Physical Hazards

Electrocutions

FACE 88-16: Power Company Worker Electrocuted in Underground Utility Vault

INTRODUCTION

On March 11, 1988, an overweight, 35-year-old male cable splicer was electrocuted when he contacted an energized pipe that was connected to a 220-volt sump pump.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The victim was a lead cable splicer employed by a power company that has approximately 14,000 employees. The victim worked in the company's Network Underground Division, which has 176 workers. Most of these workers (including 24 cable splicers) perform maintenance work on the underground components of the utility system.

The company has a safety and health department, an industrial hygiene department, a written safety policy, and specific written safety procedures for electrical work and confined space entry. Division-level and local employee safety committees conduct monthly safety meetings. A formal safety training session on electrical and confined space safety, conducted approximately 2 1/2 months prior to the incident, was attended by the victim.

SYNOPSIS OF EVENTS

The incident site was an underground transformer vault located in the downtown area of a large city. The concrete vault measuring 80 feet long, 10 feet wide, and 12 feet deep, lies beneath an alley between two large buildings. The vault is covered on top with concrete and steel grating (the grating covers approximately 20 percent of the top) which form part of the driving surface of the alley. Located on the top (at each end and in the middle) are three 27-inch-diameter manhole openings, equipped with vertical, steel ladders attached at the top and embedded in the concrete at the bottom of the vault.

The vault houses eight 480-volt transformers. Two 220-volt sump pumps (one at each end) were originally installed to remove water that accumulates in the vault. Each pump is designed to operate by means of a float valve switch mechanism, with water intake pipes submerged in a sump well 18 inches square and 18 inches deep below the vault bottom.

Electric power is supplied through an underground 220-vault cable. The power cable enters the vault and passes through two fuse boxes (located about half-way up the side of the vault), one serving the sump pumps and one serving lighting along the vault ceiling. When the pumps were installed, an effective electrical ground was not provided. Later (about 5 years prior to this incident), an electrical short circuit developed inside one of the pump motors, blowing the fuses and de-energizing the pumps. The company decided not to repair the sump pumps, but to periodically pump water from the vault with truck-mounted pumps. Despite the decision not to repair the pumps, the fuse box, wiring, pumps, and piping were <u>not</u> removed.

Over time the "moisture-proof" fuse boxes filled with condensated water and became heavily corroded. The corrosion bridge across the blown fuses re-energized the sump pumps and the pump frame and water discharge pipe of the short-circuited pump at a level of approximately 120-volts. On March 11, 1988, two power company employees, a lead cable splicer (the victim) and a winch truck operator (co-worker) were inspecting the circuit protectors on the transformers in the vault. The victim and a co-worker arrived at the vault at about 8:30 a.m. Since the vault had approximately 33 inches of water in the bottom, the victim put on rubber hip waders, removed the manhole cover at the east end of the vault, and entered the vault with a flashlight. While the victim was checking the circuit protectors on four transformers, the co-worker studied an electrical circuit map of the vault. The co-worker also directed vehicular traffic through the alley since there were no traffic cones or guard rails around the open manhole.

At about 8:40 a.m. the co-worker heard "a noise" inside the vault. When he looked into the manhole, he saw the victim facedown in the water, halfway between the ladder and the sump pump (a horizontal

distance of about 4 feet). Although the co-worker did not observe the position of the victim immediately prior to seeing him facedown in the water, circumstantial evidence suggests that the victim contacted an energized component of the sump pump (either a metal pipe, part of the housing, or another connected apparatus) with his right hand, and the steel ladder (which was at ground potential) with his left hand. This would have provided the current a path to ground through the victim. Current may have entered his right hand, passed through his chest, and exited his left hand, resulting in his electrocution. Presumably, the victim then fell forward, breaking contact.

In a rescue attempt, the co-worker entered the manhole, descended the ladder, and stretched out one hand and pulled the victim's face out of the water. However, when the co-worker stepped off the ladder onto the floor of the vault he felt a shock, so he stepped back on the ladder. It is believed that since the co-worker was not wearing rubber hip waders his foot was at some level of ground potential when it touched the vault floor. While managing to hold the victim's face out of the water with one hand and the ladder with the other hand, the co-worker called out for help.

