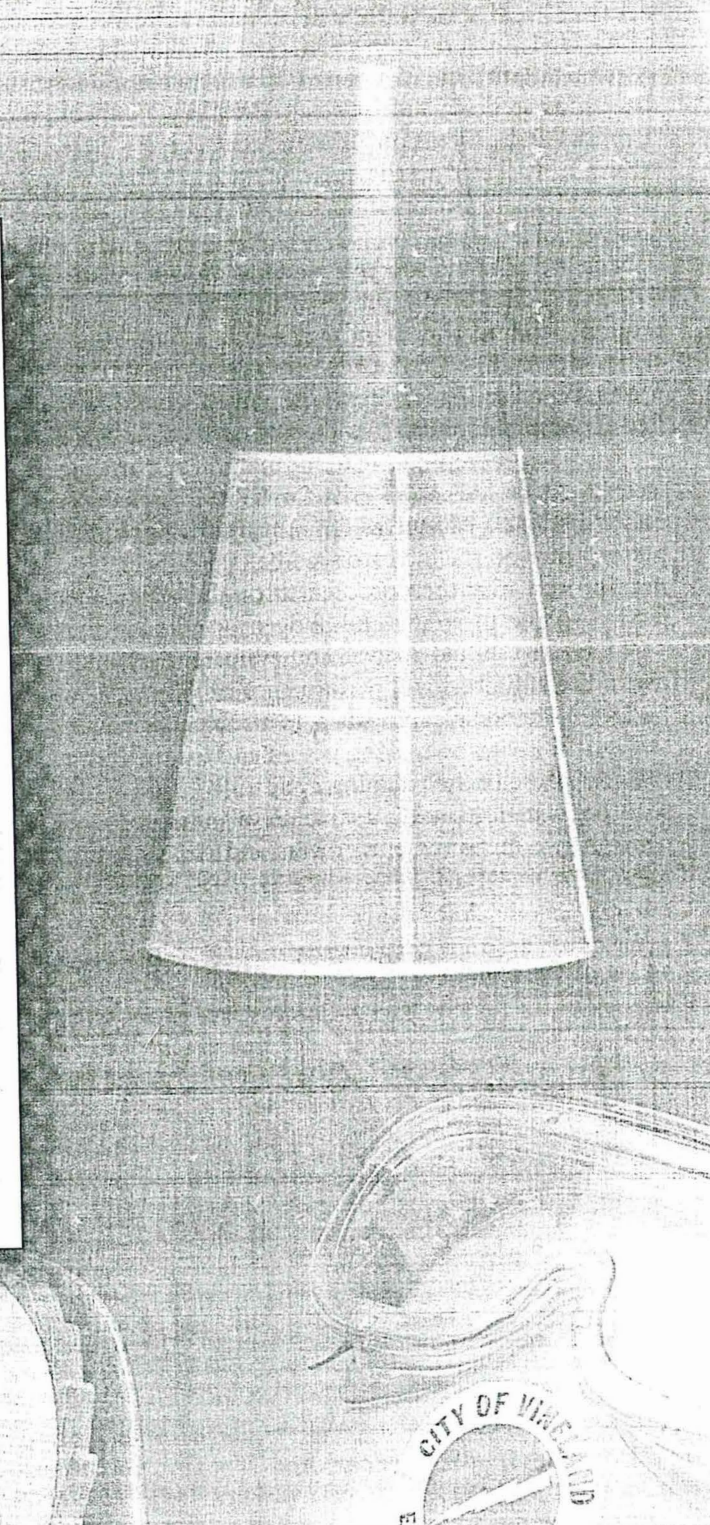
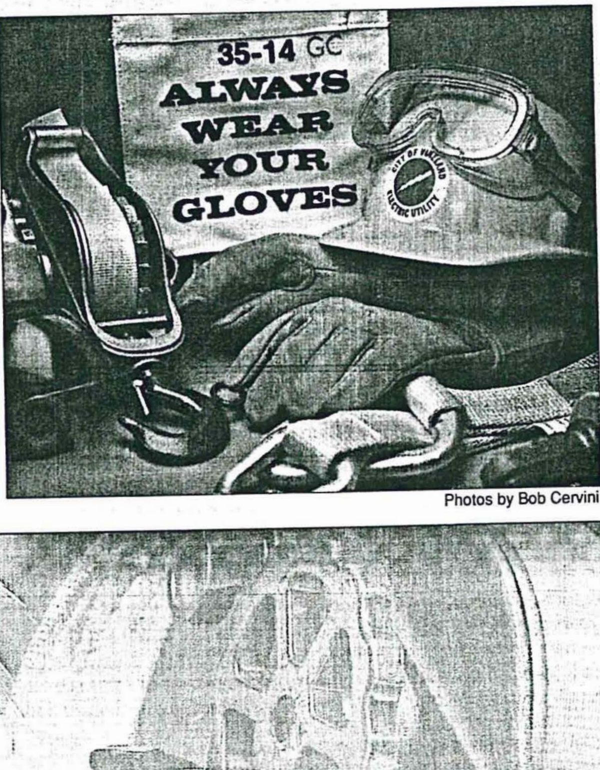


