Evaluation of a chlorine gas release at a metal recycling facility

R. Reid Harvey, DVM, MPH
Randy J. Boylstein, MS, REHS

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation.

Highlights of this Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from a public health department to assess the health of employees at a metal recycling facility following an unintentional chlorine gas release on August 12, 2015.

What We Did

- We toured the facility on September 21, 2015 to better understand details of the chlorine gas release.
- We interviewed employees September 21−22, 2015 about the chlorine gas release and health effects following chlorine gas exposure.
- We reviewed publicly available state Occupational Safety and Health Administration records.
- We reviewed medical records of employees hospitalized following chlorine gas exposure.

What We Found

- The acceptance and processing of a sealed, valved, unlabeled tank (against written company policy) that contained chlorine gas led to the release of chlorine gas.
- Four employees were hospitalized for respiratory symptoms related to chlorine gas exposure, one of whom died.

What the Employer Can Do

- Do not accept containers for processing unless they are open without a valve.
- Review and update emergency plans for a hazardous material release, including evacuation routes from all sites of the facility.
- Train employees regularly on all health and safety protocols and emergency plans.
- Train employees to remain upwind when evacuating during a suspected chemical release; consider placing wind vanes strategically to assist employees in determining wind direction.
- Refer employees who are still experiencing symptoms related to the chlorine gas release to a trained healthcare provider. Depending on symptoms, this could include

Chlorine gas was unintentionally released at a metal recycling facility when an intact, unlabeled metal cylinder was processed. At least four employees exposed to chlorine gas were hospitalized, one of whom died. Additional employees present at the metal recycling facility the day of the chlorine gas release were reported to have mucous membrane and/or upper respiratory irritation. Employees may have experienced or still be experiencing related symptoms such as respiratory or psychological symptoms. We recommend that the facility only accept for processing containers that are open with no valve.

experts in the fields of pulmonology, psychology, and/or occupational medicine.

What Employees Can Do

- Follow all employer health and safety protocols.
- Participate in all safety training that your employer offers.
- Do not process a container if you have any concerns it may contain hazardous material and/or be under pressure. Tell your manager immediately.
- Tell your manager about any health and safety concerns that you may have about your workplace.
- Seek professional assistance if you are still having any respiratory symptoms or psychological symptoms related to the chlorine gas release.

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
ARDS	Acute respiratory distress syndrome
CFR	Code of Federal Regulations
FiO2	Fraction of inspired oxygen
IDLH	Immediately dangerous to life or health
mg/m3	Milligrams per cubic meter of air
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
ppm	Parts per million
PTSD	Post-traumatic stress disorder
RADS	Reactive airway dysfunction syndrome
REL	Recommended exposure limit
STEL	Short-term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average

Summary

In August 2015, the National Institute for Occupational Safety and Health received a request for technical assistance from a public health department following an unintentional chlorine gas release at a metal recycling facility. Health concerns included mucous membrane and respiratory effects following acute exposure to chlorine gas. We visited the facility on September 21−22, 2015 to interview employees and gather information about the chlorine gas release. We reviewed publicly available records from the state Occupational Safety and Health Administration investigation. We reviewed medical records of employees hospitalized following exposure to chlorine gas. At least four employees were hospitalized for respiratory symptoms, one of whom died from complications of Acute Respiratory Distress Syndrome. Given past experience with other chlorine gas release events, it is possible that other employees may have experienced or still be experiencing symptoms related to the release. We recommend reviewing protocols designed to prevent containers under pressure and/or containing hazardous materials from being accepted for processing. Furthermore, we recommend training employees on emergency plans including evacuation routes to use in the event of a chemical release.

Introduction

On August 14, 2015, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from a public health department following a chlorine gas release at a metal recycling facility on August 12, 2015. Health concerns included respiratory and mucous membrane exposure to chlorine gas. On September 21−22, 2015, we visited the facility to interview employees and gather information about the chlorine gas release.

