Report of the Task Group on Electrical Safety of Department of Energy Facilities

January 1993

U.S. Department of Energy
Assistant Secretary for Environment, Safety and Health

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APPENDIXES

Selected Acronyms

AHJ	Authority Having Jurisdiction
AL	DOE Albuquerque Field Office
ANL-W	Argonne National Laboratory - West
ANSI	American Nuclear Standards Institute
ASTM	American Society for Testing Materials
BCSR	Boeing Computer Services - Richland
BSRI	Bechtel Savannah River, Inc.
CAIRS	Computerized Accident/Incident Reporting System
CFR	Code of Federal Regulations
CH	DOE Chicago Field Office
CPAF	Cost Plus Award Fee
DNA	Defense Nuclear Agency
DOE	Department of Energy
DP	DOE Office of Defense Programs
DWPF	Defense Waste Processing Facility
EG&G/EM	EG&G Energy Measurements, Inc.
EH	DOE Office of Environment, Safety and Health
EM	DOE Office of Environmental Restoration and Waste Management
ER	DOE Office of Energy Research
ES&H	Environment, Safety, and Health
ESH&QA	WSRC Division of Environment, Safety, Health and Quality Assurance
ESS	SF Environment and Safety Support Division
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FSES	Facility Safety Evaluation Section

Selected Acronyms (continued)

FSN	Fenix & Scisson, Nevada, Inc.
FY	Fiscal Year
GOCO	Government-Owned Company-Operated
HEHF	Hanford Environmental Health Foundation
HGET	Hanford General Employee Training
IAEI	International Association of Electrical Inspectors
IBEW	International Brotherhood of Electrical Workers
ID	DOE Idaho Field Office
INEL	Idaho National Engineering Laboratory
IS	Industrial Safety
JCS	Job Control System
JSA	Job Safety Analysis
KEH	Kaiser Engineers Hanford Company
M&O	Management and Operations
MIP	Maintenance Implementation Plan
MK-FIC	Morrison Knudsen-Ferguson of Idaho Company
MMES	Martin Marietta Energy Systems
NE	DOE Office of Nuclear Energy
NEC	National Electric Code
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NTS	Nevada Test Site
NTSO	Nevada Test Site Office
NV	DOE Nevada Field Office
OR	DOE Oak Ridge Field Office
ORNL	Oak Ridge National Laboratory

Selected Acronyms (continued)

ORPS	Occurrence Reporting and Processing System
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration (or Act)
OS&PF	REECo Occupational Safety and Fire Protection Department
OSP&A	WSRC Occupational Safety Programs & Assessments
PFP	Plutonium Finishing Plant
PMT	Program Management Team
PNL	Battelle Memorial Institute's Pacific Northwest Laboratory
PSO	Program Secretarial Office
PTM	Program Management Team
R&D	Research and Development
RAC	Remedial Action Contractor
REECo	Reynolds Electrical and Engineering Company
RL	DOE Richland Field Office
RSN	Raytheon Services Nevada
RW	DOE Office of Civilian Radioactive Waste Management
SERB	Senior Electrical Safety Review Board
SF	DOE San Francisco Field Office
SIRIM	Site Item Reportability and Issues Management
SLAC	Stanford Linear Accelerator Center
SOP	Standard Operating Procedure
SPMS	Safety Performance Measurement System
SR	DOE Savannah River Field Office
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
SSO	Stanford Site Office

Selected Acronyms (continued)

SRTC	Savannah River Technology Center
SSRL	Stanford Synchrotron Radiation Laboratory
STOP	Safety Training Observation Program
STR	Subcontract Technical Representative
TAC	Technical Action Contractor
TTA	Tiger Team Assessment
TTAP	Tiger Team Action Plan
UMTRA	Uranium Mill Tailings Remedial Action Project
WHC	Westinghouse Hanford Company
WINCO	Westinghouse Idaho Nuclear Company
WSRC	Westinghouse Savannah River Company

EXECUTIVE SUMMARY

On October 23, 1992, the Under Secretary of Energy directed the Assistant Secretary for Environment, Safety and Health (EH) to form an internal Department of Energy (DOE) Task Group to "immediately review electrical safety programs and practices across the complex to identify measures to improve and ensure the electrical safety of DOE and contractor employees . . . including recommendations for addressing these concerns."