Preventing Lineworker Fatalities

by Virgil J. Casini, James W. Collins and John R. Myers



Photos by Bob Cervini

The National Institute for Occupational Safety and Health is the federal agency responsible for conducting research to identify hazards and developing effective intervention methods to prevent work-related injuries, illnesses, and fatalities. The NIOSH Division of Safety Research is the institute's focal point for fatal and nonfatal traumatic injury research programs. Its mission is to reduce the number and severity of occupational injuries by developing and conducting research projects that yield results with real-world impact.

The Division of Safety Research analyzes occupational mortality and morbidity data to target high-risk industries and occupations for further study. Line mechanics have been identified by NIOSH's National Traumatic Occupational Fatality (NTOF) database as a high-risk occupational group for work-related deaths. The job classification ***line mechanic*** or ***lineman*** refers to workers who construct, maintain, or repair transmission and distribution power lines. The NTOF database consists of information from death certificates of workers who died as a result of traumatic occupational injuries that meet the following criteria:

- age at death—16 years or older;
- an external cause of death from the International Classification of Diseases 9th Edition (ICD-9), reported as immediate, underlying or contributory;
- a positive response to the "injury at work" item on the certificate.

From 1980 to 1985, 374 line mechanic deaths were identified by the NTOF database; of these, 59 percent were due to electrocution, 14 percent were due to falls from elevations, and 27 percent were due to other causes such as heavy objects falling on the worker, motor vehicle incidents, burns and explosions. Over that same time period, the average yearly employment of line mechanics was 110,800, according to the Bureau of Labor Statistics. The average annual number of fatalities (62.3 line mechanic deaths per year), divided by the average yearly employment of line mechanics (110,800), indicates an annual fatality rate of 56.3 deaths per 100,000 line mechanics. This rate was significantly higher than the general industry fatality rate of 7.9 deaths per 100,000 workers over the same time period.

Another source of data on lineworker fatalities is the NIOSH Fatal Accident Circumstances and Epidemiology (FACE) project. The objective of the FACE project is to identify factors that contribute to occupational deaths by conducting epidemiologic field evaluations of selected fatalities. As part of the FACE project, Division of Safety Research personnel did 203 evaluations involving 219 electrical-related fatalities during the period November 1982 to December 1990. Of these investigations, 41 involved line mechanics, resulting in 43 fatalities. For fatalities investigated as part of the FACE program, line mechanics were the second most frequently involved job classification; laborers were first. The average age of the line mechanic victims at the time of death was 36 years. Assuming a life expectancy of 65 years for each victim, the years of total potential life lost for the 43 fatally injured line mechanics added up to 1,175 years of life (an average of 27 years per victim). The FACE project personnel investigate fatalities at investor-owned utilities, municipalities, electric cooperatives and electrical contractors. Voltage levels contacted in these incidents ranged from 110 to 230,000 volts.

The U.S. Bureau of Labor Statistics Supplementary Data System also has identified line mechanics as a high-risk group for occupational injuries. The SDS is a composite of workers' compensation claims from approximately 27 participating states. Since only 27 states provided information to the SDS system during the six-year period (1980 through 1985), and not all states participated in all years, the compensation counts provided are not national values. For this six-year period, the SDS system reported a yearly average of 2,024 injuries to line mechanics in the Electric Services Industry (Standard Industrial Classification Code 4911). This information, while not providing a national quantification of line mechanic injuries, does allow for a good classification of line mechanic injuries. Analysis of this data in combination with information from the Bureau of Labor Statistics annual survey, (a national estimate of occupational injuries and illnesses based on a random sample of industries nationwide), indicated that line mechanics have an estimated annual rate of 6.3 lost-workday injuries per 100 workers, nearly twice as high as the annual rate of 3.6 lost workday injuries per 100 workers for all private sector employees.

