Ammonium Hydroxide & Sodium Hypochlorite Storage & Handling Issues

(Aqua Ammonia & Bleach)

Chlorine and ammonia are mixed to produce chloramines, an alternative disinfectant to reduce trihalomethane formation in the presence of natural organic materials. At high concentrations, chloramine is a toxic gas (NH_2Cl, $NHCl_2$), but only at concentrations higher than for chlorine gas. Used in low concentrations as a disinfectant in municipal water systems, chloramines are safe because chlorine and ammonia mixed in a water solution do not present a serious risk.

Chloramines are highly water-soluble irritant gases. Fumes contact moist mucous membranes, reacting with water to produce free ammonia gas, hypochloric acid, and hypochlorous acid. The latter then reacts with water to form hydrochloric acid and nascent oxygen, a strong oxidizing agent with corrosive effects.

At low concentration, symptoms include tearing, rhinorrhea, oropharyngeal burning, and cough. Although chloramine gases produce rapid onset of symptoms, these symptoms are mild enough that operators often do not remove themselves promptly from the toxic environment. Operators need to avoid prolonged exposure.

Pure chlorine gas may react vigorously with ammonia gas. An excessive mix of the two gases in air can produce hazardous compounds such as the explosive nitrogen trichloride. In facilities that use chloramination, the pure chlorine and ammonia need to be stored in separate, sealed rooms or buildings.

Chlorine leaks are usually confirmed using a standard ammonia test. This test is safe because it uses ammonium hydroxide (ammonia dissolved in water or moist air) rather than pure ammonia. Chlorine reacts readily with ammonium hydroxide to form ammonium chloride, a relatively harmless compound. This reaction forms a white cloud, indicating a chlorine leak. The continuous monitors now required indicate chlorine leaks automatically, but the ammonia test is still useful for pinpointing the exact location of a leak.

Ammonium hydroxide and sodium hypochlorite are both strong bases and as such do not interact violently as they do with other acids. These solutions are used because they are easy to transport, feed and inject. Bulk storage poses lower risk than gas storage. These solutions produce minor amounts of vapor or gas as the ammonia and chlorine come out of solution. As a result, exposure to fumes should be occasional. Best practices for these two chemicals:

- Store out of direct sunlight. Keep in cool dark area. Keep lids well closed.
- Per 62-555.320(13)(b)8 side-by-side storage of is not allowed for sodium hypochlorite with acid or any ammonia or organic compound. (Although, ammonium hydroxide and sodium hypochlorite are both strong bases, and are not as highly reactive when compared to anhydrous ammonia and chlorine gas).
- Recommend cross ventilation between ammonium hydroxide and sodium hypochlorite.
- Ammonium hydroxide and sodium hypochlorite could be stored in common well-ventilated areas, well away from each other.
- Consider venting tanks to exterior of building.
- Ammonium hydroxide and sodium hypochlorite should not share common floor drains.
- Feed systems should be separated to reduce unexpected cross-connection and spills
- Spill containment is recommended and required.

Exposure to Chlorine, Ammonia and Chloramine Fumes. Maximum permissible exposure levels for chlorine fumes are 30 to 50 more stringent or restrictive than ammonia fume exposure levels (see page 3 for comparison tables). Chloramine fumes are less toxic than chlorine fumes, but more hazardous than ammonia fumes.

Water Treatment Facilities which use, store, process, or manufacture any of the listed chemicals in excess of its threshold quantity are required to develop and implement a Risk Management Program. Risk Management Plans Summaries are submitted to the United States Environmental Protection Agency's Risk Management Plan Reporting Center. A full list of hazardous chemicals includes approximately 140 toxic and flammable substances that pose the greatest risk to human health and the environment, but the following are typical chemicals used in water treatment.

