

CHLORINE FACTS

Oregon Hazardous Substances Emergency Events Surveillance System¹

The devastating chlorine release in Graniteville South Carolina serves to remind us of the need to understand the hazards of chemicals we use everyday. In the US, chlorine gas is one of the most common single irritant gases to which people are accidentally exposed. Inhalation exposures may occur in both the occupational and ambient environments. Chlorine is a greenish-yellow gas used in chemical manufacturing and as a bleaching agent. Hypochlorite is an aqueous solution that is used as a disinfectant and in swimming pools. Both forms are strong oxidizing agents and have very irritating odors.

Industries that commonly use chlorine include:

- Water supply and sanitary services
- Entertainment and recreation
- Schools
- Chemical manufacturing
- Pulp and paper manufacturing
- Hotels and motels
- Primary metals manufacturing
- Machinery, except electrical

What are the health effects?

Chlorine gas is irritating and corrosive to the respiratory tract, eyes, and skin and exposure to high can produce severe eye and skin burns, lung collapse, and death. Breathing chlorine can irritate the lungs causing coughing or shortness of breath. Higher exposure levels can cause build-up of fluid in the lungs (pulmonary edema) with severe shortness of breath. Repeated exposures or a single high exposure may permanently damage the lungs. Contact can severely irritate and burn the eyes and skin causing a range of symptoms from a rash to permanent damage and even damage the teeth. Nausea, vomiting and shortness of breath are also linked with exposure to chlorine. The effects depend on the concentration of chlorine gas or acid, the duration of exposure, the water content of the exposed tissues, and individual susceptibility related to age, existing medical conditions, and other factors.

How are people exposed?

Most human exposure to chlorine occurs through inhalation. If chlorine gas is released into the air,

people may also be exposed by skin contact or eye contact. If chlorine liquid is released into water, people may be exposed by touching or drinking water that contains chlorine. *Chlorine gas is heavier than air*, so it will settle into low-lying areas and may cause asphyxiation in poorly ventilated, enclosed, or low-lying areas.

The majority of individuals can detect chlorine's odor or irritant properties at 0.32 parts per million (ppm), which is less than the OSHA permissible exposure limit of 1 ppm. Because the *odor threshold* for chlorine is approximately 0.3-0.5 ppm, distinguishing toxic air levels from permissible air levels may be difficult until symptoms of irritation are present. Exposure to chlorine gas may be prolonged because its moderate water solubility may not cause upper airway symptoms for several minutes.

Proper handling of chlorine

- *Avoid chemical mixing:*
 - ✓ Household *chlorine bleach* (sodium hypochlorite solution) *can release chlorine gas* if it is mixed with other cleaning agents such as toilet bowl cleaners, vinegar, acids, ammonia containing products, or drain cleaner
 - The most common dangerous mixtures of cleaning agents are *chlorine bleach with acids or ammonia*. Potential irritants released from such mixtures are *chlorine gas, chloramines, and ammonia gas*
 - ✓ Chlorine *reacts explosively* or forms explosive compounds with many common substances such as fuel gas, fluorides, ether, turpentine, alcohols, acetylene, hydrogen, ammonia, sulfur, finely divided metals, and metal hydrides
- Enclose industrial operations
- Wear protective clothing and equipment
 - ✓ Avoid skin and eye contact
 - ✓ Avoid inhalation of chlorine
- Immediately wash thoroughly with soap and water after exposure to chlorine or chlorine solutions
- Remove contaminated clothing

Chlorine Incidents in Oregon

Between 1993 and 2005, Oregon HSEES collected and analyzed information on 2,679 qualifying incidents. Chlorine was involved in 148 (5.6%) of these incidents. 137 out of 148 chlorine incidents (92.6%) occurred at fixed facilities and 11 (7.4%) occurred during transportation (Table 1). Five incidents were threatened releases of chlorine compounds.

Victims of Chlorine Incidents

There were no reported victims for 110 (74%) of the 148 chlorine incidents

reported in Oregon. Thirty-eight (26%) of incidents had at least **one reported victim**.

In 11 incidents (7%), at least **5 victims** were reported. **Employees** (67%) were most the **most frequent victims** during chlorine releases, followed by the general public (25%), and responders (7%) (includes firefighters, law enforcement, and other responders to the scene). The greatest numbers of people injured following inhalation of chlorine gas work in manufacturing and in the entertainment and recreation services sectors. The symptoms most frequently experienced during the incidents described here (Table 3) were

respiratory irritation, nausea and vomiting, eye irritation, headache, and skin irritation, as would have been expected from the known toxicity of chlorine.