Background

Chlorine Gas Exposure and Health Effects

Chlorine is a greenish-yellow gas with a strong, pungent smell that has an odor threshold of approximately 0.3−0.5 parts per million (ppm). Chlorine gas is moderately water soluble, allowing it to affect both the upper and lower respiratory tract. Mucous membranes, eyes, and the lower respiratory tract are often affected following chlorine gas exposure. Upon contact with water on mucosal surfaces and airways, hydrochloric acid and hypochlorous acid are formed, which are highly irritating compounds [Das and Blanc 1993]. Epithelial damage occurs due to direct oxidative injury as well as activation of inflammatory compounds, such as oxidants and proteolytic enzymes [White and Martin 2010].

The table below [NIOSH 2013] shows health effects of chlorine gas with increasing exposure. At low levels (1−3 ppm), there is mild mucous membrane irritation that can usually be tolerated for up to one hour. Beginning at 30 ppm, immediate chest pain, shortness of breath, and cough develop. Exposure to high concentrations of chlorine can result in development of Acute Respiratory Distress Syndrome (ARDS), pulmonary edema with or without infection, respiratory failure, and death [Das and Blanc 1993].

Table. Chlorine gas concentration and health effects

Concentration	Effect on human health
1−3 ppm	Mild mucous membrane irritation
>5 ppm	Eye irritation
>15 ppm	Throat irritation
15−30 ppm	Cough, choking, burning
>50 ppm	Chemical pneumonitis
430 ppm	Death after 30 minutes exposure
>1000 ppm	Death within minutes

Survivors of chlorine gas exposure can develop a condition called Reactive Airway Dysfunction Syndrome (RADS) that is characterized by asthma-like symptoms and airway hyperresponsiveness that may persist for a prolonged period [Shakeri et al. 2008]. The diagnosis of RADS is based upon a history of exposure to an irritant preceding the onset of acute respiratory symptoms, and persistent airway obstruction and/or hyperresponsiveness.

RADS has been associated with a decreased quality of life and increased depression and anxiety [Malo et al. 2009]. In addition to respiratory health effects like ARDS or RADS, the trauma associated with events such as chemical releases can lead to post-traumatic stress disorder (PTSD) [Ginsberg et al. 2012; American Psychiatric Association 2000].

Because human exposure to chlorine gas is nearly always unintentional, there are few studies assessing exposure and health outcomes. There are no specific biomarkers to measure chlorine exposure, although persons exposed to chlorine gas following a train derailment in 2005 were likely to have hypoxemia, abnormal chest radiographs, and diminished peak flow rate either on spirometry or by peak flow meter [Van Sickle et al. 2009]. Treatment for acute chlorine inhalation exposure is generally supportive, including supplemental oxygen. Inhaled β-adrenergic agents are also appropriate in those with clinical signs of airway obstruction, such as wheeze or cough [Wang et al. 2004]. Studies suggest that inhaled bicarbonate and glucocorticoids, including systemic corticosteroids and inhaled agents such as budesonide, may be beneficial, but these findings are largely anecdotal [Bosse 1994; Wang et al. 2002, 2005].

Occupational Exposure to Chlorine Gas

Chlorine gas is widely used in industries and is one of the most commonly produced chemical substances worldwide. Approximately 13-14 million tons of chlorine are produced annually in the United States and much is transported by rail for use as a reagent in the fabrication of solvents, pesticides, polymers, synthetic rubbers, refrigerants, and plastics, and as a bleach in the pulp and paper industry. It is also used as a disinfectant for purifying water [Evans 2004]. Low level exposure can occur through regular handling of chloric materials in industries that use the chemical, and is also common outside of workplaces when using detergents or mixing disinfectants [Das and Blanc 1993].

Chlorine gas exposure is unexpected in the metal recycling industry, as the industry in general does not process containers that may contain hazardous materials and/or be pressurized. For that reason, the industry standard is to only accept containers for processing that are open without a valve. However, in California in 2010, workplace incidents at two different metal recycling facilities injured at least 28 workers exposed to chlorine gas and led to a Chemical Release Alert by the California Department of Public Health to increase awareness of this particular hazard to the metal recycling industry [Choudhary et al. 2011; California Department of Public Health 2010].

