CHLORINE

Refer to the Safety Data Sheet (SDS) for additional information and before handling this material.

CAS Number:	7782-50-5
Synonyms:	chlorine, dichlorine
Chemical Formula:	Cl_2
Molecular Weight:	70.9
Description:	Liquid chlorine has a clear amber color while chlorine gas is greenish yellow and has a characteristic penetrating, irritating odor.

Product Overview

Chlorine is a naturally occurring chemical element that belongs to a group of chemicals called halogens and is an essential component in many industrial and commercial applications. It is an element that is found in nature bonded to other elements like sodium, potassium, and calcium and is an essential nutrient for plants and animals. Chlorine in its elemental form is a very powerful oxidant and chlorine containing compounds may be used to keep swimming pools clean and sanitary, protect food and crops, design pharmaceuticals, and make plastics. Ordinary table salt, sodium chloride, is the best known chlorine containing compound. Liquid chlorine vaporizes quickly under normal atmospheric conditions. At ambient temperatures, elemental chlorine is a greenish-yellow gas that is 2½ times heavier than air.

Chlorine is manufactured by the electrolysis of an aqueous sodium chloride solution (salt brine). Westlake Corporation is a global merchant producer of chlorine, manufacturing and shipping from a grid of six strategically located plants. These plants are located in Lake Charles and Plaquemine, Louisiana; Longview, Washington; New Martinsville, West Virginia; Beauharnois, Quebec; and Kaoshiung, Taiwan. Westlake produces and ships millions of tons of chlorine each year with responsible practices focusing on environmental and public safety.

Production

Westlake manufactures chlorine along with sodium hydroxide via the chlor-alkali electrolysis process. Electrolysis is an electrochemical reaction using energy to drive the decomposition reaction of an aqueous solution of sodium chloride (also called brine) into chlorine gas, sodium hydroxide, and hydrogen gas.

$$2NaCl + 2H_2O \rightarrow Cl_2 + H_2 + 2NaOH$$

There are three technological variants of the electrolysis process in use globally: diaphragm cell, membrane cell, and mercury cell. All cell types produce elemental chlorine gas at the anode and a solution of sodium hydroxide at the cathode. The salt brine is continually fed to the anode compartment liberating chlorine gas, then flows through the separator to the cathode compartment, where the caustic soda is produced.

In a diaphragm cell, a permeable diaphragm provides a separation between the anode side of the cell where chlorine is produced and the cathode side of the cell where sodium hydroxide and hydrogen are produced. Although there is flow through the diaphragm, the diaphragm separates the chlorine containing anolyte solution and the sodium hydroxide containing catholyte solution, preventing mixing and reaction of the product components.

The membrane cell differs from the diaphragm cell in that the solutions surrounding each electrode are separated by a semi-permeable membrane that selectively allows only the migration of sodium ions from the anode to the cathode chamber.

A mercury cell design is substantially different from the other two. Rather than chlorine and sodium hydroxide being formed simultaneously in one cell, two distinct processes are employed to form the caustic solution. In the mercury cell, sodium brine flows between a stationary anode and a moving mercury metal cathode. Chlorine is produced at the anode, and the mercury cathode forms an amalgam with the newly formed sodium metal. The resulting mercury-sodium amalgam is fed to the denuder for decomposition into sodium hydroxide and the mercury is recycled.

Uses

Chlorine and chlorine chemistry touches almost all aspects of daily life and its chemical properties have been harnessed innovatively for good use. There are more than 15,000 chlorine compounds in use commercially. The wide variety of uses for chlorine is derived from its high reactivity to form selective chemical compounds. The largest consumers of chlorine are polyvinyl chloride (PVC) producers, chemical industries, and water treatment facilities. Chlorine-based disinfectants may be capable of removing a wide variety of disease-causing germs from drinking water and wastewater as well as from hospital and food production surfaces. It is also used in pharmaceutical design, crop protection, and coatings applications. Additionally, chlorine plays a critical role in the manufacture of thousands of products we depend upon every day, from computer chips to crop-protection chemicals to cancer-fighting drugs. Some of these products contain chlorine, and others simply depend on chlorine chemistry for an intermediate step in their manufacture. With all downstream applications, appropriate registrations and/or approvals may be required. Possible uses are described below:

- **Chemical Production** - The chemical industry consumes a significant portion of the chlorine produced in the United States. Chlorine serves as a reactive intermediate to make a host of organic and inorganic chemicals.
- **Water Disinfection and Purification** - Chlorine may be used as an important chemical for water purification in disinfectants and in bleach. Chlorine is used as an U.S. EPA approved disinfectant and/or algaecide.
- **Titanium Dioxide** - Chlorine is reacted with mined titanium ore to produce titanium dioxide. Titanium dioxide is used to make paint, paper, food, and pharmaceuticals white and bright, and protect us from ultra-violet light in sunscreen and cosmetics.
- **Pharmaceutical Production** - Chlorine is used in 98% of pharmaceutical and drug design. The highly reactive, oxidative properties of chlorine make selective synthesis possible.
- **Polyvinyl chloride (PVC)** - The single largest end use for chlorine is the manufacture of PVC precursors. Chlorine is used to make ethylene dichloride and vinyl chloride monomer, two important intermediates in the production of PVC plastic. This is used to make hundreds of products in a variety of applications including residential and commercial construction, electrical insulation, food packaging and protection, and computer parts.
- **Isocyanates** - Chlorine is used in the production of MDI (methylene diphenyl diisocyanate) and TDI (toluene diisocyanate), which are used in the production of polyurethanes for flexible and rigid urethane foams, coatings, and adhesives. Polyurethane foams are used in a host of products including residential and commercial insulation, gaskets, sealants, and automotive components.
- **Epoxy Resins** - Chlorine is used to make epichlorohydrin, an intermediate in the manufacture of epoxy resins. This is a highly engineered material, used in the production of surface coatings, adhesives, composites, and laminates.

- **Chlorinated solvents** - Chlorine is used to produce chlorinated methanes and ethanes, including perchloroethylene, trichloroethylene, ethyl chloride, and Tri-ethane® solvent. These are used in dry cleaning, metal cleaning, refrigerants, and plastic composites.

Health Effects

Read and follow all instructions on the product label and review the Safety Data Sheet (SDS) to understand and avoid the hazards associated with chlorine. Wear appropriate personal protective equipment and avoid direct contact. Eye contact with chlorine causes serious eye damage including irreversible damage and blindness; repeated or prolonged exposure to corrosive materials or fumes may cause conjunctivitis. Skin contact causes severe burns; repeated or prolonged exposure to corrosive materials will cause dermatitis. Ingestion of chlorine may cause irreversible damage to mucous membranes; repeated or prolonged exposure to corrosive materials or fumes may cause gastrointestinal disturbances. Inhalation of chlorine may cause respiratory irritation and may be fatal; repeated or prolonged exposure to corrosive fumes may cause bronchial irritation with chronic cough.

The United States Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have established or recommended occupational airborne exposure limits for chlorine. The OSHA Permissible Exposure Limit (PEL) is a Ceiling Limit of 1 ppm (parts per million), 3 mg/m^3 (milligrams per cubic meter). A Ceiling Limit should not be exceeded during any part of the working exposure. The ACGIH currently recommends an 8 hour Time-Weighted Average (TWA) of 0.5 ppm and a 15 minute Short-Term Exposure Limit (STEL) of 1 ppm.

Chlorine has a distinct odor that is detectable by most individuals at low concentrations (approximately 0.3 parts per million (ppm) in water and 0.002 ppm in air). The odor usually provides a warning of its presence at concentrations far below the concentration level that creates a health hazard to humans.

Before handling, it is important that engineering controls are operating and protective equipment requirements and personal hygiene measures are being followed. People working with this chemical should be properly trained regarding its hazards and its safe use and should be given the opportunity to review this document and the safety data sheet. Persons in a chlorine work area should, at a minimum and at all times, carry a NIOSH-approved cartridge type escape respirator, be trained in its use, and have ready access in the work area to and full-face, supplied air respirators.