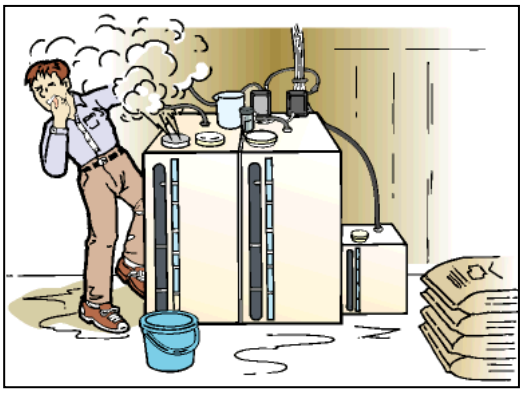
Threshold Quantity -- Typical Water Treatment Chemicals

Chemical	Threshold Quantity
Chlorine	2,500 lbs
Ammonia (anhydrous)	10,000 lbs
Ammonia (aqueous; 20% or greater)	20,000 lbs
Hydrofluoric Acid (aqueous; 50% or greater)	1,000 lbs

The type and quantity of chemicals used will determine whether a facility is subject to the Risk Management Plan requirements. A Risk Management Program consists of the following basic elements:

- Hazard assessment of accidental chemical releases upon surrounding community and environment;
- Five-year accident history of accidental chemical releases which occurred on site;
- Prevention program designed to minimize occurrence of releases through improved safety practices; and
- Emergency response program to reduce the effects of any releases which do occur.

Safety Provisions for Chloramine Generation Facilities



Facilities using chloramination disinfection should include safety provisions to prevent the formation of hydrochloric acid or nitrogen trichloride and the vaporization of ammonia at ambient temperatures. The possible formation of nitrogen trichloride is highest for systems that use anhydrous ammonia and gaseous chlorine. Designers should consider the make certain that anhydrous ammonia and gaseous chlorine storage facilities are located well away from each other.

1. *Chlorine gas and ammonia gas should never be stored in the same room.*
2. The ammonia gas application points should be located at least 5-feet away from chlorine feed solution lines.
3. Ammonia fume ventilation should be placed at high points in the room for anhydrous ammonia (if storage tanks and/or chemical feed equipment are installed indoors). Anhydrous ammonia is lighter than air, so any leaking vapor will rise quickly. Under pressure, anhydrous ammonia is a liquid. Great amounts of heat are absorbed when the pressurized liquid reverts to a gas.
4. Chlorine gas ventilation should be placed at low points in the room (if storage tanks and/or chemical feed equipment are installed indoors). Chlorine gas is heavier than air, so any leaking vapor will fall quickly.
5. Recommended ventilation design rates are typically a minimum of 4 to 6 room volume changes per minute. Vents for ammonia and chlorine should point in different directions on the plant site so fumes will not co-mingle.
6. Floor drains should not be interconnected between ammonia and chlorine storage or feed areas.
7. Ammonia and chlorine gas storage tanks should be protected from direct sunlight or direct sources of heat (i.e., greater than 125^{o} F) to avoid pressure increases in tanks.

Comparison of Ammonia & Chlorine Exposure Values / Limits

Chemical Exposure Categories	Ammonia	Chlorine
Immediately Dangerous to Life or Health Concentration Values (IDLH)	300 ppm	10 ppm
Threshold Limit Value (TLV) recommended values for worker exposure, not a legal limit -- Time-Weighted Average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek	25 ppm	0.5 ppm
Threshold Limit Value – Short-Term Exposure Limit (STEL) designated by "ST" preceding the value; the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday.	35 ppm	1 ppm
Emergency Response Planning Guidelines (ERPGs) ERPG-1 max airborne concentration for nearly all individuals exposed up to 1-hour w/out experiencing other than mild transient adverse health effects or clearly defined odor	25 ppm	1 ppm
ERPG-2 max airborne concentration for nearly all individuals exposed up to 1-hr w/out experiencing/developing irreversible or other health effects/symptoms	150 ppm	3 ppm
ERPG-3 max airborne concentration for nearly all individuals could be exposed up to 1-hour without experiencing/developing life-threatening health effects	750 ppm	20 ppm
National Institute for Occupational Health and Safety (NIOSH) Recommended Exposure Limits (RELs) are Time-Weighted Average. A ceiling REL is designated by "C" preceding the value.	25 ppm	C - 0.5 ppm [15-minute]
OSHA Permissible Exposure Limits (PEL) Time-Weighted Average (TWA) OSHA ceiling concentrations (designated by "C" preceding the value) must not be exceeded during any part of the workday; if instantaneous monitoring is not feasible, the ceiling must be assessed as a 15-minute TWA exposure.	50 ppm	C - 1 ppm