The Task Group on Electrical Safety at DOE Facilities (Task Group), which was formally established on October 27, 1992, was chaired by the Director, Office of Performance Assessment, within the Office of the Deputy Assistant Secretary for Safety and Quality Assurance, EH. Over a 6-week period in November and December 1992, the Task Group reviewed the electrical safety-related occurrence history of, and conducted field visits to, seven DOE sites chosen to represent a cross section of the Department's electrical safety activities. The purpose of the field visits was to review, firsthand, electrical safety programs and practices and to gain greater insight to the root causes and corrective actions taken for recently reported incidents.

The electrical safety "environment" of the DOE complex is extremely varied, ranging from common office and industrial electrical systems to large high-voltage power distribution systems (commercial transmission line systems). It includes high-voltage/high-power systems associated with research programs such as linear accelerators and experimental fusion confinement systems. Age, condition, and magnitude of the facilities also varies, with facilities dating from the Manhattan Project, during World War II, to the most modern complexes. The complex is populated by Federal (DOE and other agencies) and contractor employees engaged in a wide variety of occupations and activities in office, research and development, and industrial settings. The sites visited included all of these variations and are considered by the Task Group to offer a valid representation of the Department's electrical safety issues. The sites visited were Oak Ridge National Laboratory (ORNL), Stanford Linear Accelerator Center (SLAC), Idaho National Engineering Laboratory (INEL), Nevada Test Site (NTS), Savannah River Site (SRS), Hanford Reservation (Hanford), and the Uranium Mill Tailings Remedial Action Project (UMTRA) located at Grand Junction, Colorado.

The Task Group was aware of electrical safety-related incidents throughout the DOE complex, but to ensure sufficient program assessment, concentrated its review of such occurrences on those of the sites visited. Data contained in the Department's Occurrence Reporting and Processing System (ORPS), in operation over the last 2 years (68 electrical safety-related for the sites visited), and the actual investigation reports for specific incidents at the sites visited, indicate the occurrences were primarily caused by

Personnel Error (28), Management Problems (19), Procedure Problems (10), Design Problems (6), Training Deficiencies (4), and Other (1).

The Task Group found that electrical safety programs are in place in the field and these programs are providing a basic level of protection to employees and electrical workers. However, in almost every case, these programs are failing to fully implement the electrical safety requirements of the OSHA regulations as contained in 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V. For this reason, DOE and contractor employees are not receiving the full benefit of protection, particularly in the area of electrically safe work practices.

Although experience has shown regulatory compliance alone cannot assure a successful safety program, the situation in the case of electrical safety is very different. The OSHA regulations on electrical safety, particularly safe work practices, represent a transition from the traditional approach to safety to a modern one, which places emphasis on the individual's actions. The requirements are performance based, stressing electrically safe work practices which serve to permanently change the safety culture and actually prevent historically prominent electrical-related fatalities and serious injuries. These practices include requirements for work performed on or near exposed energized and deenergized parts of electrical equipment, use of electrical protective equipment, and the safe use of electrical equipment. In preparing the regulations, OSHA found that unsafe work practices, or a combination of unsafe work practices, were involved in a majority of electrical fatalities. OSHA found that under the previous practices, an average of 92 deaths and about 4,000 disabling and nondisabling injuries occurred annually between 1983 and 1987. Analysis of the then-proposed OSHA regulations revealed that approximately 3,400 of the injuries and some 80 of the fatalities should be avoidable each year after promulgation of the rule. This would represent an 85 percent reduction in both fatalities and injuries. During the approximate same period within DOE there were six electrically related deaths and 165 shocks and burns, with 1,500 lost work days resulting.

These data support and underscore the necessity of rigorous implementation of these prescribed safe work practices as a primary means of reducing fatalities and injuries throughout the DOE complex. Based on our analysis of the electrical safety-related incident data for DOE, the Task Group believes that full implementation of the OSHA electrical safety requirements will result in a substantial reduction of related occurrences and a shift away from personnel errors and seriousness of consequences to individuals involved. A chronology of fatalities and serious injuries resulting from electrical incidents at DOE facilities is provided for the period January 1983 through October 1992 as Appendix I.

Underlying the lack of full implementation of these OSHA requirements is insufficient knowledge of the requirements by both DOE and contractor managers. Implementation of OSHA's electrical safety requirements, or other regulations, requires sufficient knowledge of these requirements by management to define goals and objectives, obtain resources, and set schedules. Even though it is an appropriate expectation that management would acquire sufficient knowledge of the programs they are required to implement, without internal DOE guidance, training, and awareness campaigns, this has not occurred.