Occupational Exposure Limits of Chlorine Gas

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for chlorine is 1 ppm (3 milligrams per cubic meter of air [mg/m^3]) as a ceiling limit, meaning at no time shall a worker's exposure to chlorine exceed this value [OSHA 2017; 29 CFR 1919.1000, table Z-1]. The NIOSH recommended exposure limit (REL) for chlorine is 0.5 ppm (1.45 mg/m^3) as a time-weighted average (TWA) for up to a 10-hour workday and a 40-hour workweek, and a short-term exposure limit (STEL) of 1 ppm (3 mg/m^3) [NIOSH 1992; NIOSH 2010]. The NIOSH immediately dangerous to life or health (IDLH) concentration is 10 ppm [NIOSH 2010]. The American Conference of Governmental

Industrial Hygienists (ACGIH) threshold limit value (TLV) is 0.5 ppm (1.5 mg/m^3) as a TWA for a normal 8-hour workday and a 40-hour workweek and a STEL of 1.0 ppm (2.9 mg/m^3) for periods not to exceed 15 minutes. Exposures at ACGIH's STEL concentration should not be repeated more than four times a day and should be separated by intervals of at least 60 minutes [ACGIH 2017].

Process Description

At the time of our visit in September 2015, the plant employed approximately 30 persons. The largely open-air facility that included a number of buildings was divided into ferrous (steel and iron) and non-ferrous (other metals) sides physically separated by a road [Figure]. Our tour included only the ferrous side of the facility. Customer vehicles passed through radiation detectors and were weighed before the scrap metal was inspected and unloaded into large piles located near the various material handlers on the ferrous side of the facility. Material handler operators loaded the scrap metal from the large piles next to the equipment into the shear. The shear operator then crushed the loaded scrap metal to reduce it to a more manageable size that could be transported for further processing. Scrap metal on the ferrous side could also be loaded into the baler that further compacted the material before it was transported for further processing.

Methods

Site Visit

We visited the metal recycling facility September 21−22, 2015. On September 21, we held an opening meeting with two facility employees who were part of management and several attorneys representing the company that owns the facility. Of note, at the time of our visit, several investigations conducted by various state and federal agencies were ongoing.

We toured the facility to gather information about the chlorine gas release. Attorneys representing the company prohibited us from asking questions of employees working on the ferrous side of the facility during our tour due to expressed safety concerns. We were granted access to a conference room to speak with any interested employees following the tour. We held a closing meeting with the same individuals present at the opening meeting. We returned to the facility on September 22, 2015 to be available to speak with employees.

We had the following objectives:

1. Understand the details of the chlorine gas release that occurred on August 12, 2015;
2. Discuss any employee health concerns related to the chlorine gas release;
3. Understand company health and safety practices and programs, and how to decrease the likelihood of a similar incident occurring in the future;
4. Review medical records of hospitalized employees to better understand health effects following chlorine gas exposure.

Medical Chart Review

Under the local public health department authority, we obtained medical records of employees who sought care at three area hospitals following the chlorine gas release. Using the facility's timekeeping records, we developed a list of employees present at the facility on August 12, 2015. We queried three area hospitals for records related to these employees starting August 12 or 13, 2015 until discharge or death. We calculated a hospitalization rate for employees working on the ferrous side of the facility at the time of the chlorine gas release, and an overall hospitalization rate for all employees working at the facility according to timekeeping records. For these calculations, we used the number of employees decontaminated and transported to area hospitals as the numerator and the number of employees working on the ferrous side of the facility or total number of employees working, respectively, as the denominators.

Results

Site Visit

We observed all employees in production areas wearing hard hats, high visibility safety vests, and eye protection. We did not observe any other personal protective equipment, although hearing protection and steel-toed boots were reported to be commonly used. Although we were unable to discuss routine health and safety practices in place during our visit because the company's safety director was unavailable, we were informed that it was company policy to not accept sealed containers that may contain hazardous material or be pressurized.

Facility management described the details surrounding the chlorine gas release during the site visit. No employees came to the conference room with questions or concerns.

