U.S. Chemical Safety and Hazard Investigation Board (CSB) Investigation Exercises – Facilitator

Purpose

To review facts from an accident investigation conducted by the CSB and discuss various actions that might have presented the incident. This exercise is generally used in Industrial Emergency Response training.

Time Requirement: ½ to 1 hour

Number of Facilitators: 1

Materials

The following materials will be needed:

- Download from the internet site www.csb.gov copies of the CSB Investigation Digest or photocopy the black-and-white versions included in this guide for all participants.
- Copies of the "Key Facts," "Questions" and "Answers" for each participant.
- Pencils, note pads and paper block or white board

Facilitator Preparation

- Read the background provided on the CSB web site.

  NOTE: if you are using a Report not included in this exercise, develop the Key Facts, Questions and Answers Page (using those in this Facilitator Guide as a

template). Review with the Program Director. File final with other program materials and forward to UC to include in an update of this exercise.

- Review the fact sheets (Investigation Digest, Key Points) and edit as appropriate.
- Review the question pages and edit as appropriate.
- Review the answer sheets and edit as appropriate. Add answers for any question you have added.

Procedure

Have each participant read the articles individually or in groups. Then pass out the “Key Points” and “Questions” sheets for the exercise.

After participants have finished answering the questions, facilitate a discussion.

Distribute the “Answers” Sheet.

Kaltech Industries Building Explosion
New York, NY, April 25, 2002

Key Points

- Thirty-six people were injured as a direct result of an explosion in commercial building located in downtown Manhattan.
- The building housed Kaltech Industries Group, service firms, professional offices and other businesses.
- The tenants were not informed that Kaltech used the basement of the building to house hazardous chemicals.
- Kaltech workers combined the content of unmarked carboys into one large carboy, to be disposed.
- A metal carboy contained nitric acid.
- Some plastic carboys contained lacquer thinner.
- The other plastic carboys contained spent etching solution.
- The workers assumed all the carboys contained only etching solution.

Questions

1. What would have helped the workers at this explosion?

2. What management decisions/omissions contributed to this situation?

3. Why were OSHA regulations and federal hazardous waste laws not put into practice?

4. What can be done to correct this problem?

Kaltech Industries Building Explosion

New York, New York April 25, 2002

On April 25, 2002, an explosion in a mixed-use commercial building in downtown Manhattan injured 36 people, including 14 members of the public and six firefighters. Thirty-one of the injured were treated in hospitals, including four who required intensive care.

The explosion originated in the building's basement, which was occupied by Kaltech Industries Group, a commercial sign manufacturer that used hazardous chemicals to etch and clean metal signs. Kaltech shared the building on 19th Street in Chelsea with service firms, professional offices, and other businesses.

Building tenants were not informed about the hazards of Kaltech's operations. "We were absolutely unaware that there was anything in the basement," one tenant later told the Board. "I only knew that I worked next to a sign shop."

On April 25, Kaltech workers were consolidating various containers of liquid hazardous waste for shipment offsite. Just prior to the explosion, two workers had completed pumping the contents of several 15-gallon storage containers, called carboys, into 55-gallon plastic drums. Moments after the workers completed transferring the liquids and left the area, a vigorous chemical reaction began in one of the drums. Workers described a hissing sound rising to a jetting noise as liquid spewed from the container.

Seconds later there was an explosion, which appeared to one witness as a fiery red bubble. Falling debris caused most of the injuries, trapping some people who were later rescued by firefighters. The blast caused extensive damage to the building, blowing out portions of the elevator shaft, destroying the center stairwell, and collapsing a wall in the mezzanine. Windows and broken chunks of the building façade fell to the sidewalk, and 19th Street had to be closed for the next two weeks. Kaltech's owners suspended operations and eventually transferred company assets to Beyond Signs Inc., a firm controlled by relatives.

VIOLENT REACTION OF NITRIC ACID

Workers told CSB investigators that the last carboy they pumped into the 55-gallon plastic drum was unique because it was metal, while the others were plastic. The worker in charge mistakenly assumed that all the carboys, plastic and metal, contained spent etching solution. Investigators later found the metal carboy near where the explosion originated. A sample from that carboy was identified as nitric acid, a strong oxidizer and corrosive that is incompatible with most organic substances. Several of the plastic carboys nearby contained residues of lacquer thinner, evidently mixed with spent etching solution.

The explosion blew out windows up to the fifth floor and showered the street below with building debris.

Lacquer thinner contains flammable chemicals like acetone and toluene, and when it contacts concentrated nitric acid, a spontaneous chemical reaction can occur generating heat and gas. CSB investigators concluded that just such a reaction occurred at Kaltech.