Several passersby responded and made several unsuccessful attempts to help the co-worker remove the victim from the vault. However, they were hampered by electric shocks they received from either structural steel beams that crossed the inside of the vault or the vault bottom. Another factor that made rescue difficult was the victim's relatively large size and weight. At least three attempts were made to hoist the victim out of the vault with a handline tied around the victim's chest. Each time, the victim slipped through the rope and fell to the bottom of the vault. One of the passersby made an emergency call on the company truck radio. A policeman arrived and then minutes later paramedics, each attempting to assist in the rescue effort, and each experiencing electric shocks in the process.

According to rescuers, the power company cut off the power to the vault approximately 35 minutes from the time the victim was first observed facedown in the water. Paramedics observed that the victim was "still breathing a little" and had a slight pulse. Shortly after the power was turned off, a manual respirator was lowered into the vault and used in an attempt to resuscitate the victim. Attempts to remove the victim from the vault were unsuccessful until the fire department rescue squad arrived.

Rescuers ultimately succeeded in putting a body harness around the victim and hoisting him out of the vault with the use of a truck-mounted winch. The total time from when the victim was observed unconscious in the vault to when he was removed was estimated at approximately 1 hour and 20 minutes.

Paramedics initiated cardiopulmonary resuscitation (CPR) after the victim was removed from the vault, and continued to administer CPR while in route to a local hospital. The victim was pronounced dead on arrival by the attending physician.

CAUSE OF DEATH

The cause of death is presumed electrocution. The exact cause of death has not yet been verified, pending receipt of the medical examiner's report.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: The sump pump and pump wiring no longer in use should be disconnected from energized circuits and removed.

Discussion: The presence of water in the vicinity of energized electrical apparatus increases the potential for conduction of electrical energy. Also, holes, depressions, loose parts, debris, or other irregularities in the floor surface of the vault which could represent all hazards, might not be visible to a worker stepping into or walking through standing water.

Recommendation #2: The employer should ensure that each metal piece of equipment that is not designed to conduct electricity be permanently and continuously bonded to a grounding system.

Discussion: The metal sump pump appurtenances, metal vault ladders, beams, etc. were not only installed without effectively being grounded, but also remained ungrounded for 18 years. During those years workers entered the vault numerous times under damp and wet conditions, and were needlessly exposed to this electrical hazard.

Recommendation #3: The employer should develop and implement (1) a method of detecting the existence of ground faults (i.e., a defect in an electrical circuit creating an unintentional path for current to flow to ground), and (2) procedures to follow if a ground fault is detected, prior to employee entry to wet and damp locations where energized, electrical apparatus exist.

Discussion: The victim entered an electrical vault which had energized electrical components submerged in water. The victim was unaware that a ground fault existed within the vault. If ground fault indicators had been installed on the vault circuitry, the victim would have had the opportunity to check an indicator panel for existing ground faults prior to entering the vault. Knowing a ground fault existed in the vault, the victim may have chosen not to enter the area without first pumping the water and donning additional protective insulated gear.

Recommendation #4: The company should re-evaluate, implement, and enforce its confined space rescue procedures.

Discussion: The company had written confined space entry and rescue procedures; however, they were either not practiced, unenforced, or ineffective when attempted. The written procedures outline a confined space rescue method which proved to be ineffective in this case. This rescue procedure for underground utility vaults needs to be re-examined. The vault in this incident was classified by the company as a "Class C" confined space, which would not normally require auxiliary ventilation nor isolation procedures to be followed prior to entry. (NIOSH publication 80-106, "Criteria For a Recommended Standard...Working in Confined Spaces"). The company confined space entry procedures did not address any method for detecting the existence of ground faults prior to entering damp and wet locations such as underground utility vaults.