State OSHA Publicly Available Documents Review

We reviewed publicly available records from the state OSHA investigation which included documents pertaining to certain company safety policies and material acceptance standards. According to these documents, it is company policy to require certification that containers are empty, without hazardous waste. Drums/barrels are not to be accepted unless they are opened and rinsed. Similarly, compressed gas cylinders are not to be accepted unless the valve is removed and the cylinder is opened.

Chlorine Gas Release

The following is a brief summary of the chlorine gas release based on details provided by facility management. The chlorine gas release occurred on the ferrous side of the facility [Figure]. An unlabeled metal tank arrived at the metal recycling facility for processing on August 12, 2015. It was loaded by the material handler 1 into the shear at approximately 9:40 a.m. The tank was being placed into the shear in order to reduce the tank to small pieces for further recycling. The act of loading the tank into the shear caused the seam of the tank to burst and the subsequent release of a yellow gas plume that reportedly spread quickly throughout the ferrous side of the facility (medical records note that the fire department identified this to be chlorine gas). The extent of the spread of the chlorine gas was unclear, but according to facility management, employees reported a thick yellow plume covered the ferrous side of the facility.

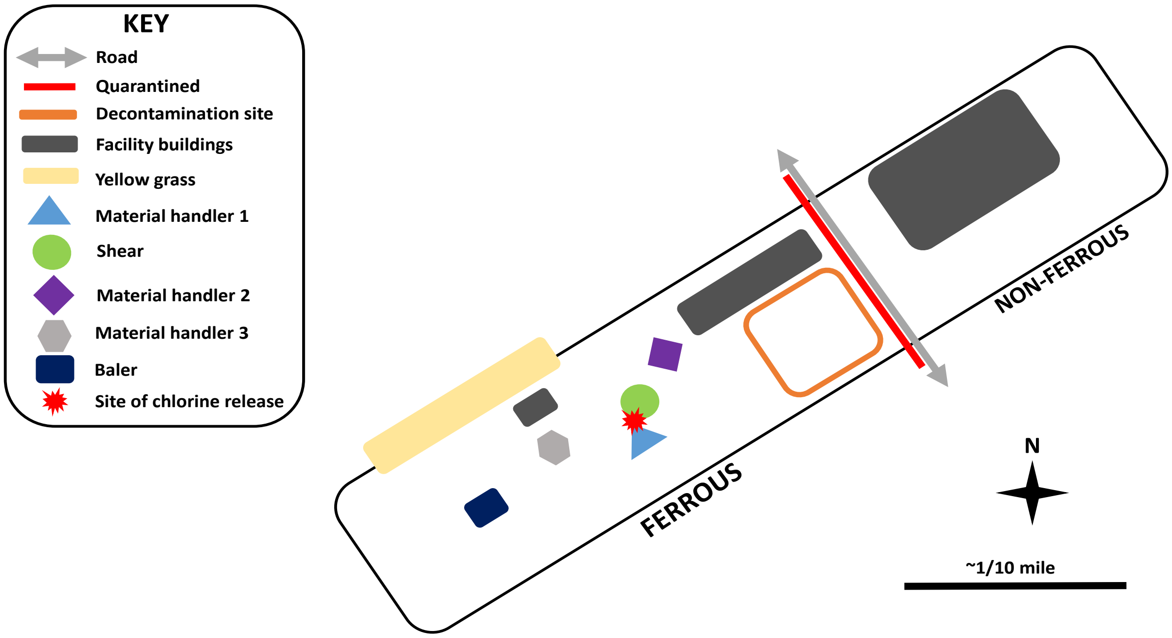

Figure. Schematic of metal recycling facility layout with details relevant to the chlorine gas release on August 12, 2015 (not to scale).

At 9:41 a.m., the administrative office, located across the road on the non-ferrous side of the facility, received an emergency call from an employee on the ferrous side of the facility. Employees from the non-ferrous side reportedly started toward the ferrous side and could see a large yellow gas plume that appeared to be moving in a northwest direction; one employee noted that the wind typically blows in the opposite (southeast) direction. Employees attempting to escape the gas plume signaled for others to stay away as they approached due to the noxious chemical. One employee reported that he did not enter the visible gas plume and remained by the radiation detectors and warehouse, yet experienced eye and upper respiratory irritation from the chemical at that distance.