The Task Group found "islands of excellence" and exemplary practices in the field. Individual managers have taken upon themselves to develop a thorough understanding of the OSHA electrical safety requirements and have established exemplary programs for their workers. Innovative measures, such as state-of-the-art preventative maintenance programs and equipment monitoring, training initiatives, coordination of common training programs, and establishing a single authority for interpretation of National Electrical Code requirements, are worthy of emulation throughout the DOE complex.

Serious problems and misconceptions were found regarding lockout/tagout systems, which are intended to protect workers from exposure to energized, hazardous electrical circuits and equipment. Various systems were found in use, with only a few providing effective protection to workers from electrical hazards. However, some sites had overlapping, multiple systems, which mixed personnel protection with administrative and operational activities. Such systems lead to confusion, loss of confidence by electrical workers, lack of efficacy, and, in some cases, have contributed to electrical incidents. A lockout/tagout system which incorporates personnel protection, as well as administrative and operational interests, can be compatible with the OSHA regulations, but only if that portion dealing with personnel protection is distinct and separate from the other uses.

Because of the lack of understanding and full implementation of the OSHA electrically safe work practices, other deficiencies exist in the field which detract from full protection of employees. There was almost a universal absence of low voltage (less than 600 volts) training, as required by the regulations. This, coupled with a complacent attitude expressed by many electricians in the field towards working on 110-volt energized circuits and a lack of appreciation for the use of personnel electrical protective equipment under these conditions, constitutes a significant gap in efforts to protect the worker from unsafe electrical conditions in the workplace.

The Task Group found a reliance on the fact that an electrical worker was a "licensed electrician" or was classified as a "journeyman electrician" or above by the local labor hall, as evidence of assurance that such individuals were "qualified" to work safely on electrical systems and circuits of almost any level of voltage and complexity. Although those individuals employed in the high-voltage power distribution and transmission line area were found to be trained in electrical safety in this area, those involved in the low-voltage (less than 600 volts) did not necessarily have such training, or the training they possessed did not comply with the requirements of the OSHA electrical safety regulations.

Principal Findings

The results of the Task Group's review, including the generic issues and the electrical safety programs at selected sites discussed in the body of the report, are underscored by the principal findings set forth below:

1. **The OSHA electrical safety regulations (29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V) have not been fully implemented, and DOE workers are not receiving the benefit of the increased electrical safety protection provided by full compliance with these regulations.** Line managers at all levels exhibited a firm commitment and interest in complying with the OSHA regulations. However, few managers had sufficient knowledge of the **content** of the regulations, and thus the requirements, to have a full appreciation of the task involved to effectively implement these performance-based regulations (which are a departure from traditional approaches to safety). The focus has been on the electrical safety programs of the past where there is enough familiarity to be comfortable in what is being implemented. When addressing 29 CFR 1910, Subpart S, the emphasis has been on Part 1, relating to physical aspects of the program, and not on Part 2, which deals with electrical safety work practices.

2. **The deteriorating or outdated electrical infrastructure of many aging facilities, which includes outdated, lost, or incomplete information, contributes to hazardous electrical working conditions.** In many cases, older facilities lack electrical drawings or vendor information necessary to establish safe work boundaries, identify energy sources, and ensure correct and timely repairs or modifications. Fires or explosions caused by or involving electrical energy have occurred across the DOE complex. These have been caused by failure to include appropriate equipment in preventive maintenance programs and aging or deteriorating equipment. Without adequate upgrade and maintenance programs, component failures will occur with increasing frequency, subjecting personnel to increasing electrical and fire risks.

3. **There is a pervasive lack of correct implementation of OSHA lockout/tagout requirements and a misunderstanding regarding consolidation of the lockout/tagout regulations, 29 CFR 1910.147, and 29 CFR 1910.333, with DOE 5480.19, Conduct of Operations Requirements for DOE Facilities.** The functions of locking out and/or tagging out systems for personnel protection while performing service and maintenance, administrative and operational purposes have been incorrectly consolidated, in some cases, in an attempt to comply with DOE 5480.19. These attempts fail to correctly apply the OSHA requirement that the specific lockout/tagout system (color, type, size of lock and tags) must be singularly identified when used for personnel protection during service and maintenance. Additionally, multiple lockout/tagout systems are in effect at several DOE sites, which detracts from worker safety and results in confusion and misapplication of the procedures.

