Process Safety Management
Section 3.0
Process Safety Information
OSHA 29 CFR Part 1910.119 (d)
USEPA 40 CFR Part 68.65

DRAFT

Introduction

The purpose of this section is to document the written process safety information related to the operation of the NTP chlorination system. This Process Safety Information includes information pertaining to the hazards of chlorine, process technology, and process equipment.

Hazards of Chlorine

PROPERTIES OF CHLORINE

Chlorine is a gas at normal temperatures and pressures and is a strong oxidizing agent. It is also extremely toxic and is considered a hazardous substance.

Chlorine, either liquid or gaseous, is not explosive and is non-flammable, but because of its very strong oxidizing properties, it is capable of supporting combustion of certain substances. Chlorine reacts readily with many organic chemicals, sometimes with great violence. This chemical does not react with most metals at temperatures below 250°F, but the presence of moisture causes chlorine to be very corrosive to all common metals.

Chlorine gas has a distinct and characteristic odor and greenish-yellow color. The gas is about 2.5 times heavier than air, and therefore will settle to the lowest level in a building or structure if it escapes from containers or pipelines. Liquid chlorine is clear and amber in color and is about 1.5 times heavier than water. One volume of liquid chlorine will vaporize to approximately 460 volumes of chlorine gas. Table 3 - 1 summarizes the physical properties of chlorine.

*TABLE 3 - 1 PHYSICAL PROPERTIES OF CHLORINE		
PROPERTY	**LIQUID**	**DRY GAS**
Boiling point at 1 atm (101.3 kPa)	- 34.05°C - 29.29°F	
Melting point at 1 atm (101.3 kPa)	- 100.98°C - 149.76°F	
Density	88.79 lb/cu ft at 60°F (16°C) (85.61 psia) (1422 kg/m^3)	0.2003 lb/cu ft at 32°F and (0°C) 1 atm (101.3 kPa) (3.2 kg/m^3)
Color	Clear amber	Greenish-yellow
Odor	Penetrating, irritating	Penetrating, irritating
Specific Gravity	1.468 at 32°F (0°C) and 3.617 atm (366 kPa)	
Relative vapor density		2.482 at 32°F (0°C) and 1 atm (101.3 kPa)

*Note: Properties obtained from the AChlorine Manual≅ of the Chlorine Institute, Inc. Property values listed in different sources may vary due to differences in experimental temperatures and pressures.

HEALTH IMPACT OF CHLORINE EXPOSURE

Chlorine gas is very irritating to the mucous membranes of the nose, throat and lungs when inhaled. Exposure to even small doses can cause severe coughing, while heavy exposure (greater than 1000 ppm or 0.1 % by volume in air) can be fatal. Table 3-2 summarizes the physiological response to various concentrations of chlorine gas.

*TABLE 3 - 2 PHYSIOLOGICAL RESPONSE TO CONCENTRATIONS OF CHLORINE GAS	
EFFECT	**PPM OF Cl_2 GAS**
Slight symptoms after several hours exposure.	1
Threshold value for detectable odor	0.08
60 - minute inhalation without serious effects	4
Noxiousness	5
Throat irritation	15
IDLH (Immediately Dangerous to Life and Health)	10
Coughing	30
Dangerous from one-half to one hour	40
Death after a few deep breaths	1000

***Note**: Information obtained from the following references: Threshold value for detectable odor from "Odor Thresholds for Chemicals with Established Occupational Health Standards", IDLH value taken from AHazardous Materials Handbook,≅ Richard P. Pohanish and Stanley A. Greene, 1996, "Operation of Wastewater Treatment Plants", California State University, 1990. American Industrial Hygiene Assoc., 1989.

At low concentrations, chlorine gas is defined as a respiratory irritant. It is so intensely irritating that very low concentrations in air are readily detectable. Exposure to low concentrations in air usually result in minor irritating effects and may produce slight symptoms after several hours of exposure. Persons repeatedly exposed to such conditions, however, have shown no chronic effects.

Higher concentrations of chlorine in air produce irritation of the mucous membranes, the respiratory system, the skin, and the eyes. Coughing and labored breathing result. If the duration of exposure or the concentration is excessive, general excitement of the person affected, accompanied by restlessness, throat irritation, sneezing and copious salivation may result. The symptoms of exposure to high concentrations are vomiting, followed by difficult breathing. In extreme cases, difficulty in breathing is followed by death from pulmonary edema or suffocation.