Ammonia Exposure	Acute Effects of Ammonia
5 ppm	Least Perceptible Odor
20 – 50 ppm	Readily Detectable Odor
50 ppm	OSHA PEL 8-hour Work Shift
50 – 100 ppm	No Discomfort or Impairment of Health For Prolonged Exposure
150 – 200 ppm	General Discomfort & Eye Tearing; No Lasting Effect on Short Exposure
400 – 700 ppm	Severe Irritation of Eyes, Ears, Nose, & Throat; No Lasting Effect on Short Exposure
1700 ppm	Coughing, Bronchial Spasms
2000 – 3000 ppm	Dangerous, Less Than One-Half Hour Exposure May Be Fatal
5000 – 10,000 ppm	Rapidly Fatal

Chlorine Exposure	Acute Effects of Chlorine
1 – 3 ppm	Mild Mucous Membrane Irritation
5 – 15 ppm	Moderate Irritation of Upper Respiratory Tract
30 ppm	Immediate Chest Pain, Vomiting, Dyspnea, And Cough
40 – 60 ppm	Toxic Pneumonitis & Pulmonary Edema
430 ppm	Lethal Over 30 Minutes
1,000 ppm	Death Within A Few Minutes -- Death is possible from asphyxia, shock, reflex spasm in the larynx, or massive pulmonary edema

Anhydrous Ammonia (ammonia, ammonia gas, NH_3)

At room temperature, anhydrous ("without water") ammonia is a colorless, highly irritating gas with a pungent, suffocating odor. Ammonia is a lighter than air gas. Ammonia is alkaline and caustic, and is a powerful irritant, with a 10.6 to 11.6 pH -- Ammonia is strongly alkaline when dissolved in water. At standard conditions anhydrous ammonia is a gas – if held in an open vessel it will boil and escape into the atmosphere. To prevent escape, it is stored under pressure and/or refrigeration (boiling point: minus-28^o F). When liquid ammonia is released from a pressurized vessel, it expands rapidly, vaporizes, and produces a white cloud of water vapor.

Inhalation of ammonia can be fatal. Ammonia's odor threshold is sufficiently low to acutely provide adequate warning of its presence. However, ammonia causes olfactory fatigue (loss of sense of smell) or adaptation, making its presence difficult to detect when exposure is prolonged. Inhalation of vapors can cause severe irritation of the respiratory system and pulmonary edema. Combustible when mixtures of ammonia and air are united under favorable conditions.

Anhydrous ammonia has a great affinity for water and is rapidly absorbed by water in human tissue. It is very irritating to the eyes, lungs, and skin. Safety precautions must always be taken. It is incompatible or reactive with strong oxidizers, acids, halogens, salts of silver, and zinc. It is corrosive to copper and galvanized surfaces; liquid ammonia will attack some forms of plastics, rubber, and coatings. It is highly water-soluble. It is easily liquefied under pressure. If the pressure in the tank is 93 psig at 60^o F, then when the outside temperature is at 100^o F the pressure in the tank will be 200 psig. If a hose ruptures or a valve is unintentionally opened, the high pressure from a tank can cause ammonia to spray out possibility into your eyes, face, and other parts of your body before you can react.

When pressure is released on liquid ammonia it quickly converts to a gas. One gallon of liquid ammonia will turn to a vapor cloud that is just less than 5-ft x 5-ft x 5-ft (or 125 cubic feet) in size. This conversion will freeze atmospheric moisture forming a white colored cloud. The temperature of the vapor cloud can range from minus-45^o F to minus-100^o F in the first 10 to 12 feet of the vapor cloud, which may rapidly freeze everything it touches. As a liquid pool of ammonia warms from it's boiling point of -28^o F and turns to a gas it will raise. Ammonia vapor has a vapor density of approximately 0.597 compared to air at 1. Ammonia vapors will rise and easily travel with any wind present. So, personnel downwind of any spill must be notified and warned of the potential hazard heading in their direction.

Gas delivered in containers ranging in size from 150 lb cylinders to 90-ton rail cars. Pressure tanks (the same size as propane tanks) are commonly used. Feed equipment consists of solution water pump/ejector to create vacuum and automatic orifice control to meter the gas. Gas can be drawn directly from storage container or be generated by an evaporator from liquid withdrawn from the container – much like chlorine gas. Risk management prevention plans should be prepared for storage over 10,000-lbs.

It is estimated that water treatment plants might use 8 to 12 lbs per day of Anhydrous Ammonia per one million gallons per day of water production. Thirty-days storage is estimated at between 240 and 360 pounds. Most water systems typically would not be required to submit Risk Management Prevention Plans.

