One baby chlorine cylinder (60 kg capacity) kept in a small factory shed in a congested locality of Kolkata started leaking from the bottom of the cylinder in a winter midnight. The leaked gas spread over the nearby area resulting in death of 4 persons and injury to 87 persons. The cylinder was found to be badly corroded.

1. Introduction

Life without chlorine is unimaginable. No fresh sparkling water will be available from taps or in swimming pools. Dreaded diseases like cholera, typhoid, and dysentery will be rampant.

It is the single element on which the manufacture of many other chemical products depends. It is a real workhorse of the industry ranks amongst the top ten in volume of all chemical produced in the world.

Chlorine is a toxic, corrosive gas that can cause severe burns if inhaled or upon skin contact. It is a greenish-yellow nonflammable liquefied compressed gas packed in cylinders under its own vapour pressure. It may fume white on contact with moist air. The degree of fuming is related to the amount of humidity in the air. It is also an oxidizer and will support combustion. Products of combustion are toxic. The exposure limits are as follows [1]

- OSHA : PEL = 1 ppm
- ACGIH : TWA/TLV = 0.5 ppm
- NIOSH : IDLH = 10 ppm

2. Description of the incident

Small unit engaged in manufacturing calcium hypochloride solution by passing chlorine into lime solution. The occupier brought a cylinder of chlorine (baby cylinder ~ 60 kg capacity) from the nearby dealer for the preparation of the said hypochloride solution. In the nighttime the cylinder which was kept lying in the ideal condition starts leaking from
its bottom all on sudden. The worker brought some ice from nearby shop and kept the cylinder in the ice pot with anticipation that the chlorine leak from the cylinder will stop if the cylinder is cool down by ice. After a few minutes the leak aggravate instead of stopping.

Profused chlorine gases come out from the cylinder and disperse according to the direction of wind affecting the people on his path in the adjacent houses, three people were died by the chlorine gas and other person who were sleeping in the nearby areas and on the passage of the dispersion of the gas was also died. The place was thickly populated area in a metropolitan city and most of the buildings were multistoried, normally shops were in the ground floor and residential accommodation on the first floor onward. As the chlorine gas is heavier than air it spreads very little quantities in the first floor level affecting 87 people who needs only first aid treatment due to minor injury by inhalation of the chlorine gas.

3. Incident analysis

The main event was identified as
1. The chlorine cylinder was badly corroded.
2. Chlorine dispersed according to the wind direction and causes the death and injury.
3. No emergency first aid response was there.

A major contributing conditions were also identified:

1. The man engaged in the manufacturing process had no knowledge regarding the hazards of the chlorine.
2. Due to the worker’s ignorant, the staff’s reaction was to put the chlorine cylinder on the ice pot and the reaction of the metals of the chlorine cylinder with chlorine and water ultimately increases the diameter of the leaky portion of the cylinder.

4. Lessons to be learned from this incident

1. Understanding of the hazards and effects Management Process needs to be implemented.
2. Incident scenarios and appropriate job safety analysis (task risk assessment) should be performed with the involvement of first line supervision. Methods statements should be prepared which clearly define roles, responsibilities and the controls to be applied.
3. Chlorine cylinder supplier’s recommended practices for safe handling of the cylinder should be understood, communicated and applied.
4. Cylinder leakage should be addressed to the manufacturer or local track force to tackle this problem immediately and to provide rescue staff with breathing apparatus and resuscitation equipment.
5. The awareness of the hazard of chlorine should be enhanced for all staff.

5. Chlorine cylinder user’s precautions [2,3]

There is a need for major precautions must be observed while working with chlorine, which is a very dangerous gas. The following outlines a program governing the moving,
storage, and maintenance procedures to be used for handling chlorine gas. Consult the Safety Engineer for procedures to be followed in an emergency, and the type of first aid treatment to be rendered to persons exposed to chlorine fumes.