FACE 88-28: Asbestos Worker Electrocuted

INTRODUCTION

On July 6, 1988, a 23-year-old male laborer on an asbestos removal crew died when he contacted an exposed overhead conductor in a utility tunnel.

OVERVIEW OF EMPLOYER'S SAFETY PROGRAM

The employer in this case was an asbestos abatement contractor with 30 employees. The company has been in business for 3 years. Company safety training focuses on asbestos removal procedures; however, other hazards likely to be encountered in the course of this work are not addressed.

SYNOPSIS OF EVENTS

The victim and a co-worker comprised one of two 2-man teams removing asbestos from steam lines in a utility tunnel which serves a large educational facility with numerous buildings. The tunnel is approximately 55 inches high by 52 inches wide and runs in a north/south direction. The steam lines run along the east wall of the tunnel. The west wall of the tunnel is covered with numerous heavy electrical cables and signal wire sets. A walkway approximately 36 inches wide extends down the center of the tunnel. Four separate, insulated wires suspended from individual insulators run along the top of the tunnel directly above the walkway. This wiring serves as the power supply for numerous 110-volt light bulb sockets hanging down on flexible conductors ("pigtail") at intervals along the tunnel. At the time of the incident, one of the "pigtails" did not have a light socket attached. Therefore, bare, energized conductors were hanging down over the walkway from the wiring circuit.

The victim was removing insulation containing asbestos from the steam lines within the tunnel, while his co-worker was following behind him bagging the insulation. During removal activities, the victim's shoulder contacted the exposed conductors hanging from the roof of the tunnel. A path to ground was established from the victim's shoulder through his right arm which was in contact with the steel steam line. The co-worker, who heard the victim yell and saw that he was in contact with the overhead wires, used his body to knock the victim away from the wires. The victim collapsed to the floor of the tunnel.

The co-worker then called the other crew to help remove the victim from the tunnel. The closest way out of the tunnel was the entry to a basement about 57 feet from the incident site. The workers dragged the victim to this entry, took down the plastic containment wall isolating the tunnel from the basement, and removed the victim from the tunnel. A university police officer who was in the basement heard the men and reported the incident via radio to his dispatcher, who called the local fire department and emergency medical service (EMS) unit. The EMS unit and the fire department were on the scene 6 minutes later. Cardiopulmonary resuscitation (CPR) was initiated at the scene and continued while the victim was transported to the local hospital. The victim was pronounced dead at the hospital 57 minutes after the police officer initially reported the incident.

(NOTE: Co-workers and rescue personnel stated that the victim was wet with perspiration at the time of the incident. The high ambient temperature in the tunnel and the protective clothing required for asbestos removal work combined to create a hot working environment for the removal crew.)

CAUSE OF DEATH

The coroner's office reported the cause of death as electrocution.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Job site surveys should be conducted prior to the start of all construction/ demolition projects to ensure that hazards within the area are identified, employees are informed of the hazards, and methods of eliminating or controlling the hazards are implemented.

Discussion: The suspended wires for the lighting circuit should have been identified as potentially hazardous. The bare conductors on the "pigtail" involved in this incident would have been detected if a survey of the actual job site had been performed prior to the start of this project. Once the hazard was identified, corrective action could have been taken to prevent this fatality from occurring.

Recommendation #2: In an area where asbestos removal work is being performed, electrical equipment should be de-energized whenever possible. If the equipment cannot be de-energized, workers should be isolated from potential contact with the energized lines or equipment.

Discussion: Workers performing asbestos abatement work typically wear personal protective clothing which serves to trap body moisture within the suit. In addition, it is standard practice in asbestos removal work to use "wet" removal techniques in which a surfactant-treated water mixture is used to saturate the asbestos-containing materials to control the release of asbestos fibers. The combination of a wet environment and energized electrical circuits or equipment sets the stage for potential disaster.

In this case, the victim was wet with perspiration when the contact with electrical energy occurred. The resistance of the human body to electrical energy (as high as 100,000 ohms when the skin is dry) may be reduced to 1,000 ohms when the skin is wet. This reduced resistance results in the potential for a much greater current flow through the body than would otherwise occur, a significantly increasing the potential for a fatal electrical shock.

