

The Missouri Department of Health in co-operation with the National Institute for Occupational Safety and Health (NIOSH) is conducting a research project on work related fatalities in Missouri. The goal of this project, *Missouri Fatal Accident Circumstances and Epidemiology* (MO FACE) is to show a measurable reduction in traumatic occupational fatalities in the state of Missouri. This goal will be met by identifying causal and risk factors that contribute to work related fatalities. The identification of these factors will enable more effective intervention strategies to be developed, and implemented by the employers and employees. This project does not determine fault or legal liability associated with a fatality incident nor with current regulations. All MO FACE data will be reported to NIOSH for trend analysis on a national basis. This will help NIOSH provide employers effective recommendations for injury prevention. All personal/company identifiers will be removed from all reports sent to NIOSH to protect the confidentiality of all those voluntarily participating with the program.

FACE Investigation #92MO01201

SUBJECT: Line Foreman Electrocuted While Performing Routine Maintenance at a Transformer Station in Missouri.

SUMMARY:

A 46-year-old municipally employed lineman was electrocuted while performing routine maintenance at a transformer station. At the time of the incident the victim and contractor were performing maintenance on an oil disconnect switch. The victim was standing on a six foot fiberglass stepladder and was leaning against the structure (providing a path to ground) when he contacted a 2,400 volt alternating current electrical lead coming out of an oil switch which was thought to be de-energized. The victim broke contact from the source and fell from the ladder to the ground. The MO FACE investigator concluded that, in order to prevent future similar occurrences, employers should:

- * ensure that linemen follow established safe work procedures to de-energize, ground, and verify through testing prior to beginning maintenance and repair operations on electrical transmission lines and equipment.
- * ensure that prior to any work on an electrical system, all involved workers are familiar with the operation of every electrical component.
- * ensure that workers are trained in and follow established safe work procedures relevant to their duties and responsibilities.
- * develop, implement, and enforce a comprehensive safety program which includes worker training in recognizing and avoiding hazards, especially electrical hazards.

- * train employees in cardiopulmonary resuscitation (CPR).

INTRODUCTION:

On June 24, 1992, a 46-year-old electrical line foreman, employed by a municipality for 28 years, died as a result of injuries he received from an initial electrical injury on March 30, 1992. The MO FACE investigator was notified of the fatality by the county medical examiner's office on June 25, 1992. The Occupational Safety and Health Administration (OSHA) does not investigate the incidents involving municipal employees because they are out of their legal jurisdiction.

The investigation was initiated by the MO FACE investigator at the time of notification by the county medical examiner's office. The investigation included the death investigator interview, the employer interview and photographs of the incident sight. The local police department was not involved. The municipality involved has been in operation for about 50 years and at the time of the incident employed 36 persons. The victim was the only electrical line foreman employed. The municipality did not have a designated safety officer, a general written safety policy or written safety rules and procedures for the task attempted. Employee training was made available through *The Lineman's and Cableman's Handbook* and on the job training. The employer provided the employee with the necessary tools, personal protection equipment, and testers for presence of electrical energy.

INVESTIGATION:

The employer had contracted the services of a electrical equipment maintenance company to perform routine maintenance on the two municipally owned transformer stations. The routine maintenance involved draining and recycling of oil used in the oil circuit reclosers located at each of the transformer stations. The employer assigned the line foreman (victim) to assist the contractor with the task. The contractor and the victim met that morning and discussed the duties to be performed that day.

Two pieces of equipment are described because they were directly involved in the incident site and were the likely source of energization of the point of contact. Oil circuit reclosers are installed on the power supply lines leaving a power source. *The Lineman's and Cableman's Handbook* states, "A recloser opens a circuit in case of fault as would a fuse or circuit breaker. The recloser, however, recloses the circuit after a predetermined time (for hydraulically controlled reclosers about 2 sec.) If the fault persists, the recloser operates a predetermined number of times (1 to 4) and "locks out" after which it must be manually reset before it can be closed again."

Another type of switch involved is called air switches. There are three types of these switches: circuit breakers, air breaks, and disconnects. The switches involved in this case are air breaks, sometimes called solid blade disconnects. They are constructed of two parallel solid bars made of copper and brass. They are used to connect and disconnect individual electrical transmission lines

from a power source.

Many of these switches are equipped with what is referred to in *The Lineman's and Cableman's Handbook* as arcing horns. An arcing horn is made of an aluminum wire and functions to reduce the amount of damage incurred from an arc. As the switch opens, these horns accept the current present, and when the horn breaks contact from the circuit, an arc can form in the air space. As the switch opens further, the arc breaks and the flow of current across the air break is stopped.

The city's electrical service is provided by two separate transformer stations. Both stations convert 34,500 volts of electricity into six lines or phases of 2,400 volts. Each station routinely serves approximately one half of the city but has the capacity to serve the entire city. To perform the needed maintenance on one of these transformer stations, the city's electrical demand must first be shifted to one transformer station. This was accomplished by closing six switches, joining the six phases of electrical service of the city. The maintenance area must then be completely disconnected or isolated from the 34.5 kv lines serving the station and the 2,400 volt lines that serve the city.

The victim and contractor proceeded to the transformer station (incident site) and began the process of isolating the transformer station from the power supply. This was done by first opening or disconnecting the six solid blade disconnects that feed power to the city. These switches, identical to those that were closed earlier, were installed on an electrical pole located just outside the fenced area of the transformer station. These switches are opened and closed with the use of a long insulated pole ("Hot Stick") with a hook attached to one end. The switch is equipped with a center pull ring by which it can be manipulated. The victim reached up with the hot stick, hooked the pull ring, and opened all the switches individually. It is believed that the victim may not had been aware of the presence of these arcing horns.