Using the workers' compensation information from SDS, overexertion and struck-by injuries each accounted for 20 percent of the injuries involving line mechanics. Falls accounted for 18 percent, while contact with electricity was noted as the cause for less than 5 percent. The leading sources of injuries, based on the SDS data, were working surfaces, metal items, electrical apparatus, bodily motion, hand tools and vehicles.

The three leading causes of fatal injury are contact with electrical injury, falls from elevations, and objects falling on line mechanics, while the three major causes of nonfatal, reportable injuries to line mechanics are over-exertion, being struck by falling objects and falls.

Due to inherent hazards involved in the construction, repair and maintenance of electrical transmission and distribution systems, employers typically provide extensive training for line mechanics and require them to adhere to stringent injury prevention and line clearance procedures.

However, the invisibility of electricity makes it difficult for a line mechanic to be constantly aware of the life-threatening hazards presented by working close to power lines. Efforts to maintain continuous electric service to customers frequently dictate that line mechanics repair and maintain transmission and distribution systems while power lines remain energized. Additionally, line mechanics must deal with a constantly changing work environment, inclement weather, working from heights, overtime, and cumbersome personal and electrical protective equipment.

Four of the FACE field evaluations involving line mechanic fatalities are described below to present typical causative factors that recur in the FACE line mechanic fatality data.

Case No. 1 (NIOSH 1985) A 38-year-old lineworker with 20 years experience was electrocuted while repairing a 13.2-kV line that he thought was de-energized. The lineworker was working from an aerial bucket truck to repair a power line damaged during an electrical storm. The damaged line was one of two power line phases serving a residential area. The third phase of the circuit supplied a three-phase transformer that provided power to a store. To repair the damaged line, both of the residential power lines were presumed de-energized by opening their respective disconnects. However, the third line remained energized to provide power to the store. Because of this, voltage fed back through the three-phase transformer, inadvertently energizing the line on which a splice was to be made. Though the lineworker presumed that the line to be spliced had been de-energized, he tested it for voltage by touching it with insulated pliers held in his gloved hand. When the lineworker did not see an arc or hear a buzzing sound, he concluded it was de-energized, removed his glove, and began to splice the line. Because fuzzing does not adequately detect lower voltages, the worker did not detect the voltage created by the back-feed circuit. [Power company engineers later estimated that the line carried 4,000 to 7,000 volts.] The lineworker inserted the supply side of the line into a splice tube and crimped it. When he grasped the load side of the line, he completed an electrical circuit between the supply and load sides of the line, causing current to pass through his arms and chest, resulting in his electrocution. Grounds had not been placed on the line, and electrically insulated lineworker gloves were not used when the incident occurred.