The five employees working on the ferrous side were reported being exposed immediately or shortly thereafter as the gas plume spread in the vicinity: material handler 1 operator; shear operator; material handler 2 operator; baler operator; and material handler 3 operator. Upon exiting their respective equipment immediately following the release, they took different routes in attempting to escape the visible yellow gas plume and were assisting each other to escape. There were also two city employees and one truck driver reported to be on the ferrous side of the facility at the time of the chemical gas release. Emergency personnel were called immediately and arrived on the scene between 9:50 a.m. and 9:55 a.m.; they cordoned off the ferrous side of the facility by the warehouse, set up decontamination, and triage [Figure].

Decontamination consisted of removing affected persons' clothes to their underwear and spraying them with water. All eight persons on the ferrous side (five company employees and three other people) were decontaminated on the scene. Some were reportedly taken to one of four different hospitals by ambulances. Once initiated, decontamination and triage took roughly 15 minutes, before individuals were transported to hospitals by ambulance. The amount of time it took for the visible yellow chemical gas plume to dissipate was not known. Although according to facility management, it appeared by some to be moving in a northwestern direction; nearby residents and possibly other workplaces reported detecting the chlorine gas in different directions from the site of release. The grass along the ferrous side of the facility to the northwest shortly following the chlorine gas release changed color from green to yellow and remained that color for weeks before returning back to green [Figure].

The facility closed for the remainder of the week following the chlorine gas release. The local fire department released control of the ferrous side of the facility to a contractor for environmental cleanup at the conclusion of their response until the facility was reopened on August 18, 2015. As of September 21, 2015, one surviving employee from the ferrous side had not yet returned to work.

Employees Exposed to Chlorine Gas

At least four facility employees working on the ferrous side at the time of the chlorine gas release were treated at two area hospitals, according to our medical records review. We do not have information on the three individuals working for other companies present on the ferrous side of the facility during the chlorine gas release, or any other individuals (nearby residents, employees of other workplaces, or first responders) who may have been exposed to varying concentrations of chlorine gas.

According to the company time sheet, 31 employees were clocked-in during the chemical release, yielding a hospitalization rate of at least 13% for the entire workforce. On the ferrous side of the facility, five employees were working at the time of the chlorine gas release, yielding a hospitalization rate of 80% for employees working the immediate vicinity of the chlorine gas release.

Additional employees reportedly were triaged by first responders and released without seeking care at area hospitals. Some of these employees reportedly had mucous membrane and/or upper respiratory symptoms suggesting exposure to chlorine gas.

Fatal Case Report

The material handler 1 operator was loading the tank into the shear for processing when it ruptured releasing chlorine gas. The 44-year-old non-smoker with history of diabetes navigated through the thick yellow plume to escape the released gas; he was decontaminated onsite by first responders and reported shortness of breath, coughing, and chest pressure. His oxygen saturation was 87% on ambient air and increased to 94% on a non-rebreather mask. Emergency personnel transported him to a local hospital. Although alert, he had tachycardia (elevated heart rate) and dyspnea (difficulty breathing) on presentation and quickly developed hypoxic (low oxygen in blood) respiratory failure, necessitating mechanical ventilation. Chest radiographs showed bilateral infiltrates consistent with pulmonary edema (fluid in the lungs); he was diagnosed with ARDS and administered the diuretic furosemide. Initial reports suggested the gas released was arsenic trichloride. Thus, the chelating agent dimercaprol was acquired from a different hospital and administered. Despite aggressive supportive therapy, he developed hypotension (low blood pressure) and hypoperfusion (inadequate blood flow), which resulted in acute kidney injury in the form of tubular necrosis. Continuous renal replacement therapy was attempted but discontinued due to profound hypotension. He also required multiple plasma exchanges due to hemolysis (destruction of red blood cells). Despite responding to pressor therapy and improvement in oxygen saturation (FiO_2 weaned to less than 50%) during three days of hospitalization, he died from cardiac arrest on August 15, 2015.