Kaltech owners and employees said they could not recall using nitric acid, and investigators found no company records indicating purchases of the chemical. CSB found it likely that the nitric acid, which can be used in some metal etching processes, had been obtained at one time and subsequently forgotten, left in an unlabeled container.

HAZARDOUS WASTE CONTAINERS NOT LABELED

Not only did the metal carboy of nitric acid have no label indicating the chemical's dangerous properties, most other waste containers were also unlabeled. Kaltech employees did not know the identity of the materials, their hazards, or their compatibility with each other. CSB concluded that that labeling would have helped prevent the accident by informing workers of the need to keep incompatible reactive materials separated. Any unlabeled waste container should be tested to determine its contents, the CSB said.

The city's Community Right-to-Know Law, state hazardous waste regulations, and federal workplace safety regulations all require that containers with hazardous materials be clearly labeled. However, the New York City Fire Prevention Code has no similar provisions, and it does not require the separation of incompatible materials.

WORKERS NOT TRAINED ON HAZARDS

The Board found that Kaltech had no organized training program, and workers received no formal instruction on the hazards of the materials they were expected to handle or package for disposal.

U.S. Occupational Safety and Health Administration (OSHA) regulations require employers to inform and train workers about the hazards of chemicals in the workplace. Likewise, federal hazardous waste laws require waste generators like Kaltech to conduct formal training — either in the classroom or on-the-job — for all personnel involved in disposal operations.

The New York City Fire Prevention Code does not mirror these requirements. While the code has a permitting process for companies that store corrosive or flammable materials, it does not require that employees be given hazardous materials safety information or training. For example, the code does not mandate that Material Safety Data Sheets (MSDSs) be provided to workers on site.

GOVERNMENT INSPECTIONS WERE INEFFECTIVE

The New York City Fire Department conducted periodic inspections of Kaltech and issued citations for minor violations. Department officials said that they were unaware that the company stored and handled flammable and corrosive materials in the basement, and inspectors only visited the aboveground portions of the business. Even if a complete inspection had been done, fire inspectors would have lacked authority under the code to correct all the safety deficiencies that led to the accident.

The New York State Department of Environmental Conservation administers the state's hazardous waste program. The department inspects only two percent of all regulated facilities annually. Kaltech was never inspected during its ten years of operation, despite the company's status as a large-quantity hazardous waste generator located in a densely populated neighborhood.

Although OSHA inspected Kaltech after the accident and cited the company for 36 serious violations, OSHA inspectors had never visited the facility during the previous decade.

NEW YORK CITY'S FIRE CODE

Although it has been amended periodically, the New York City Fire Prevention Code has never undergone a comprehensive review or revision since 1918. The code does not incorporate recent developments in hazardous materials safety, such as chemical identification, labeling, worker training, and separation of incompatible materials. In recent years, other U.S. cities — plus all New York jurisdictions except New York City — have moved to adopt model fire codes: modern, comprehensive, regularly updated codes developed by the National Fire Protection Association or other code councils. Under the model codes, a business that plans to use hazardous materials must first submit an acceptable management plan explaining how chemical risks will be controlled.

RECOMMENDATIONS

In approving the report on September 30, 2003, the CSB issued a variety of safety recommendations to prevent future accidents.

To the Mayor and Council of New York City:

Because New York City conducts more than 100,000 inspections of the city's hazardous chemical users every year, an up-to-date fire code would be a vital tool for preventing chemical accidents. The Board therefore recommended that the Mayor and the City Council revise the Fire Prevention Code in order to better control the storage and use of hazardous materials.

Such materials should be labeled, workers should be trained in handling them, and incompatible chemicals should be separated. Businesses should be required to submit a hazardous materials inventory and management plan prior to obtaining permits.

The Board also recommended that mixed-use buildings be required to develop hazardous materials safety plans, to be shared with the occupants. The Board further requested that the fire department and city environmental authorities establish a program to exchange information about hazardous chemicals stored at businesses.

To the New York State Department of Environmental Conservation:

The CSB recommended that the state increase inspections of hazardous waste generators located in mixed-occupancy buildings within densely populated areas.

To Kaltech Industries and Beyond Signs Inc.

The CSB recommended that the companies label and characterize all hazardous materials and provide employees with information and training about the chemicals they work with.

