DATE: May 29, 1996

FROM: Minnesota Fatality Assessment and Control Evaluation (MN FACE) Program Minnesota Department of Health

SUBJECT: MN FACE Investigation 96MN00101 and 96MN00102
Two Employees Die After Steam Line They Were Repairing Was Re-energized

SUMMARY

Two employees of a commercial steam heat supplier died of injuries they sustained when a steam line they were repairing was re-energized. The day before the incident, the two victims and a coworker went to an underground vault to investigate a steam leak. They suspected that the leak was from a flange in a steam line that served as an interconnect line between two steam generation facilities. The next morning, they told the facility 1 operator that they were going to facility 2 to shut down the leaking steam line before repairing it. At facility 2 they closed two control valves to isolate the leak in vault A. They did not lockout and tagout either of the control valves.

After closing the valves, they drove to the site of the leak and began to mechanically ventilate the vault. While the vault was being ventilated, they went to vault B and closed a second isolation valve. They returned to the site of the leak (vault A) and entered the vault after the steam was cleared from it. They confirmed that the leak was due to a defective flange gasket and disassembled the steam line flange.

The repair task was slowed for several hours since the workers initially did not have the correct size wrenches for the flange bolts. They were also delayed when the disassembled line became misaligned as it cooled. Because of the delays and the need for alignment pins to reassemble the line, the workers stopped for lunch and returned in the afternoon to finish the repair.

When the workers returned, the two victims entered vault A while the coworker remained above ground near the entry to the vault. While the two victims realigned the steam line flanges, the facility 2 operator started a boiler in preparation for a boiler test. He contacted the facility one

operator to determine the status of the steam line repair work. He apparently understood that the repair work had been finished and that the interconnect line could safely be re-energized to provide additional steam for the boiler test. A facility 2 maintenance engineer opened both control valves and released steam into the interconnect line and the vault where the two victims were working. Both victims were able to escape from the vault within seconds after the steam entered the vault. The coworker who had been outside the vault, called facility 1 by radio and requested immediate emergency medical assistance. Both victims were transported to a local hospital where one of them died approximately one week later and the other died three weeks later. MN FACE investigators concluded that to reduce the likelihood of similar occurrences, the following guidelines should be followed:

- employers should develop, implement and enforce a written safety program which includes task-specific training and lockout/tagout procedures; and
- employers should ensure that when more than one employee is exposed to hazardous energy, a procedure is in place for group lockout/tagout.

INTRODUCTION

On January 19, 1996, MN FACE investigators were notified of a work-related fatality that occurred on January 9, 1996. During MN FACE investigations, incident information is obtained from a variety of sources such as law enforcement agencies, county coroners and medical examiners, employers, coworkers, and family members. Due to the location of the incident, a site investigation was not possible. The employer provided a schematic diagram and video tape of the incident site.

The employer in this incident was a company that provides heat to various commercial facilities located in the downtown of a major metropolitan area. The employer had been in business for 25 years and employed 27 people including a safety officer. A safety program was in place at the time of the incident.

The company has two primary steam generation facilities. Facility 1 is a district heating facility that serves commercial buildings in the downtown area. It consists of the main plant, several smaller satellite boiler/chiller facilities controlled from the main plant, and a system of steam supply, condensate return, and chilled water piping that extends below ground throughout the downtown area. Nineteen people work at facility 1. Facility 2 is a district heating facility that serves a limited number of other customers in the vicinity of the facility. The operation consists of

the main plant and a steam supply/condensate return system similar to, but smaller than the facility 1 system. Ten people work at the facility 2. A steam supply line and a condensate return line, known as the "interconnect line", connect the facility 1 and facility 2 steam distribution systems.

INVESTIGATION

The day before the incident three employees of the heating company, including the two victims, went to an underground vault (vault A), the incident site, to investigate a steam leak. The steam generation facilities, two underground vaults, steam distribution lines, several isolation valves and an interconnect line are shown in Figure 1. The workers thought that the leak was from a flange in the 12 inch steam line, known as the interconnect line,that ran through vault A. One of the workers contacted the operation supervisor at facility 2 and informed him that the interconnect line would have to be shut down the following morning.