Autopsy findings were consistent with ARDS with purulent bronchitis and pneumonia. Erythema and petechial hemorrhages were noted throughout the upper airway and bronchi; fluid exuded from the parenchyma. Microscopic examination of the lungs demonstrated altered hyaline membranes and hypertrophy of type II pneumocytes. Cardiomegaly (heart enlargement) was also present.

Discussion

The acceptance and processing of a sealed, valved, unlabeled tank that contained chlorine gas led to the release of chlorine gas, exposure of facility employees, four hospitalizations and one death. The unintentional chlorine gas release at this metal recycling facility marks at least the third such incident in the United States since 2010, and the first involving a fatality. Prevention of similar incidents in the future will ultimately require that the metal recycling industry only accept containers that are open without a valve and treat any sealed containers as potential hazardous waste.

Occupational exposure to high concentrations of chlorine gas is rare, and most commonly due to workplace unintentional events or human error. In 2005, 71 persons were hospitalized and nine died after a train transporting 42 to 60 tons of chlorine gas derailed in South Carolina. Additionally, emergency personnel responding to such incidents can be exposed to the hazards without sufficient respiratory protection [Brinker et al. 2015]. Industries such as pulp and paper mills that use chlorine gas as part of production processes typically educate employees on chlorine safety and install chlorine detectors for added protection [Leroyer et al. 1998]. Although chlorine gas exposure is not expected in the metal recycling industry, with three separate incidents resulting in at least 32 workers hospitalized and one death since 2010, industry awareness of the hazard of chlorine gas and other chemical releases must be increased.

Though we did not evaluate employees' health, it is possible that some employees could have ongoing health effects from exposure to chlorine gas that could include RADS. RADS has been documented previously following exposure to chlorine gas [Donnelly and FitzGerald 1990; NIOSH 2013; Kim et al. 2014]. Employees with persistent respiratory symptoms, particularly cough, shortness of breath, or wheeze should be assessed for RADS and evidence of reversible airflow limitation (e.g., spirometry with bronchodilator reversibility or positive non-specific bronchoprovocation challenge). The majority of patients with RADS improve over time, although many continue to have respiratory symptoms for at least a year and have physiologic abnormalities such as bronchial hyperresponsiveness for several years [Brooks et al. 1985; Bardana 1999].

Ongoing PTSD symptoms are also possible in employees of this facility, including those exposed to high concentrations of chlorine gas, as well as those working on the non-ferrous side of the facility at the time of the chlorine gas release who were exposed to lower concentrations of the gas but still experienced the trauma associated with the death of a colleague. Twenty-two percent of employees reported symptoms consistent with PTSD following an unintentional chlorine gas release at a poultry processing plant in 2011 [NIOSH 2013], and nearly half of respondents reported PTSD symptoms following a train derailment and chlorine gas exposure in South Carolina in 2005 [Duncan et al. 2011]. PTSD symptoms have the potential to last many years, with approximately one-third of individuals diagnosed with PTSD displaying symptoms for up to 6 years in one study [Bisson 2007].

Given his initial clinical signs and rapid development of respiratory failure, the deceased employee's chlorine exposure was likely well above all published exposure limits of chlorine gas. The amount of time he spent navigating through the yellow plume of chlorine gas is unknown. Although chlorine is approximately twice as dense as air and therefore tends to settle, weather conditions, as well as piles of scrap metal serving as physical barriers, would have affected the movement and dissipation of the chlorine plume. The deceased employee was operating the equipment handling the sealed container when it ruptured and released the chlorine gas; therefore, he was likely exposed to the highest concentration of chlorine gas. Reports of eye and upper respiratory irritation in employees located near the road separating the ferrous and non-ferrous sides of the facility suggest a concentration of at least 5 ppm at that distance.

The clinical course of the deceased employee during hospitalization until his death is consistent with previous case reports of acute lung injury and ARDS following exposure to high concentrations of chlorine gas. His initial symptoms of shortness of breath, coughing, and chest pressure were consistent with RADS and/or ARDS; he developed acute respiratory failure and died from complications on the fourth day of hospitalization. While there are no widely accepted medical treatment guidelines for acute chlorine exposure, mostly due to the rare nature of the occurrence, some studies suggest that inhaled bicarbonate and glucocorticoids, including systemic corticosteroids and inhaled agents such as budesonide, may be beneficial, but these findings are largely anecdotal [Bosse 1994; Wang et al. 2002, 2005]. The initial uncertainty surrounding the chemical involved in the release (arsenic trichloride versus chlorine) could have influenced the treatment decisions made during his care. His autopsy findings including pulmonary edema, bronchial erythema, and cardiomegaly were similar to findings from those who died following chlorine gas exposure from a train derailment in South Carolina in 2005 [Van Sickle et al. 2009].