Published October 2003

Answers

1. The workers were not trained on hazards, so they had no formal instruction on the dangers of the materials they were expected to package for disposal.
2. They did not implement OSHA regulations that require employers to inform and train workers about the hazards of chemicals in the workplace. Neither did they conform to the federal workplace safety regulations, which require classroom or on-the-job training for all personnel involved in disposal operations. Other laws that were violated were the city of New York's Community Right-to-Know law, and state hazardous waste regulations.
3. The New York City Fire Prevention Code has a permitting process for companies that store corrosive or flammable materials. However, it lacks requirements for employees to be given hazardous materials safety information or training. Kaltech failed to realize that the fire prevention code dose not parallel the requirements of other federal or state laws and regulations. In fact, when there is a conflict between HAZWOPER and the general standard, the most protective regulations must be enforced.
4. The New York City Fire Prevention Code has not been updated since 1918, which means it does not include recent developments in hazardous materials safety. An update to the code would be necessary for preventing chemical accidents. Businesses should be required to submit a hazardous materials inventory and management plan, which include worker training in dealing with hazardous materials and safety, in order to obtain permits. In addition, a program to share hazardous materials safety plans with the other occupants of multiple business buildings would also be helpful in preventing exposures/injuries. Finally, an increase in inspections by the state of business handling hazardous materials in populated areas, will help to ensure businesses are complying with the correct regulations for their particular practices.

Union Carbide Nitrogen Asphyxiation
Hahnville, LA, March 27, 1998

Key Points

- Asphyxiation due to over exposure to nitrogen gas killed one Union Carbide employee and injured another at the Taft/Star plant.
- Two skilled workers were inspecting the 48-inch open pipe end to ethylene oxide unit that was in the process of a major maintenance project.
- Some of the process equipment from the plant's ethylene oxide production unit had been temporarily removed, which left the pipe connected to the process unit at one end, and open to the air at the other.
- Nitrogen gas was in use to purge air and moisture from the unit, though 150 feet away, in an attempt to protect the chemicals that were inside the pipe, an operation that was directed by one of the victims the night before.
- While using a black light to inspect the open end of the pipe after an earlier cleaning, the two workers had other workers hold a black plastic sheet over the open end to block out the sunlight.
- 15 minutes later, the men were pulled from the pipe. One was unconscious and later died. The other was in a daze, and later hospitalized in critical condition.

Questions

1. What would have helped the Union Carbide employees avoid this situation?

2. What responsibility did the employer have in this tragedy?

3. What can be done to correct these problems?

Union Carbide Nitrogen Asphyxiation

Hahnville, Louisiana March 27, 1998

On March 27, 1998, one worker was killed and another severely injured when they were asphyxiated by nitrogen, an odorless gas that was venting through the large open pipe where the men were working at Union Carbide's Taft/Star plant in Hahnville, Louisiana.

The Taft plant manufactures industrial chemicals, and the accident occurred in the plant's ethylene oxide production unit. The ethylene oxide unit was undergoing a major maintenance project, in which some process equipment had been temporarily removed. The equipment removal left the pipe connected into the process unit but open to the air at one end. The two victims, both skilled and experienced workers, were inspecting the inside of the 48-inch open pipe end to gauge the effectiveness of an earlier cleaning effort. While the men worked, nitrogen gas was being used to purge air and moisture from the unit, protecting the chemicals inside.

Large open pipe end where the two victims were working

During their inspection of the inside of the pipe, the two workers used a black light, which causes grease, oil, and other contaminants to glow in the dark. But the midday sun would make it difficult to see, so the workers asked two contractors to hold a black plastic sheet over the open pipe end while they crouched just inside. Unknown to any of the workers, the plastic sheet created a dangerous enclosure where nitrogen gas could accumulate, displacing oxygen and causing asphyxiation.

The two contract workers holding the sheet became concerned when they had not heard from the workers inside for some 15 minutes. When there was no response to their calls, they pulled the sheet away and found one worker unconscious and the other in a daze. The first worker was pronounced dead on arrival at a hospital. The second man was hospitalized in critical condition but survived.

The U.S. Chemical Safety Board investigated the accident and found that inadequate confined-space warnings and entry procedures were at the root of the tragedy.

DANGERS OF TEMPORARY CONFINED SPACES

A confined space is defined by the U.S. Occupational Safety and Health Administration (OSHA) as a space that is large enough for a person to enter, has limited means for entry or exit, and is not designed for continuous occupancy. When workers temporarily enclosed the open pipe end, they in effect created a confined space. Federal regulations as well as good practice require various safety measures for entry into such spaces. There are particular requirements for those confined

DANGERS OF NITROGEN

The air we breathe normally contains 78% nitrogen and 21% oxygen. As nitrogen is added to air, it displaces oxygen. When the oxygen concentration drops from 21% to 16%, pulse and breathing rates drop, and mental functions are impaired. Below 14%, people suffer abnormal fatigue, emotional upset, poor judgment, and faulty coordination. Further reductions result in nausea, vomiting, permanent heart damage and loss of consciousness. At about 5% oxygen or below, a person will fall into a coma within 40 seconds, requiring emergency administration of oxygen to have any chance of survival.

spaces where it may be unsafe to breathe, such as air monitoring and the issuance of a written permit identifying the expected hazards and needed precautions.