4. **Incident reporting and followup activities fail to adequately address personnel involvement in electrical safety issues.** Review of occurrence reports and investigation reports on electrical safety incidents indicates most investigators focus on mechanical or equipment shortcomings and stop short of identifying the fundamental, management-related root cause where personnel error is involved. In addition, reporting systems, such as ORPS, have built-in artifacts which discourage or prevent true root causes for personnel error to be entered in the data base. Absence of this critical information mitigates against corrective actions which would preclude recurrence of events and information for lessons-learned programs.

5. **DOE program and field managers and resources are being driven by pre-existing safety priorities, including those related to corrective action plans for Tiger Team Assessments, other external appraisals, and the required upgrading or decommissioning of facilities.** Management attention and resources are focused on these major improvements, which has tended to divert attention from basic infrastructure issues, such as outdated or substandard electrical systems.

Recommendations

Based upon the Task Group's evaluation of the DOE's electrical safety programs during its field visits, its examination of the electrical safety-related incidents which occurred at the sites visited, and specific incidents at other sites, the Task Group offers the following recommendations to improve the electrical safety of DOE and contractor employees:

1. **DOE and contractor line management must be made more aware of prescribed OSHA requirements for electrical safety, and workers need to be more consistently trained and qualified consistent with industry standards to properly handle electrical jobs. A baseline review of such programs against the OSHA requirements is a starting point, as is a vigorous internal DOE awareness campaign, which would include workshops, guides, and expanded training opportunities.** As DOE's missions and site activities increasingly change from traditional ones (defense and nuclear) to new ones (environmental restoration and energy technology development), traditional site-specific electrical safety programs will be challenged to keep pace with state-of-the-art technologies and safety practices. DOE Headquarters Program and Field Offices are responsible for assuring that their contractors verify implementation with 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V. In collaboration with EH, DOE line programs need to pursue training, workshops and guides to properly inform management of the requirements and the impact on electrical safety programs, and to assure employees are fully qualified to carry out electrically safe work practices. EH would serve as an informational resource and expand its existing Occupational Safety and Health technical assistance program to provide greater focus on electrical safety. EH would also take the lead in developing an internal DOE awareness campaign for all levels of management.

2. **Deteriorating or outdated electrical systems at DOE's older facilities need to be given more attention from the standpoint of concerted action to replace, upgrade, mitigate, or remove from service out-of-code equipment which poses increased risks to workers.** This is an issue of particular concern for those facilities nearing the end of mission and being readied for decommissioning. Program Secretarial Offices should routinely survey and replace equipment which poses increased risk to workers. Also, adequate preventive maintenance programs should be in place to preclude catastrophic or premature failure of electrical equipment, which would jeopardize worker safety. A prioritization system is needed which balances remaining facility life with the level of hazard present to assure an appropriate allocation of resources toward correcting the most serious issues at hand. Such a prioritization scheme has been developed and proposed as the risk assessment

methodology in the draft DOE 5483.XX, Occupational Safety and Health Program for DOE Contractor Employees.

3. **Only one lockout/tagout procedure should be in place at each site. The lockout/tagout procedure must conform to the requirements of 29 CFR 1910.147 and the electrical safety requirements of 29 CFR 1910.333.** Affected employees are required to be familiar with all lockout/tagout procedures in effect in their workplace. A common lockout/tagout procedure reduces worker confusion in the workplace amongst various occupational trades, as well as for personnel who work for multiple contractors. It also facilitates training and management control over implementation of the procedure, allowing for more rapid response to any developing issues. OSHA establishes specific requirements for personnel protection during servicing and maintenance. Compatibility of these OSHA requirements with DOE 5480.19, Conduct of Operations Requirements for DOE Facilities (7-9-90), Chapter IX, Lockouts and Tagouts, can be achieved through uniquely identified locks and/or tags used for personnel protection during servicing and maintenance versus administrative or operational needs.

4. **Incident reporting and followup at DOE sites need to be improved for electrical mishaps, including near-misses and minor shocks, to assure all such indicators are evaluated and appropriate management attention is given to root causes beyond a consignment to "personnel error."** The lack of an effective lessons learned program within the DOE complex is a factor in the persistence of similar electrical shock incidents. EH should develop and DOE Field Offices should implement procedures to assure investigators examine, indepth, the root causes of personnel errors to assure that proper corrective actions are taken to preclude reoccurrence. Impediments to identification of such root causes must be overcome, whether they are due to structures of the reporting system, or a reluctance to provide an indepth examination of personnel error.