Anhydrous Ammonia

Handling & Storage	▪ Store out of direct sunlight or in a well-ventilated room. ▪ Don't store near strong oxidizing / reducing agents (chlorine gas or sodium hypochlorite) ▪ Ammonia is flammable and explosive under certain conditions. ▪ Tanks are rated for 250 psig
Exposure Controls / Personal Protection	▪ AVOID ALL CONTACT! Ammonia's odor threshold is sufficiently low to acutely provide adequate warning of its presence. However, ammonia causes olfactory fatigue (loss of sense of smell) or adaptation, making its presence difficult to detect when exposure is prolonged. ▪ Respiration: Up to 100 ppm: Half face cartridge respirator with NH_3 cartridge(s) Up to 300 ppm: Full face chemical cartridge respirator with NH3 cartridge(s) Up to 500 ppm: Full face respirator (gas mask) with NH_3 canister Unlimited: Supplied air respirator, or self-contained breathing apparatus ▪ Ventilation: Local Exhaust to reduce vapor in confined spaces.

Anhydrous Ammonia (continued)

Exposure Controls / Personal Protection	▪ Gloves: Butyl Rubber, Cold-Insulating Gloves ▪ Eyes: Full eye and face protection, Chemical Splash Goggles, , or Eye Protection in Combination with Breathing Protection ▪ Clothes: Impervious Clothing where contact with liquid is possible ▪ Other Equip: Emergency eyewash stations / deluge showers ▪ Emergencies: Post list of emergency response contacts/telephone numbers
Accidental Release Measures	▪ Evacuate danger area! Consult an expert! ▪ Ventilation. Turn leaking cylinder with the leak up to prevent escape of gas in liquid state. ▪ NEVER direct water jet on liquid. Remove gas with fine water spray. ▪ Extra personal protection: Gas-tight chemical protection suit including self-contained breathing apparatus. ▪ Spill Release Procedures: Spill will evaporate / disperse in atmosphere. Sweep up ammonia-saturated debris and absorb on universal chemical absorbent pads, universal chemical absorbent powder, sand, or vermiculite and place in closed containers for disposal. ▪ Waste Disposal Methods: Comply with all regulations. ▪ Keep ammonia-saturated spill water from entering drainage / streams / lakes.
First-Aid Measures	Inhalation: Fresh air, rest. Half-upright position. Artificial respiration if indicated, give oxygen. Refer for medical attention. Burning sensation. Cough. Labored breathing. Shortness of breath. Sore throat. The symptoms of lung edema often do not become manifest until a few hours have passed. Skin: In Case of Contact, immediately flush eyes or skin with copious amounts of water for at least 15 minutes while removing contaminated clothing and shoes Refer for medical attention. Corrosive. Redness. Serious skin burns. Pain. Blisters. Frostbite: Rinse clothes with plenty of water, Do NOT remove clothes. Refer for medical attention. Redness. Skin burns. Pain. Blisters. Exposure to concentrated vapor or solution can cause stinging pain, redness of the skin, and blisters, especially on moist skin areas. Contact with liquefied ammonia can cause severe frost bite burns resulting in deep ulcerations. Eyes: First rinse with plenty of water for several minutes (remove contact lenses if easily possible), and then take to a doctor. Assure adequate flushing of the eyes by separating the eyelids with fingers. Corrosive. Redness. Pain. Blurred vision. Severe deep burns. Ingestion: N/A (see ammonium hydroxide for ingestion of ammonia-saturated water). Antidote-water. Obtain medical attention in all cases. Recommendations to doctor: Treat Symptomatically.
Fire Fighting Measures	Slightly Flammable: NO open flames, NO sparks, and NO smoking. In case of fire in the surroundings: all non-combustible extinguishing agents allowed. Firefighting Personnel: Must be equipped with appropriate protective clothing and respirators. Fire Fighting Procedures: Extinguish surrounding fire. Wear self-contained breathing units in enclosed space. Don't put water on liquid ammonia – exothermic reaction produces more heat. Keep cylinder cool by spraying with water. Gas / Air mixtures are explosive. Unusual Fire / Explosion Hazard: Vaporizes at 635^{o} F and fumes are considered toxic.
Incompatible Substances	▪ Strong Base, it reacts violently with acid and is corrosive. ▪ Reacts Violently with strong oxidants, acids & halogens (CHLORINE GAS & NaOCl). ▪ Attacks copper, aluminum, zinc, alloys, plastics, rubber and galvanized surfaces. ▪ Dissolves in water evolving heat – exothermic reaction. ▪ Shock-sensitive compounds are formed with mercury, silver and gold oxides.