Although the Union Carbide plant did have procedures for entering confined spaces, CSB found that these procedures did not generally cover temporary enclosures like the one in this case. No permit was issued prior to the workers' entry into the enclosure, nor were any precautions taken to protect the men from the risk of asphyxiation.

NITROGEN HAZARDS NOT RECOGNIZED

Even though one of the two victims had directed the nitrogen purging operation the evening before, apparently he did not realize that dangerous amounts of nitrogen were flowing through open valves to the pipe end where the incident occurred — some 150 feet and several floors away from the source of the nitrogen.

The CSB investigation report noted that it is important to look beyond an immediate task and anticipate secondary hazards that may not be obvious. In this case, operators did not evaluate the risks caused by the nitrogen purge to the workers downstream, and hazards at the open pipe end were not recognized. The investigation concluded that a hazard evaluation likely would have led operators to post warning signs at the pipe opening and prevented the accident.

After the accident, managers said they did not know that the workers were going to perform a black light inspection of the pipe, which led to the creation of a temporary enclosure. However, the CSB found that the open pipe end itself presented a hazard, and any worker who simply leaned into the open pipe could have been overcome, depending upon the wind and other conditions.

ODORLESS GAS POSES RISKS

The CSB investigation noted that humans cannot detect excess levels of nitrogen because the gas is invisible, odorless and tasteless. Natural gas and propane also lack a natural odor, but a chemical odorant is added to these gases to warn of their presence in the air. The odor warning is used along with other safety measures to prevent accidents involving these gases. In the Union Carbide case, the CSB found that if nitrogen had been odorized, the workers probably would have realized they were in danger before it was too late. Odorizing nitrogen would provide an extra measure of safety, the CSB determined, in addition to appropriate confined space procedures, hazard evaluations and warning signs.

RECOMMENDATIONS

On February 23, 1999, the CSB issued several safety recommendations designed to prevent similar accidents.

To the Union Carbide (now Dow Chemical) Taft Plant:

The CSB recommended that the plant modify its safety program to better control the hazards associated with temporary enclosures. Whenever tanks, pipes or other pieces of equipment are opened, the plant should post warning signs stating "Danger, Confined Space: Do Not Enter without Authorization." In cases where nitrogen is added to a confined space, an additional warning sign should be used.

To the National Institute for Occupational Safety and Health (NIOSH):

The Board requested that NIOSH conduct a study concerning the feasibility of odorizing nitrogen to warn personnel who work around potentially hazardous confined spaces.

To the U.S. Occupational Safety and Health Administration (OSHA):

The CSB recommended that OSHA issue a safety alert providing guidelines for temporary enclosures that are erected around equipment containing hazardous substances.

CSB STUDY FINDS MANY NITROGEN-RELATED DEATHS

In 2003, the CSB issued a Safety Bulletin drawing attention to the ongoing problem of nitrogen asphyxiation. Nitrogen asphyxiation caused 80 deaths and 50 injuries in industrial settings between 1992 and 2002, the bulletin said. Deaths and injuries occurred at chemical plants, food processing facilities, laboratories, medical facilities and other sites. The majority of incidents occurred during work in or near confined spaces, and many incidents were caused by the failure to detect an oxygen-deficient environment. The Safety Bulletin identified a number of good safety practices to prevent nitrogen-related injuries, including comprehensive worker training programs, warning systems, continuous ventilation, atmospheric monitoring and planning for emergency rescue operations. Copies of the bulletin are available from the CSB website, www.csb.gov.

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Answers

1. When the workers covered the open end of the pipe with plastic, they unknowingly created a temporary confined space. Therefore, permits and needed precautions, such as monitoring and personal protective equipment, were not utilized. The workers did not realize that dangerous amounts of nitrogen were still flowing through the pipes. Although one of the workers had directed the process the night before, they failed to look beyond the immediate task and anticipate secondary hazards. Had a hazard evaluation been performed prior to them entering the pipe, they may have realized the dangers from the nitrogen purge to the work being done on the open end of the pipe. Further, communications between management and workers is important. Management should have been informed of the workers intent to do a black light inspection of the pipe. The use of site-specific Standard Operating Procedures (SOPs) would have been key to identifying the potential dangers created by covering the pipe and taking the necessary precautions and permits before entering the temporary confined space they created.
2. The Union Carbide plant did have procedures for entering confined spaces; however, these procedures did not cover temporary enclosures. Open pipes, tanks, and other such equipment should have a sign posted to warn unauthorized personnel not to enter. Management should have been informed of the intent of the worker to do a black-light inspection of the pipe. Management should have been aware that the open end of the pipe itself was a potential hazard to any worker who was near the pipe, depending on the direction of the wind.
3. Union Carbide should update its safety program to include temporary enclosures, and better communications between workers and management. Also, additional warning signals could be used such as odorizing nitrogen gas, as this problem is reoccurring in many other industrial environments. Comprehensive worker training programs, warning systems, and continuous ventilation, atmospheric monitoring and planning for emergency rescue operations are other good safety practices that could be implemented.