To assure worker safety, OSHA has set an IDLH concentration of 10 ppm. At this concentration, workers are required to immediately evacuate the area. OSHA defines an immediately dangerous to life or health situation as follows:

> An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere. [29 CFR Part 1910.120]

MATERIAL SAFETY DATA SHEET FOR CHLORINE

The Chlorine Material Safety Data Sheet (MSDS) meeting the requirements of 29 CFR Part 1910.1200(g) is provided as Attachment 3-1 following this section. The data sheets include information on the physical and chemical characteristics of chlorine, along with safety information. The MSDS include toxicity information; permissible exposure limits; physical, reactivity, corrosivity, thermal, and chemical stability data. Chemical characteristics may vary from source to source due to varying experimental temperatures and pressures.

Water Treatment Plant - Chlorination System Overview

The Chlorination System at the WTP transports chlorine gas to the injectors. This process is used to disinfect the water before it enters the distribution system. The WTP Chlorination System is located in the Chemical Building where specific tasks involved with the chlorination process are carried out. This design isolates equipment in the event of gas leaks, spills, electrical fires, or electrical damage. The chlorination area in which employees may be exposed to chlorine is equipped with emergency ventilation and an eyewash / shower area.

CHLORINE STORAGE

The chlorine storage area is located in the chemical building in the general area of the chlorination equipment. The storage area can house six one-ton containers of pressurized liquid chlorine for use at the chlorination process.

A monorail and hoist assembly is provided for the handling and transfer of the one-ton containers to the storage facility from flat-bed delivery trucks, the loading of empty one-ton containers, and the moving of one-ton containers inside the chemical building.

CHLORINE FEED

The facility is equipped to receive pressurized chlorine gas. The chlorine process consists of four one-ton chlorine containers connected in pairs to a manifold. When one pair of containers is in service, the other set of containers is connected to the manifold for standby service. Each pair of two containers is mounted on its own

scale, and the containers are connected on the gas side to a common chlorine supply header. Plant Operators monitor the chlorine container weight to determine when the container is empty.

Downstream of the active containers, the header is equipped with a filter and a pressure regulator, followed by a motorized valve associated with an automatic changeover system. From the changeover system, the pressurized chlorine gas is controlled by a vacuum regulator/ check valve. The injector units create the vacuum which draws the chlorine gas through the system to mix with water flowing through the injector unit.

CHLORINATORS

Three chlorinators are located in the Chlorine Room. The chlorinator meters the flow of chlorine gas to the finished water. Chlorine addition is flow paced, with the chlorinators adjusting chlorine feed with changes in water flow. Each chlorinator houses a vacuum regulator to convert pressurized chlorine gas to gas under vacuum and a rotameter to measure chlorine flow.

The chlorinator operates under a vacuum. If a leak develops in any of the gas lines or equipment in the chlorinator, the vacuum condition causes air to be drawn into the unit rather than chlorine gas escaping from it.

CHLORINE INJECTORS

Each chlorinator is associated with an injector. The function of the injector is to:

- X Produce a vacuum to draw chlorine from the chlorinator.
- X Mix chlorine with the plant water flowing through the injector to make chlorine solution.

Each injector is an adjustable throat, orifice type, designed to operate efficiently over the full range of the chlorinator capacity.

CHLORINE LEAK DETECTORS

One chlorine leak detector is located in the WTP Chlorine Room. The detector is set to fully alarm at a detection level of 1.0 ppm of chlorine. The detector is connected to a local alarm panel with a visual indicator light. When the alarm signals, an audible alarm also sounds outside of the room. The alarm also notifies the plant's control center of actuation or malfunction.

MAXIMUM INTENDED INVENTORY

The WTP chlorination facility has a maximum intended inventory of ten one-ton containers (20,000 pounds) of chlorine.