Ammonium Hydroxide (NH_4OH, aqueous ammonia, ammonium hydrate, and ammonia water)

Ammonium hydroxide is a pungent, colorless, aqua ammonia solution 10.6 to 11.6 pH -- strongly alkaline. Since ammonia ionizes to a small extent, ammonium and hydroxide ions will be present in an aqueous solution of ammonia. $NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$

Typical aqua ammonia solutions usually contain 20-30% nitrogen (or 1.5 to 3 lbs/gal) because they have vapor pressures less than 5-lbs per square inch gauge at 90° F. Aqua ammonia solutions with concentrations lower than 22% nitrogen have no vapor pressure at 90° F; solutions with concentrations of 23% and 24% nitrogen have vapor pressures of 1.6 and 3.2-lbs per square inch, respectively.

Ammonium hydroxide can be purchased bulk in quantities ranging from 5 to 10 gal carboys, 55 gal drums, to 4,500 gal truck loads. Bulk loads can be stored in carbon steel, stainless steel, or plastic tanks. Solution is fed directly into the process stream. Ammonium hydroxide is toxic and classified as hazardous. Storage facilities should be designed with day tanks and secondary containment.

It is estimated that water treatment plants might use 4 to 6 gpd of Ammonium Hydroxide per one million gallons per day of water production. Thirty-days storage is estimated at between 120 and 180 gallons. Most water systems typically would not be required to submit Risk Management Prevention Plans.

Ammonium Hydroxide

Handling & Storage	*-- Refer to Exposure Controls / Personal Protection --* ▪ Store in a Cool Dry Place. Well tightly closed. Keep in a well-ventilated room. ▪ Ammonia vapor can evaporate from ammonia solution. Vapor is flammable and explosive under pressurized conditions. ▪ Do NOT completely fill containers with the substance; strong solutions may develop pressure.
Exposure Controls / Personal Protection	▪ Avoid prolonged or repeated exposure! STRICT HYGIENE! ▪ Wash thoroughly after handling. ▪ Respiration: Respiratory protection must be used when exposure levels exceeded. Use approved by NOSH / MSHA devices. ▪ Ventilation: Do NOT breathe vapor. Local exhaust to reduce vapor in confined spaces. Ammonia vapor lighter than air. ▪ Gloves: Chemical-Resistant Gloves ▪ Eyes: Chemical Splash Goggles, Non-Venting Safety Goggles, Face Shield, or Eye Protection in Combination with Breathing Protection ▪ Clothes: Normal Protective Clothes, Impervious Clothing where contact with liquid is possible. Remove and wash contaminated clothing promptly. ▪ Other Equip: Emergency eyewash stations / deluge showers ▪ Emergencies: Post list of emergency response contacts/telephone numbers
Accidental Release Measures	▪ Evacuate danger area! Consult an expert in case of a large spillage! Ventilation. Wear self-contained breathing apparatus, rubber boots and heavy rubber gloves. ▪ Absorb on universal chemical absorbent pads, universal chemical absorbent powder, sand, or vermiculite and place in closed containers for disposal. ▪ Cautiously neutralize residual liquid with a dilute acid, such as dilute sulfuric acid. Wash away remainder with plenty of water. ▪ Do NOT let this chemical enter the environment (Use extra personal protection: complete protective clothing including self-contained breathing apparatus).
First-Aid Measures	Inhalation: Fresh air, rest. Artificial respiration if indicated, give oxygen. Refer for medical attention. Burning sensation. Cough. Labored breathing. Shortness of breath. Sore throat. The symptoms of lung edema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation is therefore essential.