Georgia-Pacific Hydrogen Sulfide Release
Pennington, AL, January 16, 2002

Key Points

- Eight workers were injured and two workers were killed after they inhaled hydrogen sulfide gas leaking from a sewer in the Georgia-Pacific Naheola mill.
- Seventy-five gallons of NaSH solution was drained into a collection pit, which was attached to a sewer system being treated with sulfuric acid.
- To make the pit more accessible to workers, the mill operator drained the pit into the waste water system.
- A hydrogen sulfide cloud formed as a result of the chemical mixture, and quickly overtook three workers.
- Three other workers tried to help the fallen worker to safety, and were overcome by the gas.
- Although they were not hospitalized, six of the paramedics who transported the victims reported symptoms associated with hydrogen sulfide exposure.

Questions

1. What errors did Georgia-Pacific Naheola mill management make?

2. What would have helped the workers avoid the situation that contributed to this emergency?

3. What can be done to prevent this from happening again?

Georgia-Pacific Hydrogen Sulfide Release

Pennington, Alabama January 16, 2002

On January 16, 2002, two workers were killed and eight others injured when they inhaled deadly hydrogen sulfide gas leaking from an underground process sewer at the Georgia-Pacific Naheola mill in Pennington, Alabama. Among the injured were workers who attempted to assist their colleagues from the deadly cloud. The gas was the product of a sudden, uncontrolled chemical reaction taking place in the sewer as the men worked above.

The accident occurred in the vicinity of a tank truck unloading station at the Naheola mill, which makes products like tissue paper, towels, and cardboard from wood pulp. Nine of the victims were employees of Burkes Construction Company, who were working on a maintenance project near the unloading station. The tenth victim was a driver from a local trucking company.

STAGE SET FOR DEADLY REACTION

The plant's pulp-making process involves treating wood chips with chemicals such as sodium hydrosulfide (sometimes abbreviated by its chemical formula NaSH and pronounced NASH). NaSH solution was delivered to the mill periodically by tank truck. CSB determined that 15 trucks had delivered sodium hydrosulfide to the unloading station in the 24 hours leading up to the accident, losing up to five gallons of the liquid into a collection pit during each delivery.

As the NaSH deliveries continued, several Burkes employees were working on a project which would require them to stand in the collection pit. To assist them, a mill operator opened a valve to drain the contents of the pit into the wastewater system.

Unknown to the operator, the collection pit drained directly into a sewer line where sulfuric acid was being added to treat the mill effluent. As soon as the sodium hydrosulfide from the collection pit contacted the acidic contents of the sewer, it began reacting to form hydrogen sulfide gas.


Site of toxic gas release at Naheola mill

The hydrogen sulfide gas leaked through the seal of a fiberglass manhole cover near the Burkes construction workers. All ten victims were exposed to the escaping gas. Three workers were overcome almost immediately and fell to the ground. Instead of evacuating the area, three of the remaining workers attempted to drag the fallen men to fresh air. Two of them passed out in the course of assisting the others. Mill workers farther away saw the victims collapsing and called in emergency help.

Two Burkes workers died rapidly of hydrogen sulfide poisoning. Seven other Burkes employees and one driver, a Davison Transport employee, were injured from exposure to the gas. Six county paramedics who transported the victims later reported symptoms consistent with hydrogen sulfide exposure — evidently due to gas released from the victims and their clothing — but none required hospitalization.

DANGERS OF HYDROGEN SULFIDE

Hydrogen sulfide, or H_2S, is a colorless, flammable, extremely toxic gas. A component of "sewer gas," hydrogen sulfide is found in industrial as well as municipal sewer systems. Hydrogen sulfide can be formed in various ways, such as the decomposition of organic matter or the reaction of sulfides with acid. It has a rotten egg odor that most people can smell at very low concentrations. However, exposure at higher concentrations deadens the sense of smell, resulting in an inability to detect the gas. Exposure to the gas at concentrations of 500 parts per million (ppm) causes unconsciousness. Concentrations as low as 700 ppm can cause immediate death.

INADEQUATE ENGINEERING & SAFETY PRACTICES

The immediate cause of the accident was the unexpected chemical reaction producing hydrogen sulfide gas. Looking into root causes, the CSB found the plant — then owned by James River Corporation — did not follow good engineering practices when in 1995 the drain from the collection pit was connected to the sewer line where acid was periodically added. There was no review of the potential hazards that might result when chemicals from the collection pit mixed with other materials in the sewer line. The plant did not identify the unloading station as a hydrogen sulfide risk area and did not install any gas warning devices.