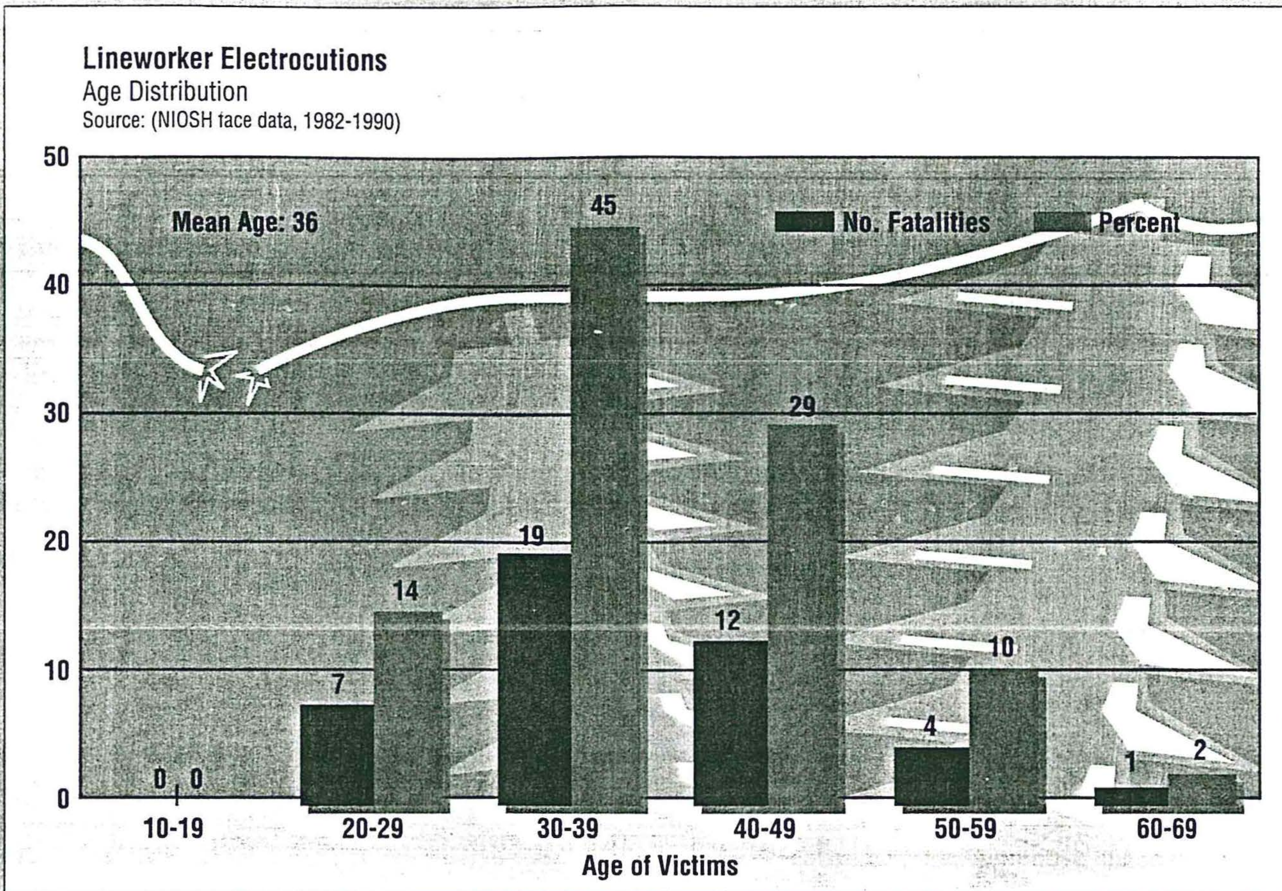
In a multiphase distribution system, the possibility that any one phase can serve as the supply for the transformer should always be considered. Lineworkers should treat all power lines as energized unless they have personally de-energized the power lines, have applied proper grounding to their work area and have tested the line to verify de-energization.