INTRODUCTION AND BACKGROUND

Establishment of the Task Group on Electrical Safety

The U.S. Department of Energy (DOE) electrical safety review was requested by the Secretary, and on October 23, 1992, the Assistant Secretary for Environment, Safety and Health (EH) was directed by the Under Secretary to establish the Task Group on Electrical Safety. (See Appendix B.) The purpose of the Task Group was to conduct an immediate review of electrical safety programs and practices across the complex that would identify measures to improve and ensure the safety of DOE and contractor personnel from electrical hazards, as well as to make recommendations addressing identified concerns. The Task Group was formed as directed and has completed its assignment as described in this report.

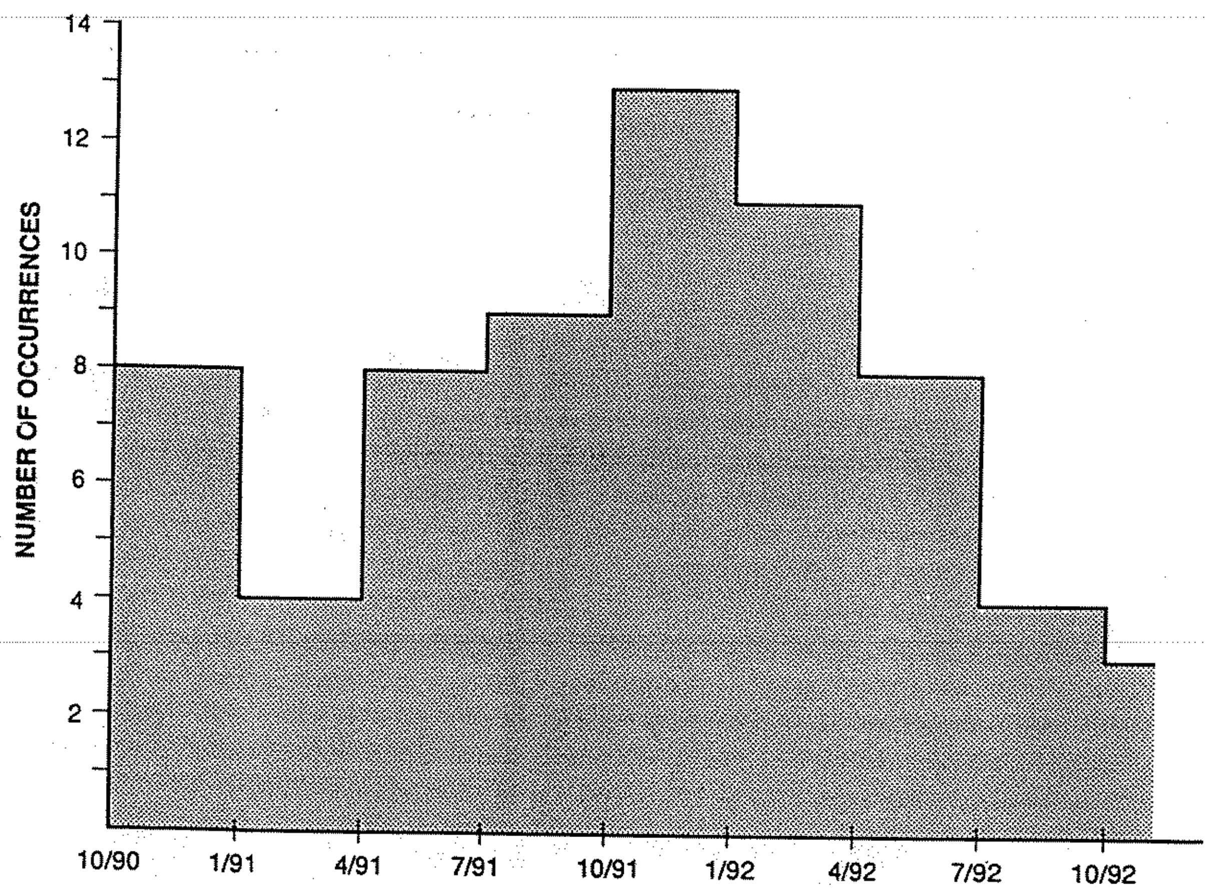
The requirement for an electrical safety program is founded on the need for a safe workplace and is based on (1) DOE Orders requiring that the Department and its contractors comply with the regulations of the Occupational Safety and Health Administration (OSHA), (2) other industry standards concerned with electrical safety, and (3) the Secretary's March 1991 Occupational Safety and Health (OSH) initiative for DOE and its contractors. Concern over the Department's electrical safety program is based on (1) recent and recurring electrical safety events that could have resulted in fatalities and (2) the results of the Tiger Team Assessment (TTA) program. More than 2,300 OSHA electrical safety finding have been documented by TTAs. Additional data from the Safety Performance Measurement System (SPMS) indicate that from January 1983 to October 1992, approximately 165 DOE or contractor personnel reported shocks or burns due to contact with electricity in the workplace. Six deaths have been directly attributable to electrical incidents, and at least 97 fires and explosions were either caused by or involved electrical energy.