The next morning the operations supervisor called from his home and instructed the facility 2 operator to reduce the steam flow in the interconnect line. The three workers who had discovered the steam leak arrived at the facility 1 control room. They told the facility 1 operator that they were going to facility 2 to fix a steam leak and that they would shut down the interconnect line. When the crew arrived at facility 2 they informed the operator on duty that they were going to "put the interconnect to sleep" which apparently meant they were going to isolate the interconnect line. The crew members closed the interconnect control valve and the interconnect manual isolation valve. No lockout or tagout was applied to either of these interconnect valves at facility 2. After closing the valves, the crew went to vault A which was the site of the steam leak.

The crew removed the manhole cover and started mechanical ventilation of the underground vault. While the vault was being ventilated, they went to vault B, another underground vault, and shut off the isolation valve in that vault (Figure 1). This isolated the facility 1 side of the leaking flange. After the steam was cleared from vault A, the workers shut the isolation valve located inside the vault. With the isolation valve shut in vault A, one of the workers returned to vault B and opened the isolation valve there in order to return the steam supply to a major facility in the downtown area.

The workers entered the vault and began to remove the bolts from the leaking interconnect line flange. Although the workers did not have the correct size wrenches, the flange bolts were loose and were easily removed. In order to reassemble the bolts tightly, they knew that they would need wrenches of the correct size. Shortly after 9 a.m. two of the workers went back to facility 1 to look

for the wrenches. They could not find them and returned to vault A. The third worker then went to a supply store in the area to buy the wrenches. The supply store did not have them in stock either. At this point, the worker called the facility 1 plant and another individual was assigned to procure wrenches.
While the wrenches were being procured, the workers at vault A began repairing the flange. At this point the steam line had cooled and the flange became misaligned, further delaying the workers. They spent the remainder of the morning and part of the afternoon attempting to make alignment pins to realign the flange.

In the early part of the afternoon, the facility 2 plant operator started a boiler in preparation for a boiler test. At about this same time two of the three workers were working inside vault A. One of the workers was working at the end of the vault nearest the manhole cover. The second worker was working at the other end of the vault, furthest from the manhole cover. The third worker remained outside the vault at the edge of the manhole. The facility 2 operator thought that the three workers had completed the repair