Environmental Effects

Chlorine should be kept out of lakes, streams, ponds, or other water sources to preserve aquatic life. Because it is highly reactive, chlorine will likely react with materials in the soil that contain calcium, sodium, and potassium. Degradation of chlorine is expected in the soil environment, although the biodegradation rates of other substances may be reduced or stopped by excessively high concentrations of chlorine.

Exposure Potential

Precautions should be taken to minimize potential harm to people, animals and the environment. Potential for exposure may vary depending upon site-specific conditions. When handling chlorine, refer to the Safety Data Sheet and Product Warning Label and follow all instructions and warnings. Based on the expected uses for chlorine, exposure could be through:

- **Workplace exposure** - Exposure can occur either in a chlorine manufacturing facility or in the various industrial facilities that use chlorine. Good industrial hygiene practices and the use of personal

protective equipment will, when combined with proper training and environmental, health and safety practices, contribute to a safe work environment. Additionally, chlorine is handled in closed systems, so special precautions are typically required for employees involved in maintenance activities, sample collection, or similar activities.

- **Environmental releases** - If a release occurs, the area should be evacuated. Emergency personnel should wear protective equipment to minimize exposures during response operations. The high vapor pressure makes chlorine vaporize into the air, which creates an inhalation risk. Many aspects of a spill control program are mandated by federal, state and local requirements. In addition, if a spill occurs, governmental reporting may be required. Refer to the Safety Data Sheet for instructions to minimize exposure.
- **Consumer exposure** - Consumer exposure to chlorine can occur at large public pools and spas where chlorine based disinfectants are used to treat water. Consumers can also be exposed through hypochlorite compounds in cleaning products, such as bleach. Refer to instructions provided with products and follow public safety guidelines to protect against unnecessary exposure.

Safe Handling and Storage

Since chlorine gas is approximately 2½ times as heavy as air, it settles toward the ground and collects in low spots. This property is an important consideration for persons planning the location and ventilation of chlorine storage areas.

Dry chlorine containing less than 50 ppm moisture, as manufactured by Westlake, does not appreciably corrode common metals at temperatures below 110°C (230°F). However, chlorine reacts with moisture to form hydrochloric and hypochlorous acids, which are highly corrosive. Therefore, the following precautions should be taken:

- Make sure that piping is dry and free of contamination of any type before admitting chlorine.
- Use only dry (-40°F dew point or below) oil-free air or nitrogen for purging, testing for leaks or padding tank cars.
- Never use water to detect or absorb leaking gas and never put a leaking container into water.

For additional information, refer to the Safety Data Sheet.

Packaging and Shipping

Westlake ships chlorine in rail tank cars, barges, and pipelines.

- **Tank car** - Most chlorine shipments are made in single-unit tank cars with capacity of 90 tons. Shipping points in the United States are Lake Charles and Plaquemine, Louisiana; Longview, Washington; New Martinsville, West Virginia; in Canada, Beauharnois, Quebec; and in Taiwan, Kaoshiung.
- **Barge** - Westlake pioneered barge shipments of chlorine and currently has barges of 1100-ton capacity. Shipping points are Lake Charles and Natrium.
- **Pipeline** - Westlake works with many different companies to bring chlorine safely onto their site via chemical pipelines.

Fire and Explosion Hazards

Chlorine liquid and gas by themselves are nonflammable and nonexplosive. However, chlorine can support the combustion of certain substances. For example, carbon steel ignites at 251°C (483°F) in the presence of chlorine gas, and finely divided metal ignites even more readily. Many organic chemicals react readily with chlorine; some can result in a violent explosion.

During a fire, promptly isolate the scene by removing all persons from the vicinity of the incident. No other action shall be taken without suitable training. Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode. For incidents involving large quantities, thermally insulated undergarments and thick textile or leather gloves should be worn. Water will reduce the reaction rate, but should not be applied directly to a chlorine leak. Contain fire water run-off to minimize the potential for adverse environmental impacts.

