an emergency response plan that shall address, at a minimum, the following elements:

Pre-emergency planning and coordination with outside parties. Personnel roles, lines of authority, training and communication. Emergency recognition and prevention.

Safe distances and place of refuge.

Site security and control.

Evacuation route and procedures.

Decontamination.

Emergency medical treatment and first aid.

Emergency alerting and response procedures.

Critique of response and follow-up.

Personal protective equipment (PPE) and emergency equipment.

29 *CFR* 1910.1200: Hazard Communications

Employers shall provide employee training on the chemical hazards that may be encountered on the job. The training program must contain the following items:

Guidance on how to read and understand the MSDS.

Information on the location of the facility's emergency response plan and what the employees' responsibilities would be during an emergency.

Education as to the physical and health hazards of chlorine gas and any other hazardous material that may be present in the employees' work place.

Procedures that employees can take to protect themselves from health hazards.

Information regarding actions taken by the employer to provide protection, such as emergency procedures and personal protective equipment, and so on.

29 *CFR* 1175.1: General Requirements

Compressed gases shall be stored, handled and used in accordance with generally accepted standards.

Cylinders, pressure vessels or containers shall be identified as to the gas contained therein.

Compressed gas cylinders in storage or in service shall be secured to prevent falling or being upset, and shall be protected against tampering by unauthorized persons.

Storage tanks and cylinders located in areas subjected to traffic shall be protected against vehicle damage.

Compressed gas cylinders when not being used shall have their protective caps in place over the valve assembly.

In addition to these sections from 29 *CFR*, you should review the following OSHA regulations in 29 *CFR* concerning the specific topics indicated:

Section 1910.132 -139 on personal protective equipment

Section 1910.38(a) on employer emergency plans and fire prevention plans

For further information on OSHA regulations as they apply to government-owned or government-operated facilities, contact the state department of labor, public employees' safety and health, or a similar organization in your state.

APPENDIX C

PROCESS SAFETY MANAGEMENT

The Clean Air Act Amendments of 1990 mandated, under the OSHA act of 1970 that a chemical process safety standard be set to prevent accidental releases of chemicals that pose a threat to employees. It targets highly hazardous chemicals that have the potential to cause a catastrophic incident both in the workplace and the surrounding community. As a result, "Process Safety Management of Highly Hazardous Substances" (29 *CFR*) covers more than 3 million U.S. workers at nearly 25,000 sites. Sites with 1,500 pounds or more of chlorine in a single process must comply with PSM.

Process safety management is the proactive identification, evaluation, and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures, or equipment. The major objective of a chemical process safety program is to prevent unwanted releases of hazardous chemicals, especially into locations that could expose employees and others to serious hazards. An effective program requires a systematic approach to evaluating the entire process including design, technology, operational and maintenance activities and procedures, non-routine activities, and training programs. A complete process safety management program includes the following elements:

- Introduction to process safety management
- Employee involvement
- Process safety information
- Process hazards analysis
- Operating procedures
- Employee training
- Requirements applicable to contractors
- Pre-start safety
- Mechanical integrity
- Non-routine work permits
- Managing change
- Incident investigation
- Emergency preparedness
- Compliance audits

To control hazards, employers need to develop the necessary expertise, judgment, and proactive initiative within their workforce to properly implement and maintain an effective process safety management program as envisioned by the OSHA standard.

The various lines of defense that have been incorporated into the design and operation of the process to prevent or mitigate the release of hazardous chemicals need to be periodically evaluated and strengthened to assure their effectiveness at each level.

APPENDIX D

RISK MANAGEMENT PROGRAM

You are covered by the Risk Management Program Rule (RMPR) if you operate a stationary source and have more than 2,500 pounds of chlorine in a process.

The Environmental Protection Agency (EPA) defines stationary sources as buildings, structures, equipment, installations, or substances emitting stationary activities that belong to the same industrial group, which are located on one or more contiguous properties, which are under the control of the same person (or persons under common control) and from which an accidental release may occur (40 *CFR*). The term stationary source does not apply to transportation including storage incident to transportation of any regulated substance, but it does include transportation containers used for storage not incident to transportation and transportation containers connected to equipment at a stationary source for loading or unloading.

This issue is not fully resolved because there is some confusion among several government agencies over regulating and enforcement authority. However, it is the intent of the EPA to apply the RMPR to chlorine tank cars and tank trucks unloading or feeding a process at a facility. In addition, the amount of chlorine in transportation vehicles is an important factor in determining worst-case and alternate scenarios and complying with other parts of the Rule.

The EPA defines process to mean any activity involving a regulated substance, including any use, storage, manufacturing, handling, or on-site movement of such substances, or any combination of these activities. Any group of vessels that are interconnected, or separate vessels that are located in such a way that a regulated substance could be involved in a potential release, is considered a single process. The EPA also says that the owner or operator of a facility must make a reasonable determination as to whether two or more vessels may be involved in the same accident, or whether a release from one vessel may be likely to lead to a release from another.

To our knowledge, neither the Occupational Safety and Health Administration (OSHA) nor the EPA has issued guidelines further refining this definition of process. Each individual site must use the guidelines that are given to determine the number of processes it has. Since the two agencies will not issue additional guidelines, the Chlorine Institute cannot do so either.

If the RMPR applies to your facility, then you will be required to develop a formal risk management program and to register and submit a risk management plan (RMP). The regulations apply to 77 toxic substances (including chlorine, anhydrous ammonia, and sulfur dioxide) and 63 substances that are flammable when certain threshold amounts are met or exceeded in a process. Many of the requirements are similar to Process Safety Management (PSM) rules developed by OSHA (Appendix C), but there are important additional requirements.

The EPA regulations go beyond the PSM rules and require facilities to determine the effect potential workplace chemical accidents may have in the surrounding community. Also, the EPA rules require facilities to register and submit certain data about your risk management program to government agencies and local emergency planning committees (LEPCs), as well as make it available to the general public.

Note: In addition, the list of chemicals covered and the threshold amounts are different for the PSM and RMP. It is technically possible to be covered by the PSM but not by the RMP except under the general duty clause.

Compliance with both the OSHA standard and the EPA's RMP is required by the Clean Air Act Amendments. Operators who incorporate the stipulations of both sets of requirements will be better equipped to meet full compliance while enhancing their relationship with the local community.

The deadline for completing all of the elements in the Risk Management Program and for registering and submitting the RMP is the day you first have a quantity over the threshold in a process.