There had been earlier indications of problems with the fiberglass manhole cover from which the hydrogen sulfide escaped. Employees reported previous occasions where another toxic gas, chlorine dioxide, leaked through the seal

of the manhole cover. However, these leaks were not reported or investigated as near-miss incidents. Maintenance personnel repaired the leaks but were unable to find a permanent solution to the problem. Had the earlier incidents been investigated, it is likely that management would have redesigned the sewer system opening, the CSB said.

SAFETY INFORMATION NOT CONSIDERED IN DESIGN

The material safety data sheet provided by the sodium hydrosulfide manufacturer states that the chemical will react with acids to generate hydrogen sulfide gas and should be prevented from entering potentially acidic sewers. Plant management did not incorporate this safety information in designing the truck unloading area and sewer system or in developing plant procedures and worker training.

Collection drain next to tank truck unloading station

Hydrogen sulfide is a known hazard at pulp mills. But not having identified the truck unloading station as a hydrogen sulfide hazard area, Georgia-Pacific did not require Burkes Construction to provide its workers with detailed hydrogen sulfide safety training. The CSB report said the contract workers involved in the incident had only a minimal awareness of the gas and its hazards. The victims did not know how to respond appropriately when the gas release occurred, and several attempted to aid injured coworkers without protective equipment, increasing their own exposure.

RECOMMENDATIONS

In approving the report on November 22, 2002, the U.S. Chemical Safety Board issued a number of safety recommendations designed to prevent similar accidents.

To the Georgia-Pacific Corporation:

The Board called on the parent company to conduct periodic safety audits of all of its pulp and paper mills. The company should evaluate sewers and identify potential hazards from chemical reactions, particularly when changes are made to sewer lines. The CSB said the company should identify mill areas where hydrogen sulfide gas could be present, provide warning devices, and train personnel to recognize the presence of hydrogen sulfide. The company should ensure adherence to various other good safety and engineering practices.

To the Naheola Mill:

The Board issued additional recommendations to the Naheola Mill. The CSB said the mill should establish programs to prevent sodium hydrosulfide from entering potentially acidic sewers, as recommended by the chemical's manufacturers, and should also require the proper design and maintenance of manhole seals where hazardous materials are present.

The plant should require hydrogen sulfide emergency response training for company employees and contract workers, including training on rescue procedures. The Board also recommended that Burkes Construction provide similar training for its workers.

REACTIVE HAZARDS - A WIDESPREAD PROBLEM

The CSB defines a reactive incident as a sudden event involving an uncontrolled chemical reaction — with significant increases in temperature, pressure or gas evolution that causes, or has the potential to cause, serious harm to people, property or the environment. A CSB study released in 2002 identified 167 reactive incidents which caused 108 deaths over a twenty-year period. More than half involved chemicals like sodium hydrosulfide that are not covered by OSHA and EPA process safety regulations. The CSB recommended that the agencies expand regulations to reduce reactive hazards, saying they posed on ongoing danger to workers and the public.

To the Agency for Toxic Substances and Disease Registry (ATSDR):

The CSB recommended that ATSDR evaluate and amend its Medical Management Guidelines to consider the risk to responders handling victims exposed to high levels of hydrogen sulfide gas. ATSDR was urged to specify procedures for decontaminating victims. ATSDR should communicate guideline changes to organizations such the American Association of Occupational Health Nurses.

The CSB called on several other organizations to communicate the report's findings and recommendations to their members: the American Forest and Paper Association; the Pulp and Paper Safety Association; and the Paper, Allied-Industrial, Chemical & Energy Workers International Union (PACE) and the International Brotherhood of Electrical Workers (IBEW), which represent employees at the mill.

Answers

1. In 1995 when the drain was originally connected to the sewer, no review of the possible hazards that could occur when the chemicals from the drain mixed with the content of the sewers was conducted. The material safety data sheet from the manufacturer specifically warns about allowing NaSH solution to drain into acidic sewers; however, since no risk factors were evaluated prior to connecting the drain to the sewer, no gas warning systems were established. Despite previous problems with other types of gas leaks coming from the manhole cover, only temporary solutions to the immediate problems were corrected. Investigations of the previous incidents would have lead management to redesign the sewer system—a permanent solution to the problem. Also, the employees were not trained on how to respond to the gas leak; and thus, harmed themselves more by trying to aid their coworkers without proper protective equipment.
2. Because they were untrained in how to handle a potential gas leak, the workers endangered themselves to save their coworkers. They should have allowed the emergency response team to assist the endangered workers, rather than entering the life-treating situation unprotected.
3. The Naheola Mill should establish programs to prevent sodium hydrosulfide from entering acidic sewers, adhering to the recommendations on the chemicals MSDS. The Mill should also consider installing proper manhole covers where hazardous materials are nearby. Proper training for company employees and contractors on handling, identifying, and res- cue procedures is also necessary for prevention of reoccurrence.