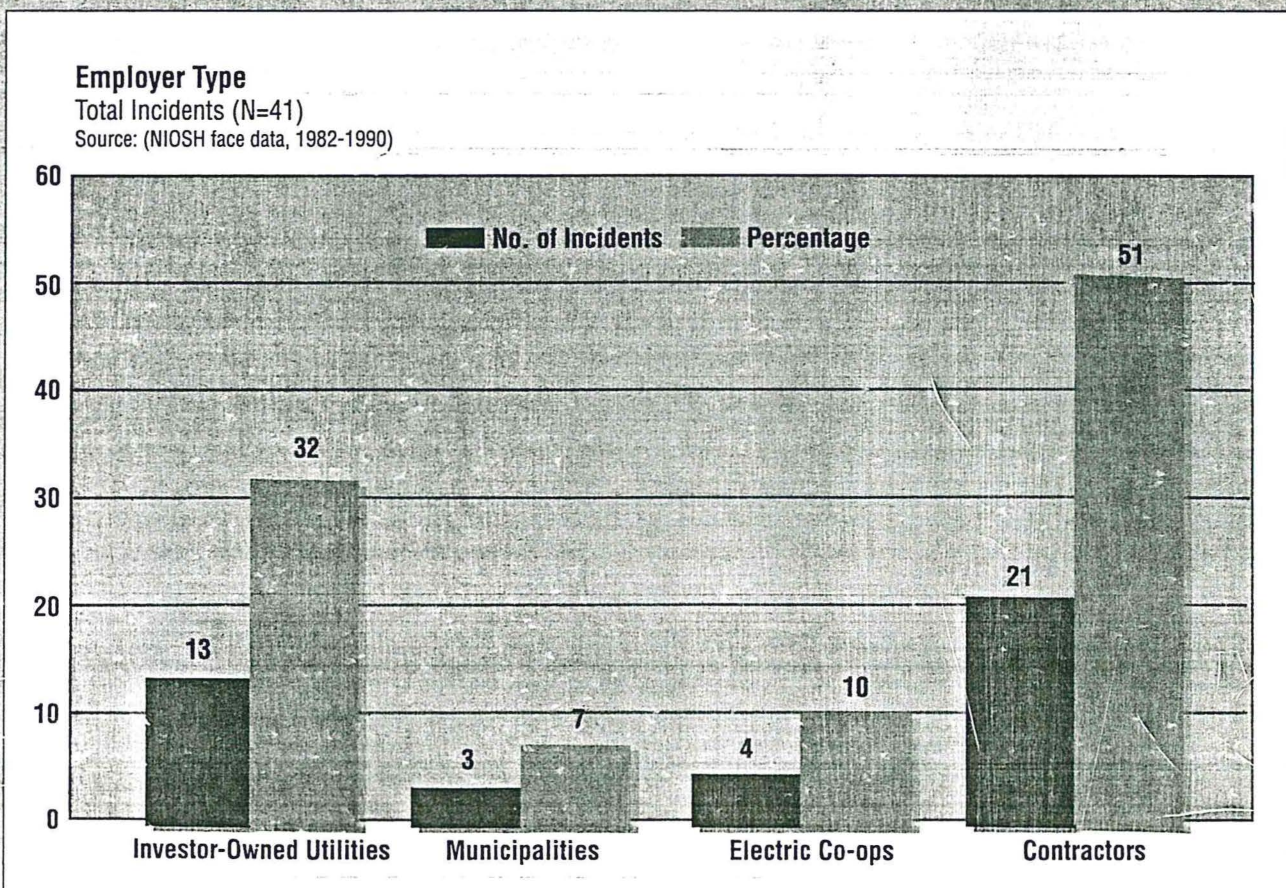
Case No. 2 (NIOSH 1986) A 40-year-old meter technician, who was working overtime as a lineworker technician, was electrocuted while repairing a downed line. The victim had worked as a meter technician constructing, maintaining, and repairing electric meters for the full 20 years of his work life. However, several years earlier, he had attended a seven-week basic lineworker training course which qualified him as a lineworker technician, permitting him to climb poles and work with electrical conductors. During his regular shift, he worked as a meter technician; however, during unplanned power outages, he worked as a lineworker technician restoring electrical service. On the day before the incident, the victim worked more than 14 hours, finishing work at 11:45 p.m. He reported to work at 8 a.m. on the day of the incident and worked his regular shift. Upon completion of his regular shift, he was asked to work overtime to restore electrical service to a residential customer.