WTP - SAFE UPPER AND LOWER LIMITS FOR TEMPERATURE, PRESSURE AND FLOWS

Chlorine Room / Storage Area:

Chlorine concentration at which alarms will respond:	
- Emergency response condition	1.0 ppm
Building temperature:	
- Normal	70 ^{B}F
- Minimum	60 ^{B}F
- Maximum	104 ^{B}F
Chlorine Gas pressure:	
Ton containers	20 to 85 psi
Piping to vacuum regulator check valve:	
- Normal	20 to 85 psi
- Minimum	20 psi
- Maximum	140 psi
- Vacuum regulator	-0.5 to -1.4 psi
Chlorinators:	
- Gas flow minimum	250 lb/day
- Gas flow maximum	5,000 lb/day
Injector:	
- Normal Vacuum (gauge readings)	24 in Hg
- Dilution water pressure:	
Normal	60 - 70 psi
Minimum	40 psi
Emergency Exhaust:	
Air Flow Maximum	5,000 scfm
Changeover Pressure:	
- Normal	20 psi

EVALUATION OF THE CONSEQUENCES OF DEVIATIONS

The Process Hazard Analyses (PHAs) evaluate the potential consequences of operating deviations at the WTP chlorination system. The PHA information for this facility is located in Section 4.0.

WTP - Process Equipment and Design Information

MATERIALS OF CONSTRUCTION

The WTP chlorination facility Contract Documents contain all specifications pertinent to the facility and equipment construction.

Piping and Instrument Diagrams (P&IDs)

Piping and instrument diagrams are included with this section as Attachment 3-3.

ELECTRICAL CLASSIFICATION

The electrical equipment for the WTP chlorine disinfection system has been designed and constructed according to good engineering practices at the time of the construction of the facility. Future electrical system modifications and upgrades will be completed using the procedures described in the Management of Change, Section 11. Modifications will be designed according to current classifications set by the National Electrical Code (NEC) and National Electrical Manufacturers Association (NEMA).

Since chlorine is a non-combustible substance, this chemical is unclassified under the current NEC system.

RELIEF SYSTEM DESIGN AND DESIGN BASIS

Container valves: All ton containers are equipped with pressure relief devices, referred to as fusible plugs. Containers have three plugs in each end, six plugs total, placed 120E apart. The fusible plugs, made of metal, are designed to yield or melt between 158E and 165EF to relieve pressure and prevent rupture of the container in case of fire or other exposure to high temperature.

VENTILATION SYSTEM DESIGN

The ventilation system inside the Chlorination Room has been designed and constructed according to good engineering practices at the time of construction of the facilities. Future ventilation system modifications and upgrades to the Chlorination Room will be completed using the procedures described in the Management of Change, Section 11. Modifications will be designed according to current ventilation standards set by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Chlorine Institute - Chlorine Manual, and the BOCA Code.

The ventilation system is not interlocked with the detector.

DESIGN CODES AND STANDARDS EMPLOYED

Reference codes and standards:

1. Ohio Basic Building Code.
2. Ohio Basic Mechanical Code.
3. Ohio Fire Code.
4. Recommended Standards for Water Works, Edition (A.W.W.A.).
5. Underwriters Laboratories (UL).
6. National Electrical Manufactures Association (N.E.M.E.).
7. Occupational Safety & Health Administration (OSHA).
8. American National Standards Institute (A.N.S.I.).
9. National Fire Protection Association (N.F.P.A.).
10. Military Standards (M.I.L.).
11. National Electrical Code (N.E.C.).
12. Factory Mutual (F.M.).
13. Joint Industrial Council (J.I.C.).
14. Recommendations of the Chlorine Institute, Inc.
15. Instrument Society of America (I.S.A.).
16. BOCA Code.

SAFETY SYSTEMS

The facility is equipped with several safety systems:

- A chlorine leak detector is in the WTP Chlorine Storage and Feed Room. The leak detector is programmed to provide an alarm at 1.0 ppm. The leak detector is not interlocked with the facility ventilation system, which will not operate in an event of a leak. The leak detector has an alarm which sounds in the event of power loss. The alarm beacon and an audible alarm also go to the plant monitoring and control system. A light will illuminate and the alarm horn will sound in the event of a chlorine leak.

- Leak repair kits: A AB≡ chlorine repair kit for the one-ton containers is available at the plant.

- Emergency showers / eyewash units are located in each room within the facility where employees may be exposed to chlorine. An alarm is interlocked with the emergency eyewash and showers operation to notify the control center of its use.

An equipment storage bunker located outside the chlorination room stores breathing devices available to employees in the event of an emergency.

Additional alarms are also provided identifying malfunctions throughout the facility and tasks involved in the chlorination process:

1. HVAC malfunction.
2. Chlorine leak sensor malfunction.
3. Smoke or Fire Alarms.

A complete alarm schedule is included as Attachment 3-4.