Physical and Chemical Properties

At standard pressure and temperature, two chlorine atoms bond to form the diatomic molecule, dichlorine (Cl_2 or "chlorine"). This bond is very weak, which drives the high reactivity of chlorine gas. Chlorine reacts with almost all elements to give chloride compounds, especially at elevated temperatures. Chlorine is not explosive or flammable, but it will act as an oxidizer and support combustion, even in the absence of oxygen.

Chlorine gas is highly reactive and oxidative. As such, chlorine rarely exists in its elemental state in nature, and is typically found bonded to other elements in compounds. The most common form of chlorine is sodium chloride, or table salt, from which Westlake manufactures chlorine by electrolysis. Chlorine reacts with most elements and many organic and inorganic compounds, usually with the evolution of heat. Unless controlled, these reactions can give off significant energy.

Chlorine, at ordinary conditions of temperature and pressure, is a greenish-yellow gas with an irritating odor. Chlorine gas is 2½ times as heavy as air and can be liquefied by the application of pressure at reduced temperature to form a liquid that is amber in color and about 1½ times as heavy as water. At atmospheric pressure, it boils at about -30°F.

Properties of Chlorine	
Boiling Point	-29°F (-34°C)
Specific Gravity of Gas @ 0°C, 1 atm (air = 1)	2.49
Specific Gravity of Liquid @ 0°C	1.47
Vapor Pressure, psig @ 25°C (77°F)	98.3

Regulatory Information

The chlorine Safety Data Sheet contains regulatory information, including Chemical Inventory Status, California Proposition 65 status, and Transportation Classifications. The following is additional regulatory information.

North American Regulatory Information

- **CONEG Regulation/Model Toxics in Packaging Legislation** - Lead, cadmium, mercury and hexavalent chromium are not intentionally added to chlorine, and based on the formula and Westlake's experience with the product, the sum of the incidental concentration levels of these metals is not expected to exceed 100 parts per million (ppm) by weight.
- **VOC Information** - Chlorine does not contain constituents that qualify as volatile organic

compounds (VOC) based on the definition in 40 CFR 51.100.

- **HAP Information** - Chlorine is a hazardous air pollutant (HAP) as listed in the Clean Air Act Amendments of 1990, 42 USC 7412 (b).
- **Ozone-Depleting Chemicals** - Chlorine is not/does not contain ozone depleting chemicals (40 CFR 82, Subpart A, Appendix F).
- **CERCLA Hazardous Substance** - Chlorine appears in the List of Hazardous Substances and Reportable Quantities table (40 CFR 302.4) with a reportable quantity (RQ) of 10 pounds (4.54 Kg).
- **FDA Bioterrorism Act of 2002 Section 305 (Registration of Food Facilities)** - The following facilities have been registered with the FDA: Beauharnois, Quebec, Canada (Registration Number 19271135316), Lake Charles, Louisiana, USA (Registration Number 14461027778), Longview, Washington, USA (Registration Number 15630199746), Plaquemine, Louisiana, USA (Registration Number 11208062940) and New Martinsville, WV, USA (Registration Number 11696337946).
- **TSCA Information** - This product is not currently subject to any rule or order under TSCA Sections 4,5,7,8(a), or 8(d).

Other Regulatory Information

- **RoHS/WEEE** - Chlorine has been reviewed with regard to the EU Directive 2011/65/EU "Restriction on the Use of Certain Hazardous Substances" (RoHS 2). Based on our knowledge of this product and information on the raw material suppliers' Safety Data Sheets, this product does not contain cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBBs) or polybrominated diphenyl ethers (PBDEs) at levels greater than the tolerated maximum concentration values established by the directive.