The next step was to disconnect the three lines of 34.5 kv power that come into the transformer station. This was accomplished by the use of a gang operated air break. This device successfully disconnected the power source entering the transformer. The victim and contractor believing they had isolated the oil circuit recloser unit began to do the required maintenance. They did not ground or test the circuits.

To do the maintenance, the tank enclosing the circuits and holding the oil is unbolted and lowered to the ground by a wire cable winch. The victim and contractor were attaching the come-along winch to the tank. The victim was standing on a six-foot fiberglass step ladder and was leaning against the structure supporting the recloser unit, which provided a path to ground when his upper left arm contacted an energized part of the unit. The current entered the upper arm and exited through his chest. The victim clothes caught fire. He then fell away from the unit and off of the ladder, suffering a broken pelvis and was unresponsive. The contractor extinguished the burning clothes and administered CPR, regaining heart and respiratory function. The contractor radioed in an emergency situation and requested an ambulance. The victim was conscious and responsive when the ambulance arrived. He was taken to a local hospital then transferred by ambulance to a trauma center. The victim recovered from his thermal injury but developed intra-abdominal bleeding which led to multiple organ system failure.

The victim's supervisor surveyed the incident and found a burn mark on one of the bushings on the

oil recloser. He also found that the transformer station had not been fully isolated from the city's power supply because three of the six solid blade disconnects with arcing horns had failed to be fully opened, breaking the flow of current. With these arcing horns still maintaining contact electricity provided by the other transformer station supplying the city feedback into the transformer station and energized the oil circuit recloser. The supervisor also acknowledged that a circuit tester which is used in determining the presence of electrical energy had not been employed and was still in the company truck.

CAUSE OF DEATH:

Multiple organ system failure due to electrical and thermal burns.

RECOMMENDATIONS/DISCUSSION:

RECOMMENDATION #1: Employers should ensure that linemen follow established safe work procedures to de-energize, ground, and verify through testing prior to beginning maintenance and repair operations on electrical transmission lines and equipment.

DISCUSSION: The Code of Federal Regulations Standard 29 Part 1926.954 (a) states: "All conductors and equipment shall be treated as energized until tested or otherwise determined to be de-energized and grounded."

Additionally, CFR Standard 29 Part 1926.950(d)(c)(iii-iv) states, "After all designated switches and disconnectors have been opened, rendered inoperable, and tagged, visual inspection or tests shall be conducted to ensure that equipment or lines have been de-energized. Protective grounds shall be applied on the disconnected lines or equipment to be worked on."

Even though municipality employees are not under OSHA jurisdiction, these regulations should apply to all workers and should be considered the minimum requirements for the safety and health of all individuals. It should also be noted that these regulations are also referred to in industry manuals such as *The Lineman's and Cableman's Handbook* and *The American Public Power Association (APPA) Safety Manual for an Electrical Utility*.

RECOMMENDATION #2: Employers should ensure that workers are trained in and follow established safe work procedures relevant to their duties and responsibilities.

DISCUSSION: Although both the lineman and the contractor were experienced in electrical service, evidence suggests that the men believed they had isolated the transformer station from any current present. Even though they had disconnected the switches, the arcing horns were still making contact and did not prevent the feedback of electrical energy into the transformer station. If the workers would have followed safe work procedures and tested and grounded the equipment, they would have found the transformer station had not been completely isolated from all sources of

electrical energy.

RECOMMENDATION #3: Employers should ensure that prior to any work on an electrical system, all involved workers are familiar with the operation of every electrical component.

DISCUSSION: The lineman may not have been aware of the arcing horns present when disconnecting the switches outside the transformer station. Three of the six switches that were disconnected still had the arcing horn making contact. Visual inspection from the ground would have revealed that the arcing horns had not cleared and the disconnection was not complete.

RECOMMENDATION #4: Employers should develop, implement, and enforce a comprehensive safety program which includes worker training in recognizing and avoiding hazards, especially electrical hazards.

DISCUSSION: Employers should emphasize the safety of their employees by developing, implementing, and enforcing a comprehensive safety program. The safety program should include, but not be limited to, training workers in the proper selection and use of personal protection equipment, along with the recognition and avoidance of electrical hazards.

RECOMMENDATION #5: Employees who work around electrical transmission lines, electrical circuits, and electrical equipment should be trained in cardiopulmonary resuscitation (CPR).

DISCUSSION: According to a NIOSH Alert, *"Request for Assistance in Preventing Fatalities of Workers Who Contact Electrical Energy"* (NIOSH Publication 87-103), "prompt emergency medical care can be lifesaving for workers who have contacted either low voltage or high voltage electrical energy. Immediate cardiopulmonary resuscitation (CPR) followed by advanced cardiac life support (ACLS) has been shown to save lives." CPR was administered immediately after the victim contacted the electrical energy. He was revived, conscious and alert when emergency personnel arrived. This is an excellent example of the importance of having CPR Training in the workplace.

REFERENCES:

1. The Lineman's and Cableman's Handbook. Edwin B. Kurst, E.E., P.E. Ph.D. Thomas M. Shoemaker, P.E., B.S.E.E. Eighth edition. McGraw-Hill Book Company. Section 18.
2. American Public Power Association, Safety Manual for an Electric Utility Sections 502 (a) and (b), 504 (d), and 507 (a), 1983.
3. Office of the Federal Register, Code of the Federal Regulations, Labor, 29 CFR 1926.954(a), pp.316. July 1, 1991.
4. Office of the Federal Register, Code of the Federal Regulations, Labor, 29 CFR 1926.950(d)(c)(iii-iv), pp.313. July 1, 1991.
5. National Institute for Occupational Safety and Health, NIOSH Alert, Request for Assistance in Preventing Fatalities of Workers Who Contact Electrical Energy, Publication Number 87-103, December, 1986.

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