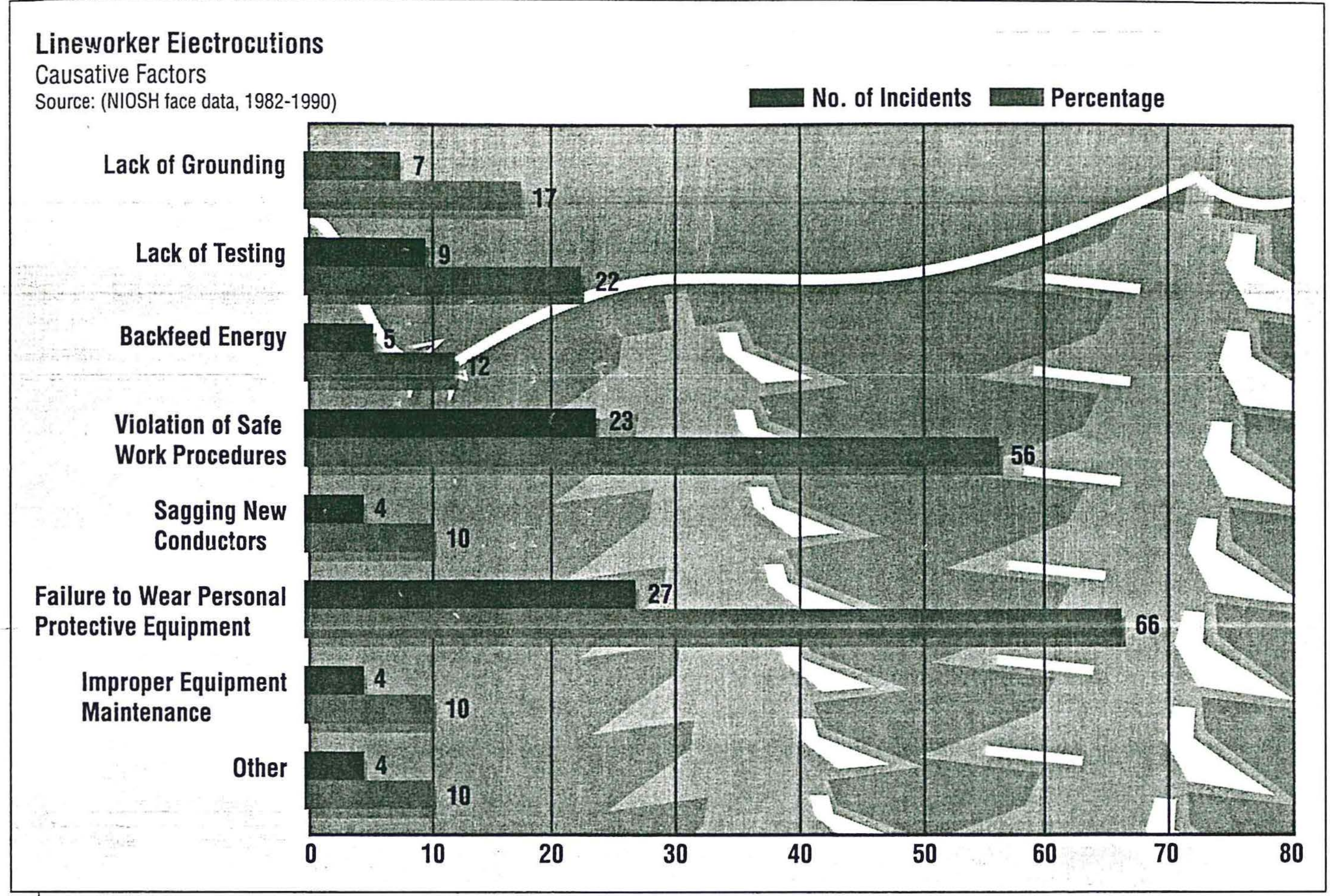
At 5:00 p.m., the victim arrived at the site and discovered a tree limb had fallen across a power line. The line had detached two 120-volt conductors and the neutral wire from the utility pole. After removing the tree limb from the conductors, the technician cut the electrical conductors on either side of previous splices, attached a rope to the three conductors, fished the rope through a block and tackle, and attached the rope to the bumper of his utility truck. He then moved the utility truck until all the slack in the conductors was removed between the two utility poles (a span of approximately 130 feet). He then reclimbed the utility pole wearing his insulated gloves, hard hat and safety glasses. The technician was pulling an energized cable when a splice in the cable caught the left cuff of his glove. The cuff of the glove was pulled down, allowing the energized conductor to contact the victim's forearm near the wrist, resulting in his electrocution. The meter technician did not use his lineworker technician training on a regular basis and had been assigned a task that was very difficult to be performed safely by one person.

Case No. 3 (NIOSH 1987) A 37-year-old lineworker, who was working for an electrical contractor that specializes in power line construction and maintenance, was electrocuted when the boom of a digger derrick truck contacted a 7,200-volt power line while he was leaning against the truck. The crew consisted of two lineworkers and an apprentice lineworker. One of the lineworkers, who was serving as a working foreman, told the apprentice lineworker where to position the truck and then went over the job procedures with the crew. After the pre-job briefing, the victim began to install the truck's ground rod, which was attached to a 30-foot ground cable. The apprentice lineworker climbed onto the truck's platform and raised the boom. This action was in violation of the contractor's policy that the truck's boom not leave the truck's cradle until the ground has been installed. While it is unknown why the apprentice lineworker raised the boom, it is suspected that he either thought the ground had been installed or he may not have been able to see the victim clearly. The boom contacted the overhead power line, electrocuting the victim.