Case Study 1

A manufacturing facility experienced a combined chlorine and hydrogen bromide gas leak during evening maintenance activities. The in-house emergency response team evacuated the area where the leak occurred and called 9-1-1. Fifty firefighters and 15 emergency response vehicles responded. The release was not sufficient to trigger automatic alarms, but seventeen employees reported labored breathing and headaches. They were treated on scene and transported to one of seven local hospitals for further treatment and observation. The seventeen employees were treated and released from the hospitals and returned to work. Both gases are strong irritants, but patients were treated for chlorine exposure due to its known potential to cause respiratory irritation and headaches.

Case Study 2

A chlorine release occurred at an indoor hotel swimming pool resulting in chlorine exposures through pool water and airborne fumes. Seventeen people reported upper respiratory irritation, skin irritation, vomiting, and swollen eyes. Eleven were children, ages 6 to 13 years. Twelve people were transported to four area hospitals, treated and released. The cause of the release was improper mixing of pool chemicals. No formal evacuation was ordered, but the pool remained closed for the weekend.

Table 1. Summary of Chlorine Incidents in Oregon 1993 - 2005

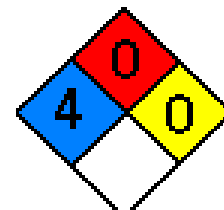
	Fixed Facility (%)	Transport (%)	Total
Incidents	137 (92.6)	11 (7.4)	148
Evacuations	61 (98.4)	1 (1.6)	62
Shelter-in-Place	3 (100)	0 (0)	3
People Receiving Emergency Decontamination	88 (100)	0 (0)	88
Events w/ Victims	36 (94.7)	2 (5.3)	38
Victims	149 (98.0)	3 (2.0)	152

Affected industries

The industry categories most frequently involved in chlorine releases were water supply, sanitary services, and entertainment and recreation (Table 2). Entertainment and recreation incidents occurred at swimming pools and involved the use of pool disinfecting chemicals, either improper mixing or defective equipment. Industries with the most events with victims were

water supply, entertainment and recreation, industrial and miscellaneous chemical manufacturing, and pulp and paper manufacturing. Industry sectors with the greatest number of victims per incident were hotels and motels, entertainment and recreation, pulp and paper manufacturing, and non-electrical machinery manufacturing.

[Substances categorized as chlorine for this analysis include chlorine gas, chlorine, sodium hypochlorite, sodium chlorite, bleach, and chlorinated water]



Recommendations:

Most of the human exposures to chlorine and chlorine compounds described in this fact sheet could have been avoided through proper training and preparedness of employees of affected industries as well as responders to these incidents. Chemical releases, human and environmental exposures to chemical releases, and resulting adverse health effects and injuries are tragic to the individuals affected and expensive to society in terms of loss of life and limb, lost work time, industry downtime, resources expended for response, clean up, and business continuity.

Industry category	Incidents (%)	Events w/ Victims (%)	Victims (%)
Water Supply	22 (14.9)	5 (13.2)	7 (4.6)
Sanitary Services	20 (13.5)	2 (5.3)	8 (5.3)
Entertainment and Recreation	19 (12.8)	5 (13.2)	23 (15.1)
Industrial & Misc. Chemicals	13 (8.8)	4 (10.5)	10 (6.6)
Schools	7 (4.7)	1 (2.6)	1 (0.6)
Transportation	7 (4.7)	2 (5.3)	2 (1.3)
Pulp & Paper Manufacturing	5 (3.4)	4 (10.5)	19 (12.5)
Hotels & Motels	4 (2.7)	3 (7.9)	26 (17.1)
Primary Metals Manufacturing	4 (2.7)	1 (2.6)	1 (0.6)
Machinery, expt electrical, nec.	1 (0.7)	1 (2.6)	17 (11.2)
All Other	46 (31.1)	10 (28.9)	38 (25.0)
Total	148 (100)	38 (100)	152 (100)

Suggested prevention strategies:

Injury	Frequency	Percent
Respiratory Irritation	136	46.7
Gastrointestinal Distress	35	12.0
Shortness of Breath	28	9.6
Eye Irritation	28	9.6
Headache	23	7.9
Skin Irritation	22	7.6
Dizzy or CNS Symptoms	10	3.4
Heart Problems	4	1.4
Chemical Burn	2	0.7
Heat Stress	2	0.7
Trauma	1	0.3
Total	291	100.0