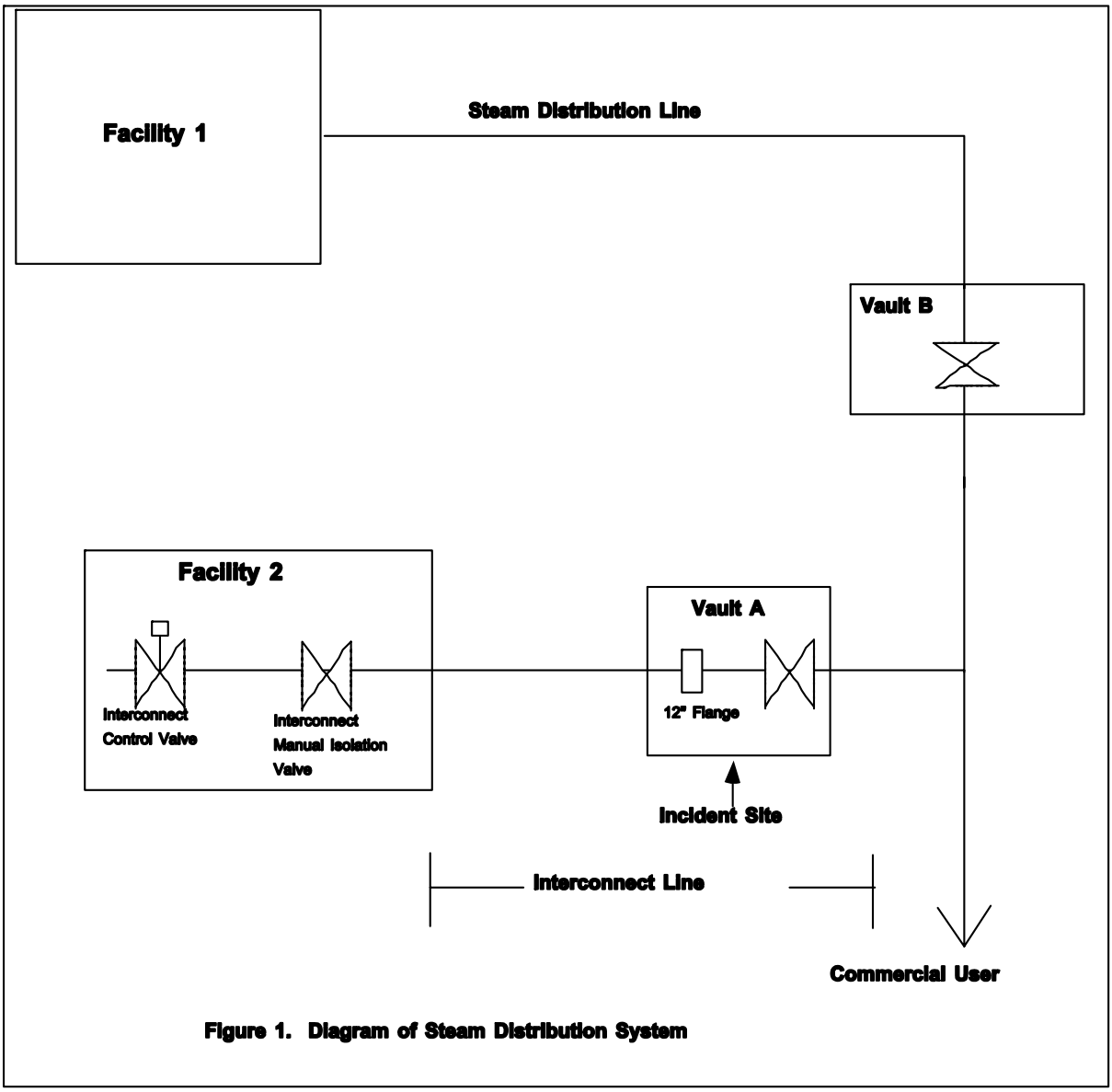


Figure 1. Diagram of Steam Distribution System

of the steam leak in vault A. The facility 2 operator wanted to use the interconnect line to provide additional steam from the boiler test. At this time, the facility 2 operator contacted the facility 1 operator and was left with the impression that the crew had completed the interconnect work. The facility 2 operator asked one of the maintenance engineers to open the manual isolation valve to the interconnect line. The maintenance engineer opened the valve which was not locked or tagged out.

After the manual isolation valve was opened, the facility 2 operator opened the interconnect control valve. Immediately steam filled the vault where the victims were working. The worker who was closest to the manhole was able to climb the ladder and exit the vault almost immediately. The

worker who was further inside the vault reached the ladder in approximately 4 to 5 seconds. The worker who had been sitting outside of the vault near the manhole was able to help the workers out of the vault. The worker who had been outside of the vault called facility 1 by radio for an ambulance and assistance. The interconnect control valve was shut off at facility 2. Emergency medical personnel transferred both workers to a nearby hospital. One of the workers died approximately one week later and the other died 3 weeks later.

CAUSE OF DEATH

The cause of death, for the worker who died first, was listed on the death certificate as bowel infarction complicating thermal burns. The cause of death for the other worker was multi-organ system complications of thermal burns.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should develop, implement and enforce a written safety program which includes task-specific training and lockout/tagout procedures.

Discussion: Although the employer in this incident had a formal safety program in place, it is critical that it be enforced throughout the entire company. Currently, OSHA standard 29 CFR 1910.147 requires the control of hazardous energy through the use of lockout/tagout. If the workers are exposed to the release of hazardous energy, then the energy should be locked out to prevent inadvertent activation of the equipment. A comprehensive lockout/tagout program should include procedures for: 1) de-energization of potentially hazardous energy, (electrical, chemical, mechanical, etc.; 2) locking and tagging of the energy control source; 3) dissipation or blocking of any stored energy, e.g., energy stored in fly wheels, springs, etc; and 4) verification that the hazardous energy has been controlled. The program should also include procedures to safely re-energize equipment once maintenance or cleaning has been completed.

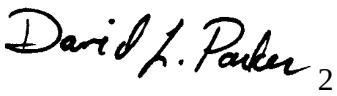
Recommendation #2: Employers should ensure that when more than one employee is exposed to hazardous energy, a group lockout/tagout procedure is in place and enforced.

Discussion: Currently, OSHA standard 29 CFR 1910.147 (f) (3) requires that when servicing and/or maintenance is performed by a crew, craft, department or other group, they shall utilize a procedure which affords the employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device. Each authorized employee shall affix a

personal lockout or tagout device to the group lockbox, or comparable mechanism when he or she begins work, and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.

REFERENCES

1. Office of the Federal Register: Code of Federal Regulations, Labor, 29 CFR Part 1910.147, U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C., July 1, 1994.



Margee Brown, M.P.H.
Safety Investigator
MN FACE

David L. Parker, M.D., M.P.H.
Principal Investigator
MN FACE