Shutting down the major electric lines which run through this tunnel was not feasible since they control power to half of the campus; however, these armored cables posed a relatively small threat to the workers. Plastic sheeting along the side of the tunnel could have been erected to isolate these lines from the workers. The lines which actually caused the fatality served only to provide lighting for the tunnel. These lines could have been de-energized prior to the start of the project and a substitute lighting system utilizing ground fault circuit interrupters (GFCI's), battery powered lights, or similar safe systems, could have been installed to ensure worker protection.

(NOTE: Further information on electrical hazards encountered during asbestos abatement work is included in Appendix D, "General Safety Considerations," of A Guide to Respiratory Protection for the Asbestos Abatement Industry, a joint publication of NIOSH and Environmental Protection Agency (Doc. # EPA-560-OPTS-86-001).)

Recommendation #3: Property owners should periodically inspect all areas of their facilities and grounds for the purpose of identifying safety hazards. Unsafe conditions identified during such inspections should be corrected and potential hazards should be controlled in a timely manner to prevent injuries.

Discussion: The lighting circuit in the utility tunnel was an outmoded type of single insulated wire suspended upon individual insulators. The light sockets that hung down from these wires were otherwise unsupported. As a result, the insulation of the wires, as well as the unguarded light bulbs, were subject to damage.

The bare conductors which caused the fatality posed a threat to anyone using the tunnel. A comprehensive safety inspection program conducted by the property owner would have revealed these hazards. Corrective action could have been taken to protect both the employees of the property owner and contract personnel working in or moving through the area.

FACE 90-32: Electrician Electrocuted When He Contacts Energized Conductor in a Manhole in Virginia

INTRODUCTION

The employer in this incident is an electrical contractor, engaged primarily in commercial and industrial electrical construction. The company has been in operation for 22 years and employs 97 workers, including 51 electricians. The company has a written safety policy and safety rules which are administered by the loss control/personnel manager. In addition, weekly safety toolbox meetings are held. The employer also uses a safety incentive program and a stepped (graduated) disciplinary system which consists of: 1) first incident - verbal counseling, 2) second incident - a written warning, and 3) third incident - discharge. The victim worked for this employer for 3 years and 9 months prior to the incident.

INVESTIGATION

The company had been contracted to install a new lighting system for the taxiway and runway at a local airport. Work had been intermittent since September 5, 1989. At the time of the incident, the job was within 3 weeks of completion. Pre-formed concrete manholes 5-feet-square by 7-feet-deep with 24-inch-diameter openings (manways), which provided access to the underground circuitry for the three lighting systems, had been previously installed. An existing, energized 2,300-volt, 6.6-amp, runway lighting circuit was operating during twilight and night hours each day. Additionally, each manhole contained an energized, 700-volt temporary taxiway lighting circuit, and a de-energized permanent taxiway lighting circuit. Work was in progress to complete the wiring for the permanent taxiway lights. Temporary work area lighting (vapor lights) had been installed.

On the evening of the incident, a crew of six employees (i.e., one equipment operator, four apprentice electricians, and one electrician/foreman) arrived at the incident site to continue work on the lighting systems. The victim and a co-worker were assigned the task of splicing the new conductors for the permanent taxiway lighting circuit, and making the appropriate connections. All the conductors were buried underground and the manholes provided access to the conductor junctions. Standard company procedure involved testing each circuit in the manhole by using an amp probe (i.e., a device used to detect current in a conductor) prior to working on that circuit, identifying the energized runway and temporary taxiway circuits, cutting the de-energized circuit (permanent taxiway circuit), and splicing together the appropriate de-energized conductors.

Prior to the incident, the victim and co-worker had completed connections for the permanent taxiway lights in six separate manholes without incident. The victim entered the seventh manhole via a 24-inch-diameter manway, descended a metal ladder attached to the inside of the manhole, and positioned himself on the ladder facing the circuit conductors. He removed a pair of insulated side (wire) cutters from his tool belt and, without using the amp probe to test for current in the conductors, cut a hanging conductor. The conductor, which was part of the energized runway lighting circuit, came in contact with the back of the victim's right hand after being cut in half. Current passed through the victim's right hand and exited his right thigh at the point of contact with the grounded ladder.