1. Appropriately train employees about the hazards associated with workplace chemicals, their safe use and handling, and awareness the impact of accidental releases on the surrounding community
2. Development, training, and exercise emergency response plans for all industries and employees
3. Provision of appropriate personal protective equipment to employees.
 - Training in the proper use and maintenance of personal protective equipment
 - Education about the adverse consequences of inappropriate or neglected use of personal protective equipment
4. Train and educate both management and employees in the proper use, care and maintenance of engineering controls to prevent releases, spills, and exposures to hazardous materials
 - Educate the public about recognition of and response to chemical releases
 - Hazards associated with use of common household chemicals
 - Proper disposal of common but hazardous household chemicals

About the Oregon Hazardous Substances Emergency Events Surveillance (HSEES)

What is HSEES?

Oregon's HSEES system collects and analyzes data on hazardous substance spills and releases in order to determine how accidental spills, releases, and the injuries associated with them come about. The purpose of this work is to increase safety among responders, employees, and the public; to decrease the number and severity of release incidents, and to reduce morbidity and mortality due to incidents. The value of the HSEES system is its unique ability to provide feedback to the persons responding to and involved in these hazardous incidents in a timely fashion, so that information can be utilized to prevent future incidents and injuries.

Oregon HSEES goals:

- To characterize hazardous substances emergency events in the state.
- To describe morbidity and mortality associated with releases.
- To identify risk factors associated with morbidity and mortality.
- To develop strategies for reduction of morbidity and mortality due to hazardous substances emergency events.

History of the Program:

Oregon has participated in HSEES since 1992. The goal of this surveillance project is to reduce the morbidity and mortality resulting from hazardous substance emergencies, by describing the distribution of these emergency events within Oregon and the 14 other participating states; by characterizing the adverse effects experienced by employees, responders and the general public; by identifying risk factors associated with releases and injuries; and by developing strategies to reduce subsequent morbidity and mortality. We have built relationships with partners in federal, state, and local responder agencies; community organizations; and with principal hazardous materials incident reporting and data sources. We maintain and improve collaboration with partners to enhance the value of the HSEES system to the state, and to prevent releases of hazardous materials and their public health consequences.



TO REPORT A SPILL, call the Oregon Emergency Response System (OERS), toll-free, at [1-800-452-0311](tel:1-800-452-0311).

Other Resources:

National Library of Medicine's Web WISER (wireless information system for emergency responders)
<http://webwiser.nlm.nih.gov/getHomeData.do>

Oregon Poison Center: 1-800-222-1222

If you have questions or comments about the role of Oregon HSEES in monitoring chemical leaks and spills, please contact HSEES staff at (971)673-0440.

References:

1. Oregon Poison Center. Oct 25, 2005. *Chlorine: Health Care information. Fast Facts.*
2. Segal, E, Lang, E. Dec 29, 2005. *Toxicity, Chlorine Gas. emedicine*, from WebMD, <http://www.emedicine.com/emerg/topic851.htm>.
3. EPA. March 2001. *Safe storage and handling of swimming pool chemicals.* Chemical Safety Alert. www.epa.gov/ceppo/
4. ATSDR. April 2002. *CHLORINE CAS#7782-50-5.* ToxFAQs. DHHS. <http://www.atsdr.cdc.gov/tfacts172.pdf>
5. CDC. 2003. *Facts About Chlorine.* Chemical Emergencies. DHHS. www.bt.cdc.gov/chemical
6. National Library of Medicine, TOXNET, Hazardous Substances Data Bank (HSDB), *Chlorine.* (Accessed 1/25/07). <http://toxnet.nlm.nih.gov>
7. New Jersey Department of Health and Senior Services *Hazardous Substance Fact Sheet on Chlorine.*

This fact sheet does not replace the material safety data sheet (MSDS) required for a hazardous chemical under the Occupational Safety and Health Act of 1970 (29 USC 651 ET SEQ.) and regulations promulgated under this Act.

This publication was supported by funds from the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) trust fund and the Office of Terrorism Preparedness and Emergency Response of the Centers for Disease Control and Prevention (CDC), provided to the Oregon Public Health Division, Department of Human Services, under a cooperative agreement by the Agency For Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of ATSDR.