Several factors may have contributed to the chlorine gas release at the metal recycling facility. The specific events leading to the chlorine gas release were not the focus of our investigation; however, in April 2016 at the conclusion of its investigation, the state OSHA cited the company for not effectively enforcing written policies aimed to prevent accepting sealed containers, and not properly training employees how to handle large sealed containers [Washington Department of Labor and Industries 2016]. During our site visit, we requested health and safety protocols from the company but did not receive any documents. However, employees reported that it was policy to not accept or process sealed containers that could contain hazardous material and/or be pressurized, which was confirmed by the publicly available records from the state OSHA investigation. The particular protocol(s) in place to prevent that from happening at the time of the chlorine gas release is/are unknown to NIOSH. The citations administered by state OSHA suggest certain health and safety protocols are in need of review by the metal recycling facility. Training as well as clear risk communication between management and employees is required to prevent similar incidents in the future.

The unintentional chlorine gas release at this metal recycling facility is the third such occurrence since 2010. Industry awareness must increase to prevent similar events in the future. Scrap recycling is a $106 billion industry in the United States directly employing 149,000 workers [ISRI 2015]. In 2015, the U.S. ferrous scrap industry was valued at more than $18.3 billion, and processed 67 million tons of ferrous scrap [ISRI 2016]. Steel is the most recycled material worldwide. The scrap metal recycling industry must heighten awareness of the risk of processing sealed, unlabeled containers and treat such containers as potential hazardous materials, notifying the appropriate authorities before processing. The threat of radioactive materials is controlled during the process of metal recycling as radioactive detectors monitor incoming scrap metal at this facility and others. Administrative controls to identify sealed, unlabeled containers brought to metal recycling facilities may further protect employees of these facilities.

This evaluation has limitations. Without conducting a health evaluation of employees of the metal recycling facility, we were not able to assess ongoing health effects in these employees directly, that might be associated with RADS, PTSD, and/or other health conditions. Rather, we describe possible health effects that have been reported following similar incidents in other workplaces.

Conclusions

The acceptance and processing of a sealed, valved, unlabeled tank that contained chlorine gas led to the release of chlorine gas, exposure of facility employees, four hospitalizations and one death. In addition to those employees who sought care, other employees present at the metal recycling facility the day of the chlorine gas release may have experienced or still be experiencing respiratory, psychological, or other symptoms related to the release. Employees should be encouraged to report ongoing health concerns that might be related to the chlorine gas release to their manager and/or their healthcare provider(s). Steps should be taken by the employer to ensure safety protocols are in place to prevent accepting sealed containers for processing that may contain hazardous materials and/or be pressurized, and that adequate emergency plans are developed in case of an unintentional hazardous material release. Furthermore, employees should be regularly trained on all health and safety protocols as well as emergency plans, including remaining upwind when evacuating for a chemical release.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage this metal recycling facility to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan.

1. Do not accept containers for processing unless they are open without a valve. If this policy was already in place at the time of the chlorine gas release, investigate and address potential gaps that could have allowed a sealed container with hazardous materials under pressure to be accepted for processing.
2. Revisit or develop emergency plans in case of a hazardous material release, including evacuation routes from all sites of the facility.
3. Train employees regularly on all health and safety protocols and emergency plans. Train employees to stay upwind when evacuating for a chemical release. Consider placing wind vanes strategically to assist workers in determining wind direction.
4. Refer employees who are still experiencing symptoms related to the chlorine gas release to a trained healthcare provider. Depending on symptoms, this could include experts in the fields of pulmonology, psychology, and/or occupational health.

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Availability of Report

Copies of this report have been sent to the employer and employees at the facility. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

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