A. Cylinder movement

i. A chlorine gas cylinder valve cap should be in place when the movement of cylinder takes place.

ii. Do not drop a cylinder or allow an object to strike the container with extreme force.

iii. Heat should not apply to chlorine cylinders or valves.

iv. Clamp support (at least two-third of the way up the cylinder) must essential for cylinder movement in hand truck.

v. Rope sliding chain or magnetic device should not used to carry the cylinder or lifting the cylinder by crane.

vi. Never lift the cylinder by the valve cap or its neck.

B. Cylinder storage

i. Store cylinder in a well-ventilated, secure area, protected from weather.

ii. Cylinders should be stored upright with valve outlets sealed, and valve protection caps in place.

iii. Storage should be away from heavily traveled areas and emergency exits.

iv. Avoid areas where salt or other corrosive materials are present.

v. Full and empty cylinders should be segregated.

vi. Use a first-in first-out inventory system to prevent full containing from being stored for long periods of time.

vii. Visually inspect stored cylinders on a routine basis, at least weekly for any indication of leakage or other problems.

viii. Never store containers near turpentine, ether, anhydrous ammonia, finely divided metals, hydrocarbons, oxygen cylinders, acetylene cylinders, or any flammable materials.

ix. Chlorine cylinder storage & consumption area should be provided with leak detectors, at least two/three points depending upon size of the area, with high concentration audio visual alarm.

x. Consumption point process exhaust should be provided with on line chlorine sensors and audio visual alarm.

xi. To avoid liquid/water ingress in the cylinder while consuming the chlorine, outlet line from cylinder to consumption point should be provided with 32ft high barometric leg.

C. General precautions

i. Do not drag, roll or drop cylinder.

ii. Never tamper with the fusible plug safety device on containers.

iii. Never alter or repair a container or valve. Tell the chlorine supplier if any damage is found.

iv. Never place a container in hot water, or apply direct heat to increase the flow rate, or for any other reason.
v. A flexible copper tube connection should be used between the container and the piping system. Copper tubing shall be type K or L and sized for a minimum of 3500-kPa (500-lb/in²) working pressure. A type L 9.5 mm (3/8-in) o.d. flexible copper tube is recommended.

vi. Once the cylinder has been connected to the process, open cylinder slowly and carefully.

vii. If user experiences any difficulty operating cylinder valve, discontinue use and contact supplier.

viii. Never perform maintenance work on a system unless the tank valves are closed.

ix. When a container is empty the valve should be closed, lines disconnected, and the valve tested for leakage. An outlet pipe cap should be promptly attached and the cylinder valve cap secured. If the valve does not seat immediately, open and close it lightly until it seats. Never impact the valve or cylinder with anything, with the mistaken idea it would help make a tight valve closure.

x. To detect a chlorine gas leak, attach a cloth to the end of a stick, soak it with ammonia, and hold it close to the suspected area. A white cloud of ammonia chloride will result if there is a chlorine leak. Commercial 26° Be ammonia must be used; household ammonia is not strong enough.

xi. Do not enter a chlorine contaminated area without wearing a self-contained breathing apparatus. Canister-type chlorine masks do not protect against chlorine concentration over 1 percent when the oxygen concentration is below 16 percent.

xii. If a leak develops in chlorine system, shut off the cylinder valves and ventilate the area to the outdoors prior to repairing the leak. Should a major leak develop which can not be controlled, clear the area of personnel, and exhaust the fumes to the outdoors.

xiii. If a cylinder valve leaks, tighten the packing nut with the special wrench. Should it continue to leak, replace the outlet pipe cap and remove the cylinder to the outdoors.

xiv. If a cylinder leaks, tilt the cylinder to permit gas instead of liquid to escape. Less equivalent leakage can flow through a crack as gas than as liquid.

xv. Do not use water on a chlorine leak.

xvi. In case of fire all cylinders should be removed from the fire zone immediately.

xvii. Always store and handle compressed gas cylinder in accordance with the safe handling of compressed gases in containers (Gas cylinder rules, 1981).

References

1. Material Safety Data Sheet for chlorine