Ammonium Hydroxide (continued)

First-Aid Measures		Ammonia is extremely destructive to mucous membrane tissue of the upper respiratory tract. Inhalation of elevated concentrations may be fatal. Inhalation may cause inflammation and accumulation of fluid in the lungs
	Skin:	In Case of Contact, immediately flush eyes or skin with copious amounts of water for at least 15 minutes while removing contaminated clothing and shoes Refer for medical attention. Corrosive. Redness. Serious skin burns. Pain. Blisters. Severe tissue damage to the skin can occur from exposure to liquids if contact is prolonged (more than a few minutes). Dilute aqueous solutions (less than 5%) seldom cause serious burns, but are moderately irritating. Liquids are corrosive to body tissue.
	Eyes:	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), and then take to a doctor. Assure adequate flushing of the eyes by separating the eyelids with fingers. Low concentrations of 20-50 ppm may produce eye irritation after 5-minutes. High concentrations of gas or concentrated ammonium hydroxide, (ammonia dissolved in water), may cause swelling and sloughing of surface cells. High ammonia concentrations can destroy tissues of the eyes causing permanent blindness.
	Ingestion:	Loosen tight clothing around the neck and waist. Flush mouth several times with cold water and spit out. Give victim 1 to 2 cups of milk. Do not induce vomiting. Do not give oils or attempt to neutralize with an acid. Do not give sodium bicarbonate or carbonated drinks. If vomiting occurs, keep the head lower than the hips to prevent vomitus from entering the lungs. Obtain medical attention in all cases. Recommendations to doctor: Treat Symptomatically. Swallowing ammonium hydroxide, (ammonia dissolved in water), causes immediate burning in the mouth and throat. Concentrated solutions cause severe pain in the mouth, chest, and abdomen; swallowing difficulty; drooling; and vomiting. Acute burns to the esophagus and perforation of the esophagus or stomach may occur.
Fire Fighting Measures	Not Flammable: Use noncombustible extinguishing media appropriate to surrounding fire conditions. Firefighting Personnel: Must be equipped with appropriate protective clothing and respirators. Fire Fighting Procedures: Extinguish surrounding fire. Wear self-contained breathing units in enclosed space. DON'T put water on liquid ammonia – exothermic reaction produces more heat. Gas / Air mixtures are explosive. Unusual Fire / Explosion Hazard: Emits toxic fumes under fire conditions. Vaporizes at 635^{o} F.	
Incompatible Substances	▪ CHLORINE GAS, Copper, Copper Alloys, Galvanized Iron, Zinc -- Reacts with many heavy metals and their salts forming explosive compounds. ▪ Attacks many metals forming flammable/explosive gas (hydrogen). The solution in water is a strong base and reacts violently with acids.	

Chlorine Gas (Chlorine, molecular chlorine Cl_2)

Chlorine is a greenish-yellow gas with a pungent, irritating odor. It reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen, and finely divided metals. It is a noncombustible gas, and a strong oxidizer.

Chlorine is heavier than air, and less water-soluble than ammonia. Water dissolves about twice its volume of chlorine gas, forming a mixture of hydrochloric and hypochlorous acids.

Chlorine is 2.5 times heavier than air, has an expansion ratio of about 450:1 and supports the combustion of iron and steel at low temperatures (approximately 450 degrees F). It is also hygroscopic, and when moist, it immediately produces several acidic byproducts, such as hydrochloric and hypochlorous acids. Industrial grade chlorine is hardly ever found without at least 2 to 3 percent impurities, such as ferric chloride, ferric sulfate and ferric oxide, as well as several varieties of waxes.

While chlorine gas is usually stored at low pressure (approximately 60 psig), its high expansion ratio makes it dangerous to handle. For example a 150-lb upright cylinder of chlorine gas can turn into an unguided missile if its valve is sheared off by dropping it accidentally. The open top of the cylinder vents gas much like a rocket nozzle.

Gas delivered in containers ranging in size from 150 lb cylinders to 90-ton rail cars. One-ton cylinders are commonly used. Feed equipment consists of solution water pump/ejector to create vacuum and automatic orifice control to meter the gas. Gas can be drawn directly from storage container or be generated by an evaporator from liquid withdrawn from the container.

Gaseous chlorine is classified by the Uniform Fire Code as an oxidizing, highly toxic, compressed gas. New gaseous chlorine facilities should be designed with enclosures and air scrubbers to capture and neutralize any gas that leaks. Risk management prevention plans should be prepared for storage over 2,500-lbs.

It is estimated that water treatment plants might use 30 to 40 lbs per day of Chlorine Gas per one million gallons per day of water production. Thirty-days storage is estimated at between 900 and 1,200 pounds. Water systems under 2.0 MGD typically would not be required to submit Risk Management Prevention Plans.