Case No. 4 (NIOSH 1990) A 46-year-old male distribution line technician working from a tree to clear limbs off a 7,200-volt power line, was electrocuted then fell 20 feet to the ground. The victim and a coworker had been dispatched to an area to clear tree limbs off a 7,200-volt primary power line. The limb damage occurred when a tropical storm passed through the area. An aerial bucket truck could not be used because the dirt access road had been rendered impassable by heavy rains. The victim got a telescopic fiberglass hot stick from the back of his truck and walked the access road with his coworker until he saw a white pine limb lying across the power line. Following standard operating procedure, the victim extended the hot stick and knocked the limb off the power line. The victim retracted the hot stick and was walking toward the truck when he heard a popping sound above him. The victim told the coworker that he thought he saw a second limb contacting the power line at a point where the line passed through the pine tree. Because of the dense


Lineworker Electrocutions
Age Distribution
Source: (NIOSH face data, 1982-1990)
Mean Age: 36
No. Fatalities
Percent
0
10
20
30
40
50
0
0
7
14
19
45
12
29
4
10
1
2
10-19
20-29
30-39
40-49
50-59
60-69
Age of Victims


Employer Type
Total Incidents (N=41)
Source: (NIOSH face data, 1982-1990)
No. of Incidents
Percentage
0
10
20
30
40
50
60
13
32
3
7
4
10
21
51
Investor-Owned Utilities
Municipalities
Electric Co-ops
Contractors



growth of the limbs, the victim was not sure which of the limbs was making contact. The density of the limbs also negated the use of the telescopic hot stick. The victim and coworker traveled to a pole-mounted transformer 300 feet away and opened a fused switch on the transformer. The victim thought he had de-energized the 7,200-volt primary line. However, the victim did not ground the primary power line as required by standard operating procedures. The fused switch actually controlled the electrical current to a tap line that provided electrical service for several houses in the area. This tap line was mounted on the same pole as the primary power line. The victim told the coworker that he was going to climb the tree to see if he could correct the situation. Then he reported that the limb was not contacting the power line where he thought. The coworker could not clearly see the victim, but he heard an arcing sound and saw the victim falling to the ground. The coworker ran to the truck and called the company dispatcher to summon the emergency medical squad. He then returned to the victim and initiated cardiopulmonary resuscitation. A second worker in the area heard the call over the truck radio and went to the scene to aid the coworker. The EMS transported the victim to the hospital where he was pronounced dead. Although the event was unwitnessed, electrical burns on the victim's back, torso and limbs suggested the victim lost his balance and fell into the power line. A path for the electric current was established through the victim and the tree to the ground.

The FACE evaluations of line mechanic fatalities identified several common factors in these line mechanic fatalities. These factors are detailed in the graph above. In many of the FACE cases, more than one of these factors were present. The "other" category on the graph represents factors such as improper vehicle maintenance, equipment failure and component failure.

To reduce the incidence of line mechanic fatalities, the following safe work practices and preventive suggestions are presented:

1. All organizations that employ people who work on or close to power lines or any other components of transmission or distribution systems should develop and implement a comprehensive safety program. The program should be designed to help workers recognize, understand and control hazards that they may confront during the performance of their duties. Companies should evaluate each task performed by workers, develop and implement a safety program addressing these hazards, and provide training in safe work procedures.

2. Line mechanic training should include, but not be limited to, instruction in electrical theory, safe work practices, pre-job planning, operation of aerial equipment (bucket trucks, derrick trucks, etc.), the use of personal and electrical protective equipment, use of voltage detection devices, and lockout/tagout procedures for de-energizing, grounding, and testing power lines and equipment. Line mechanics should receive task-specific training that correlates steps in the task with control of the identified hazards. A line me-

chanic should be required to demonstrate proficiency in performing line mechanic duties before being allowed to work on energized or de-energized power lines.

3. All persons performing work on or in the vicinity of unverified de-energized power lines should treat all power lines as hot unless they positively know these lines are properly de-energized, grounded and have been tested. If a line is not grounded, it is not de-energized. If work is being performed on a multiphase system, grounds must be placed on all lines. Lines should be grounded within the sight of the working area and work should be performed between the grounds whenever possible. If work is to be performed out of sight of the point where the line has been de-energized, an additional ground should be placed on all lines on the source side of the work area. Because of the possibility of a feedback circuit, the person performing the work should personally de-energize, ground, and test all lines on both sides of the work area unless he or she is wearing the proper protective equipment.