Two co-worker's were standing near the top of the manhole, one co-worker was using a flashlight to light the interior of the manhole while the other co-worker observed the victim. After realizing what had occurred, one co-worker entered the manhole to assist the victim. The other co-worker simultaneously notified the airport tower to have the runway and taxiway lights turned off. The airport emergency rescue personnel were summoned and arrived within 3 minutes after being contacted. The rescue squad provided advanced cardiac life support and transported the victim to the local hospital where he was pronounced dead 45 minutes after the incident occurred.

CAUSE OF DEATH

The medical examiner listed the cause of death as electrocution.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should establish required procedures for the protection of employees exposed to electrical hazards and provide worker training in the recognition and avoidance of such hazards.

Discussion: Employers should comply with OSHA construction safety standard 29 CFR 1926.416(a)(1) by prohibiting employees from working in close proximity to energized electrical circuits where the employee could make contact in the course of work, unless the employee is protected against electric shock by de-energizing and grounding the circuit and/or by effective guarding. Employers should provide worker training in the recognition of electrical hazards and safe work procedures, including identifying circuits, testing circuits, de-energizing circuits, locking/tagging de-energized circuits, and verifying de-energization.

Recommendation #2: Employers should conduct initial jobsite surveys to identify all hazards associated with each specific jobsite, and develop specific methods of controlling the identified hazards.

Discussion: Employers should comply with OSHA construction safety standard 29 CFR 1926.416(a)(3) by conducting initial jobsite surveys prior to the start of any work to identify potential situations for employee contact with energized electrical circuits, and by providing subsequent employee notification about protective measures (i.e., identification, testing, de-energization, locking/tagging of energized conductors, verification, and sufficient work area lighting) to be implemented to control the hazards.

Recommendation #3: Employers should provide and enforce the use of personal protective equipment as required by 29 CFR 1926.416(a)(2).

Discussion: The victim was working inside a 5-foot-square by 7-foot-deep concrete manhole. The manhole contained at least two energized electrical conductors and one de-energized electrical conductor, all with identical characteristics. Also, about six inches of water was present on the floor of the manhole. Employers should provide personal protective equipment (e.g., insulated protective gloves) to workers who are exposed to electrical hazards, and enforce the use of that equipment.

Recommendation #4: Employers should comply with 29 CFR 1926.56 - Illumination.

Discussion: Work was being performed at about 11:30 p.m. in a 5-foot-square by 7-foot-deep concrete manhole. Illumination of the interior of the manhole was provided by a flashlight being held by a co-worker outside the manhole. The manhole contained at least two energized electrical conductors and one de-energized conductor, all with identical characteristics. Also, about 6 inches of water was present on the floor of the manhole. Adequate illumination of the work space should be of paramount importance in instances such as these. Employers should comply with 29 CFR 1926.56 - Illumination.

Recommendation #5: Employers should tag (label) electrical circuits being worked on as required by 29 CFR 1926,417(c).

Discussion: The manhole contained at least three electrical circuits that had identical characteristics. In instances such as these, employers should label electrical circuits being worked on as required by 29 CFR 1926.417(c), to facilitate identification.

Recommendation #6: Property owners and prime contractors should ensure that areas of responsibility for safety and health issues are clearly specified as part of the contract provisions.

Discussion: Contracts between all parties (i.e., property owners and contractors) should contain language that identifies the specific site safety and health programs to be implemented before the initiation of work. Any safety program should be consistent and compatible with the agreed upon language, and any differences should be negotiated before work begins. Where property owners and

contractors are involved, the contract should contain clear and concise language as to which party is responsible for each safety and health issue. The respective parties should periodically inspect worksites to ensure that the provisions of the contract regarding safety and health issues are being upheld.