Chlorine Gas

Handling & Storage	AVOID ALL CONTACT! ▪ Separate from combustible and reducing substances. ▪ Keep in a well-ventilated room. ▪ Chlorine is a dangerous gas that is lethal at concentrations as low as 1-percent air by volume.
Exposure Controls / Personal Protection	▪ AVOID ALL CONTACT! Recommend chlorine monitors – do NOT rely on smell. ▪ Respiration: Up to 10 ppm: Safety goggles or eye protection in combination with breathing protection Up to 30 ppm: Full face respirator (gas mask) with chlorine rated canister Unlimited: Supplied air respirator, or Self-Contained Breathing Apparatus. Respiratory protection approved by NOSH / MSHA for chlorine must be used when exposure levels exceeded. ▪ Ventilation: Local Exhaust to reduce vapor in confined spaces. Chlorine gas heavier than air. ▪ Gloves: Butyl Rubber, Cold-Insulating Gloves ▪ Eyes: Full Eye and Face Protection. Chemical Splash Goggles, Non-Venting Safety Goggles, Face Shield, or Eye Protection in Combination with Breathing Protection ▪ Clothes: Normal Work Clothes, Butyl Rubber, or Impervious Clothing where contact with liquid is possible.. ▪ Other Equip: Emergency eyewash stations / deluge showers ▪ Emergencies: Post list of emergency response contacts/telephone numbers

Chlorine Gas (continued)

Accidental Release Measures	▪ Evacuate danger area! Consult an expert! ▪ Ventilation if concentration is below 10 ppm and leak is repaired. ▪ DO NOT ventilate building if concentration is above 10 ppm – seek expert assistance. ▪ NEVER direct water jet on liquid. Remove gas with fine water spray (extra personal protection: complete protective clothing including Self-Contained Breathing Apparatus).
First-Aid Measures	Inhalation: Fresh air, rest. Half-upright position. Artificial respiration if indicated. Give oxygen. Refer for medical attention. Burning sensation. Cough. Labored breathing. Corrosive. Burning sensation. Cough. Headache. Laboured breathing. Nausea. Shortness of breath. Sore throat. Symptoms may be delayed. Skin: In Case of Contact, immediately flush eyes or skin with copious amounts of water for at least 15 minutes while removing contaminated clothing and shoes Refer for medical attention. Corrosive. Redness. Serious skin burns. Pain. Blisters. Eyes: First rinse with plenty of water for 15+ minutes (remove contact lenses if easily possible), and then take to a doctor. Assure adequate flushing of the eyes by separating the eyelids with fingers. Corrosive. Redness. Pain. Blurred vision. Severe deep burns. Ingestion: N/A
Fire Fighting Measures	Not combustible but enhances combustion of other substances. Many reactions may cause fire or explosion. NO contact with combustibles, acetylene, ammonia and finely divided metals. In case of fire in the surroundings: all extinguishing agents allowed.
Incompatible Substances	Reacts violently with many organic compounds, AMMONIA and finely divided metals causing fire and explosion hazard. Attacks many metals in presence of water. Attacks plastic, rubber and coatings.

Sodium Hypochlorite ±12.5% (NaOCl, Bleach, Liquid Chlorine)

Sodium hypochlorite (like all hypochlorites) is a salt of hypochlorous acid, HClO. Sodium Hypochlorite can be considered a solution of dissolved chlorine gas in sodium hydroxide. Simply put, its character is that of common household bleach or "swimming pool" chlorine; however, sodium hypochlorite for wastewater treatment usually is found in 12.5% concentration.

Sodium Hypochlorite is a strong base and carries a relatively high pH (about 12.8) and a concentrated chlorine gas element that again is easily released into solution. Chlorine fumes are released from sodium hypochlorite through natural decomposition of the chemical solution. Chlorine and oxygen are the most prevalent gases to consider when designing safety relief of piping systems or when making valve selection. Equipment used in piping systems must be carefully selected to withstand the high and fluctuating pH levels, vapor concerns, and scaling effects. Chemical resistance, design safety, and system performance become major issues.

Sodium hypochlorite can be purchased bulk in quantities ranging from 55 gal drums to 4,500 gal truck loads. Bulk loads can be stored in fiberglass or plastic tanks. Solution is fed directly into the process stream. Hypochlorite solution is toxic and classified as hazardous. Storage facilities should be designed with secondary containment.