Product Certifications and Listings

- **American Water Works Association Standard** - Chlorine conforms to the chemical identity, physical composition and packaging requirements of the AWWA Standard for liquid chlorine, ANSI/AWWA B301-10.
- **NSF Standard 60 Drinking Water Treatment Chemicals** - Chlorine has the Health Effects Listing and is certified for maximum use levels as noted on the NSF website, which can be viewed at www.nsf.org/certified/PwsChemicals.
- **Kosher Certification** - Chlorine, including the equipment used in its manufacture, does not come into contact with or contain any animal by-products, animal fats, or animal products, nor does it contain chemical additives that are organic in nature. According to the current policies of the Orthodox Union (OU) chlorine is acceptable for use in Kosher-related activities without Kosher certification.
- **Halal Certification** - Westlake's chlorine is not Halal certified. However, chlorine does not contain alcohol, natural L-cysteine extracted from hair or feathers, animal fats and/or extracts, blood of any origin, blood plasma, or pork/or other meat byproducts. Alcohol is not used as processing aid. As such, this product may be acceptable for Halal consideration.

Additional Product Information

- **Source** - Chlorine is derived from a mineral source and has not been derived from plant, animal, synthetic, petroleum or fermentation sources.
- **Allergenic Materials** - Chlorine is not manufactured using any of the following allergenic materials: carmine/cochineal extracts, celery, colors/color additives, dyes/food dyes, eggs/

egg products, seafood/fish/shellfish/crustaceans, flavors, glutens, legumes, milk, mollusks, monosodium glutamate (MSG), mustards, plant nuts/seeds/oils (sesame, sunflower, safflower, canola, etc.), peanuts/peanut products, protein hydrolysates, soy/soybeans/soybean products, spices, sulfites, sulfates, tree nuts/tree nut oils and wheat.

- **Bovine Spongiform Encephalopathy** - Chlorine is not of animal origin, and, to Westlake's knowledge, does not contribute to Transmissible Spongiform Encephalopathy (TSE)/Bovine Spongiform Encephalopathy (BSE).
- **Genetically Modified Organisms (GMOs)** - Chlorine is not manufactured with and does not contain genetically modified organisms.
- **Natural Latex Rubber** - Chlorine is not manufactured with and does not contain natural latex rubber as defined in 21 CFR 801.437(b)(1).
- **Nutritional Value** - Chlorine does not have nutritional value.

Product Stewardship

Westlake Corporation is committed to managing chlorine so that it can be safely used by its employees and customers. Westlake's relationships with its customers encourage communication about safety and environmental stewardship.

Westlake Corporation is a member of The Chlorine Institute, Inc. The Chlorine Institute, Inc. was formed over 75 years ago by chlorine producers to promote the safe use of chlorine and to standardize chlorine handling equipment. The Institute also sponsors a mutual assistance program in which trained teams respond to chlorine emergencies on a 24-hour-a-day, 7-day-a-week basis. In the United States, this response program is known as CHLOREP (Chlorine Emergency Plan). The United States is divided into 16 sectors with CHLOREP teams available from 53 plant sites (one to three plant sites in each sector).

Additional Information

For more information regarding Westlake's chlorine, contact our customer service department by calling **800-243-6774.** Or, in Canada, contact Westlake Canada Inc., 31 Industry Road, Beauharnois, Quebec J6N 1W5 Canada, 450-429-4641.

References

- Westlake Corporation Web page: http://www.Westlake.com/

Notice

Prior to its use, the user is responsible for determining the suitability of the product or products covered by this Product Stewardship Summary and for complying with all federal, state, and local laws and regulations in connection with its use. Neither Westlake Corporation nor any of its affiliates shall be responsible for any damages of any kind whatsoever resulting from the use of or reliance on this Product Stewardship Summary or product or products to which it refers.

This Product Stewardship Summary is intended only to provide a general summary of the potential hazards associated with the product or products described herein. It is not intended to provide detailed information about potential health effects and safe use and handling information and, although Westlake Corporation believes this information is correct, Westlake Corporation makes no warranties as to its completeness or accuracy. Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the Westlake Corporation product(s) mentioned in this document. Before working with any of these products, users must read and become familiar with the available information on product hazards, proper use, and handling. Information is available in several forms, such as safety data sheets (SDS) and product labels. A copy of Westlake's SDS for chlorine can be obtained by going to the company's website www.Westlake.com.

This information is subject to change without notice.

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