4. Procedures should be established to perform a dual voltage check on the grounded load and supply sides of open circuits. Once it is determined that high voltage is not present, low voltage testing equipment, such as a glowing neon light or a light-emitting diode, should be used to determine if lower voltages are present.

5. Before beginning any work on an electrical system, all workers involved should be aware of the function of each component in the system, and of any hazards created by the functioning of these components. Additionally, workers should be instructed that if any questions regarding the electrical system arise, qualified personnel should be contacted to answer these questions before work proceeds.

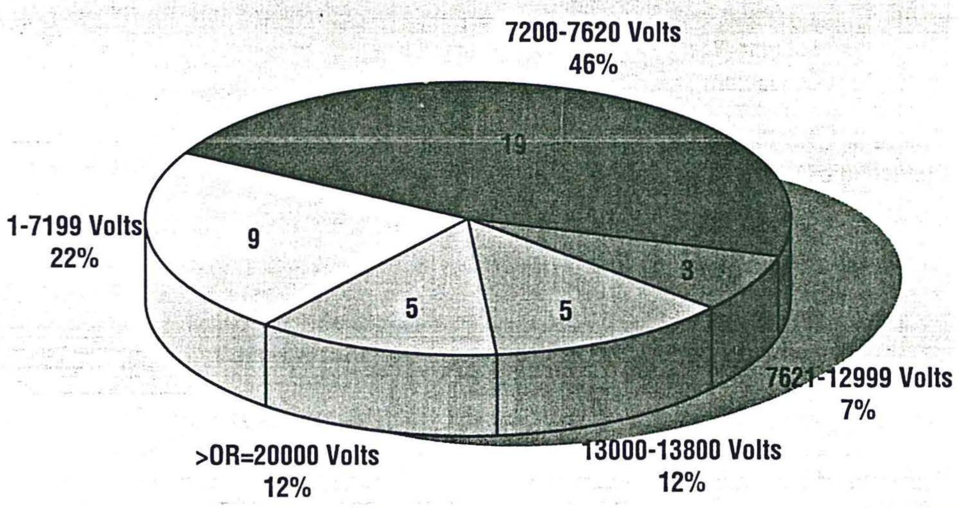
6. All installation and maintenance work performed by line mechanics should comply with the safety rules for the installation and maintenance of overhead and underground electric supply and communication lines as outlined in Sections 2 and 3 of the National Electrical Safety Code (ANSI 1990) and any applicable sections of existing standards from the Occupational Safety and Health Administration.

7. Line mechanics should be trained in and instructed to adhere constantly to all established safe work procedures relevant to their duties and responsibilities. Management should periodically conduct random site visits to ensure work crews are following established safe work procedures.

8. Power lines should not be prepared or otherwise accessed without adequate personal protective equipment unless the line mechanic personally verifies that the line is de-energized and properly grounded. Line mechanics must be provided with and specifically instructed to wear all required proper personal protective equipment, such as gloves and sleeves, for the specific tasks to be performed.

9. Qualified personnel should conduct a comprehensive inspection of each worksite prior to the start of each job to identify all potential hazards at the worksite, including any damaged equipment. Then measures should be implemented to control these hazards. The specific tasks to be performed by each worker at the site should be clearly defined at this time. Damaged equipment must either be repaired to manufacturer's specifications or replaced.

Lineworker Electrocution
Voltage Level - No. of Incidents
Source: (NIOSH face data, 1982-1990)



10. All personnel working on or in the vicinity of high voltage power lines should be certified in CPR.

As part of the FACE program, the Division of Safety Research investigated 41 line mechanic electrocution events resulting in 43 fatalities. Circumstances surrounding these events have been analyzed and indicate that many events could have been prevented if existing regulatory and consensus standards and known safe work procedures had been followed. These data indicate that although many organizations had comprehensive safety programs, they were not fully implemented. This underscores the need for utilities to increase management and worker understanding and awareness of the hazards associated with working on or in proximity to high-voltage power lines or other components of transmission and distribution systems. In some cases, this may entail the development of additional training, the evaluation and restructuring of existing safety programs or both. Companies, unions and trade associations should work together to recognize the dangers associated with working on or near high-voltage transmission and distribution systems, and to work toward preventing these deaths by implementing appropriate control measures. ❑

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