It is estimated that water treatment plants might use 30 to 40 lbs per day (or 30 to 40 gpd) of Sodium Hypochlorite per one million gallons per day of water production. Thirty-days storage is estimated at between 900 and 1,200 gallons. Most water systems typically would not be required to submit Risk Management Prevention Plans.

Sodium Hypochlorite ±12.5%

Handling & Storage	*-- Refer to Exposure Controls / Personal Protection --* AVOID ALL CONTACT! ▪ Store in a Cool Dry Place. Well tightly closed. Keep in a well-ventilated room. ▪ Chlorine Gas can evaporate from solution ▪ Separated from acids (Chlorine Gas) and incompatible substances (see Chemical Dangers). ▪ Sodium hypochlorite is very corrosive and should be stored with care and kept away from equipment that can be damaged by corrosion. ▪ Hypochlorite solutions decompose and should not be stored for more than one month. ▪ Do NOT completely fill containers with the substance; strong solutions may develop pressure.
Exposure Controls / Personal Protection	AVOID ALL CONTACT! ▪ Wash thoroughly after handling. ▪ Respiration: *See Chlorine Gas for vapor exposure.* Respiratory protection must be used when exposure levels exceeded. Use approved by NOSH / MSHA devices. ▪ Ventilation: Do not breathe vapor. Local exhaust to reduce vapor in confined spaces. Chlorine gas is heavier than air. ▪ Gloves: Chemical-Resistant Gloves ▪ Eyes: Chemical Splash Goggles, Non-Venting Safety Goggles, Face Shield, or Eye Protection in Combination with Breathing Protection ▪ Clothes: Normal Protective Clothes, Impervious Clothing where contact with liquid is possible. Remove and wash contaminated clothing promptly. ▪ Other Equip: Emergency eyewash stations / deluge showers ▪ Emergencies: Post list of emergency response contacts/telephone numbers
Accidental Release Measures	▪ Evacuate danger area! Consult an expert in case of a large spillage! Ventilation. ▪ Wear self-contained breathing apparatus, rubber boots and heavy rubber gloves. ▪ Do NOT wash away into sewer. ▪ Do NOT absorb in sawdust or other combustible absorbents. Absorb on universal chemical absorbent pads, universal chemical absorbent powder, sand, or vermiculite and place in closed containers for disposal.

Sodium Hypochlorite ±12.5% (continued)

First-Aid Measures	Inhalation:	Fresh air, rest. Half-upright position. Artificial respiration if indicated. Refer for medical attention. Burning sensation. Cough. Shortness of breath. Sore throat. The symptoms of lung edema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation is therefore essential. Chlorine is extremely destructive to mucous membrane tissue of the upper respiratory tract. Inhalation of elevated concentrations may be fatal. Inhalation may cause inflammation and accumulation of fluid in the lungs.
	Skin:	In Case of Contact, immediately flush eyes or skin with copious amounts of water for at least 15 minutes while removing contaminated clothing and shoes Refer for medical attention. Corrosive. Redness. Serious skin burns. Pain. Blisters.
	Eyes:	First rinse with plenty of water for 15+ minutes (remove contact lenses if easily possible), and then take to a doctor. Assure adequate flushing of the eyes by separating the eyelids with fingers. Corrosive. Redness. Pain. Severe deep burns. High Chlorine concentrations can destroy tissues of the eyes causing permanent blindness.
	Ingestion:	Flush mouth several times with cold water and spit out. Do NOT induce vomiting. If vomiting occurs, keep the head lower than the hips to prevent vomitus from entering the lungs. Obtain medical attention in all cases. Recommendations to doctor: Treat Symptomatically. Corrosive. Abdominal cramps. Burning sensation. Unconsciousness. Vomiting. Weakness
Fire Fighting Measures	Not combustible. Many reactions may cause fire or explosion. Heating will cause rise in pressure with risk of bursting. Gives off irritating or toxic fumes (or gases) in a fire.	
Incompatible Substances	The substance decomposes on heating, on contact with acids and under influence of light producing toxic and corrosive gases including chlorine. The substance is a strong oxidant and reacts violently with combustible and reducing materials causing fire and explosion hazard. The solution in water is a strong base (~13 pH); it reacts violently with acid and is corrosive. Attacks many metals.	