Tosco Avon Refinery Fire
Martinez, CA, February 23, 1999

Key Points

- Four Tosco Corporation workers were killed and one injured while in the process of trying to replace corroded pipes on an oil fractionator.
- The fractionator had an exterior temperature of 500°F
- The project was classified as low-risk routine maintenance.
- The pipe was leaking Petroleum Naphtha (Hydrocarbon mixture with a flash point of 450°F).
- The workers tried to correct the leak by resealing the pipe, opening a flange 36 feet above, and redirecting the leaking fuel into a vacuum truck using a plastic sheet and a bucket.
- The workers were 40- to 100-feet high on the still operating fractionator pipe. Thirty minutes later vapor pressurized naphtha from the above pipe, sprayed the workers and ignited.

Questions

1. Were there any warning signs prior to this incident?

2. Were good work practices being put to use? What should have happened?

3. Identify what errors were made on the part of the management team?

4. What could the workers have done when their supervisor assigned them the task of replacing the corroded pipe on the leaking heated fractionator?

Tosco Avon Refinery Fire

Martinez, California February 23, 1999


Tosco Avon Fractionator

On February 23, 1999, four workers were killed in a fiery accident at Tosco Corporation's Avon refinery in Martinez, California. The men were in the process of replacing corroded pipes at one of the refinery's oil fractionators, a 150-foot distillation tower designed to heat and separate components of crude oil.

Because the project was classified as low-risk routine maintenance, no special precautions were in place. The fractionator continued to operate, with large volumes of flammable vapor and liquid flowing inside the tower and its attached piping. The surface temperature of the equipment was over 500°F.

WHAT IS A FRACTIONATOR?

Crude oil fractionation is the first step in the oil refining process. A fractionator is a vessel that separates heated crude oil into components, such as natural gasoline, naphtha, kerosene and diesel. Inside the vessel, trays are used to collect the different fractions as liquids. Pipes connected to each tray withdraw the liquids to storage or other processes. Processing is continuous.

Earlier that morning, under the direction of a Tosco maintenance supervisor, workers had removed a section of corroded naphtha piping 112 feet up the tower, near where the piping joined the fractionator. But things had not been going as planned. When a second cut was made 26 feet below the first, petroleum naphtha – a volatile hydrocarbon mixture that ignites spontaneously at 450°F – began to ooze out and workers had to immediately reseal the pipe.

After breaking for lunch, the workers climbed 40 to 100 feet up scaffolding alongside the tower. They tried to drain the piping system of naphtha by opening a pipe flange 36 feet up and directing the leaking fuel into a vacuum truck using makeshift plastic sheeting and a bucket.

The operation proceeded without apparent problem for 30 minutes, when suddenly a large volume of naphtha, propelled by vapor pressure from the operating fractionator, shot out of the open pipe overhead, spraying the workers. For the five men high on the scaffold, there were few avenues of escape as the hot surface of the fractionator ignited the naphtha, engulfing them in flames.

Although emergency teams arrived quickly, no one could approach the victims for 20 minutes because of the fire. One man died at the scene, three died at the hospital and another, who had thrown himself off the scaffolding to escape the flames, survived with critical injuries.

RECURRING NAPHTHA LEAKS

The Chemical Safety Board investigated the accident, Tosco's second in two years, to determine root causes. Almost two weeks before the accident, on February 10, operators had observed a naphtha leak coming off the fractionator, which they treated as an emergency at the time. Workers located a pinhole leak in the naphtha piping 112 feet up and closed a series of valves in an effort to eliminate it. But the leaks kept recurring. In succeeding days, one attempt after another failed to completely staunch the flow of naphtha. Shut-off valves malfunctioned repeatedly, and drain valves were found to be clogged beyond use or repair.

Ultrasound and X-ray tests were ordered, and these revealed that both the piping and the valves were severely corroded and needed to be replaced. Although the unit operator argued for shutting down the process before attempting to replace the deteriorated piping, a maintenance supervisor decided to do the job while the hot fractionator continued to run. This fateful decision did not receive any oversight or scrutiny from the facility's management.

PROCESS SHOULD HAVE BEEN SHUT DOWN

Good operating practice calls for draining hazardous materials from lines and equipment and verifying that the equipment has been isolated before opening for maintenance. But that could not be done at Tosco so long as the fractionator was operating. The repeated recurrence of naphtha leaks was a strong indicator that shutoff valves were corroded and were not functioning properly. As long as the fractionator was running, naphtha continued to leak into the piping, and vapor from the fractionator pressurized the escaping fuel.

In the 13 days that elapsed between the first occurrence of the leak and the fatal accident, Tosco personnel missed numerous opportunities to reassess the hazards of the pipe replacement work and take measures to ensure the work would be performed safely. In this case, such safety measures would have included shutting down the fractionator as the only way to eliminate both the source of the naphtha and the potential sources of its ignition.

Avon did not have a systematic job planning and authorization process to ensure that this kind of maintenance work received appropriate scrutiny before going forward. No formal hazard evaluation was conducted before or during the maintenance project, and managers and safety specialists were not sufficiently involved in decision-making and oversight. Instead, individual workers were given the authority to put a halt to unsafe work. In the CSB's view, vesting such authority in individuals – who may be subject to a variety of external pressures to get the job done – is no substitute for having effective safety reviews before work starts.

CORROSION, MANAGEMENT OF CHANGE PROGRAMS INADEQUATE

The naphtha piping and valves had been run to the point of breakdown due to corrosion, leading to a potentially hazardous situation. The valves and piping had corroded at an excessive rate because an upstream vessel known as the crude oil desalter – which removes salt, water, and solids from the oil feed – was being operated beyond its design limits. Tosco had routinely processed excessive volumes of crude oil with high water content, overtaxing the desalter.

As a result, water and corrosive materials like ammonium chloride were carried over into the fractionator, where they began to deteriorate the piping and valves.

The CSB found that Tosco should have evaluated operational changes that could worsen the corrosion of piping and valves. These changes included feeding different material into the process, increasing the amounts being processed and making long-term adjustments to valve positions. Such an evaluation, known as management of change (MOC), was not applied to these process modifications. This omission contributed to the final breakdown and the fire.

DEVIATIONS FROM SAFE PRACTICE WERE NOT CORRECTED

The incident highlighted several ineffective safety practices and procedures at the Avon refinery. The CSB found the Avon tragedy could have been prevented had better procedures been in place for opening process equipment, controlling sources of hazardous energy, managing process changes, and isolating piping prior to maintenance.

But problems existed in these areas before the February 1999 fire occurred. Had Tosco Corporation or Avon refinery management conducted an audit of these programs, problems could have been corrected prior to the accident.

However, no relevant documented safety audits were performed during the three years leading to the fire.

KEY RECOMMENDATIONS

After analyzing the root causes, the CSB on March 21, 2001, made a number of safety recommendations to reduce the risks of similar accidents at the Avon refinery and other Tosco facilities.

To the Tosco Corporation:

The CSB recommended that Tosco (now ConocoPhillips) conduct periodic safety audits of its refineries and document all findings in writing. The CSB said audits should examine the conduct of hazardous non-routine maintenance, the role of management in overseeing safety, and the corrosion control and management of change programs. Audit findings and recommendations should be shared with the workforce and tracked to completion.

To the Former Tosco Avon Refinery:

The Board recommended that the refinery, now owned by Tesoro, implement a program to ensure that hazardous non-routine maintenance is conducted safely. The refinery should require a written hazard evaluation by a multidisciplinary team before any hazardous job is started. The refinery should also require higher levels of approval for higher hazard jobs, develop a written protocol for making shutdown decisions, and make sure that managers and safety officials provide adequate oversight for hazardous work.

The Board also recommended that the refinery improve its management of change and corrosion control programs to prevent situations where safety is compromised, e.g. through the loss of containment or shutoff capability for hazardous materials.

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Answers

1. The unit operator, maintenance supervisor, and facility management knew the pipe was leaking and the shut-off valves were malfunctioning due to severe corrosion thirteen days prior to the incident. And although the original leaks were treated as emergencies, the maintenance supervisor decided the repairs could be done while the fractionator was still running.
2. No, shutting down the fractionator was the only way to eliminate both the source of the naphtha and the potential sources of its ignition. Isolating the equipment before opening it for maintenance is good operating practice. The workers were unable to isolate the piping as long as the fractionator was operating.
3. The management team failed to ensure the oil desalter was working within its limits using an evaluation system called a management of change (MOC). This led to the corrosion of the piping and shut-off valves. The management also failed to correct the leakage problem nor did they shut down the fractionator prior to corrections. The safety coordinator knew that the liquid ooze had a flash point of 450°F, and should have known the exterior of the piping was above 500°F; thus, alerting him/her to the potential/ enviable possibility of ignition of the flammable gas vapors. Lastly, Avon did not have a systematic job planning and authorization process, so no formal hazard evaluation was conducted.
4. Workers on hazardous work sites also need to be able to identify potential hazards. When assigned the task of replacing the corroded pipes on the fractionator, they should have questioned the safety of working on the heated fractionator while it was still leaking petroleum naphtha. They should have insisted the safety specialist and/or OSHA inspect the site for dangers. Citing their rights under the OSHAct for inspection of workplace, in this case there would be a complaint inspection.