The Task Group analyzed reports from the Occurrence Reporting and Processing System (ORPS) for the seven sites visited. Sixty-eight electrical safety-related occurrences have been reported since October 1990, when ORPS was instituted. Root causes were assigned as shown in the Table 1. The frequency of the electrical safety incidents on a quarterly basis during the same time period is shown in Figure 1. These data indicate that work practices and management issues are the primary root causes assigned to electrical safety incidents. OSHA regulations on electrical safety are designed to prevent incidents of this nature, since they contain requirements for both electrically safe work

TABLE 1 ROOT CAUSES INDICATED FOR ELECTRICAL SAFETY INCIDENTS AT SEVEN DOE SITES AS REPORTED TO THE OCCURRENCE REPORTING AND PROCESSING SYSTEM FROM OCTOBER 1990 THROUGH NOVEMBER 1992

PERSONNEL ERROR (28)	
Violation of requirement or procedure	13
Inattention to detail	12
Verbal communication problem	2
Not categorized	1
MANAGEMENT PROBLEM (19)	
Inadequate management control	9
Policy not adequately defined	3
Improper resource allocation	2
Work organization/planning deficiency	1
Inadequate supervision	1
Other	1
Not categorized	2
PROCEDURE PROBLEM (10)	
Defective or inadequate procedure	10
DESIGN PROBLEM (6)	
Inadequate man-machine interface	1
Inadequate or defective design	1
Error in equipment or material selection	1
Drawing, specification, or data errors	1
Not categorized	2
TRAINING DEFICIENCY (4)	
Inadequate content	2
Insufficient refresher training	1
No training provided	1
OTHER	1

FIGURE 1 QUARTERLY ANALYSIS OF ELECTRICAL SAFETY INCIDENTS AT SEVEN DOE SITES FOR THE PERIOD 1990 TO 1992



practices and safe installation and operation of electrical equipment and systems. Full compliance with OSHA 29 CFR 1910, Subpart S (Electrical), and 29 CFR 1926, Subparts K (Electrical) and V (Power, Transmission, and Distribution), should preclude their recurrence. (See Appendixes C and D.) The data also indicate that until late 1991 the incident frequency increased, and decreased thereafter. Limitations on the data include the fact that most electrical incidents are interpreted as being "off normal," with optional reporting. All electrical safety incidents are therefore not entered into the ORPS data base. The ORPS data are also truncated within the root cause category for personnel error, where preselected causes stop short of identifying any relevant cause of greater depth.

Approach to Electrical Safety Review

The Task Group was composed of a chairperson and deputy chairperson from EH and included representatives from the four Program Secretarial Offices (PSOs) that have jurisdiction over the sites visited: Defense Programs (DP), Energy Research (ER), Nuclear Energy (NE), and Environmental Restoration and Waste Management (EM). The group was supported by representatives from the Field Offices and technical experts in the areas of management and electrical safety. Two seven-person teams were formed to visit selected DOE sites. Each team consisted of a team leader (the Task Group Chairperson or Deputy), the Task Group member from the affected PSO, a representative from the cognizant Field Office, a management specialist, and three individuals highly qualified in the field of electrical safety. The Task Group was structured to promote a cooperative effort between the cognizant PSO, Field Office, and EH. A team member was assigned as a representative from each of these groups. Open daily meetings were held at each site for all team discussions and deliberations to facilitate that cooperation further.

A total of seven DOE sites were visited by the teams. The sites were: Hanford Reservation, Idaho National Engineering Laboratory, Nevada Test Site, Oak Ridge National Laboratory, Savannah River Site, Stanford Linear Accelerator Center, and the Uranium Mill Tailings Remedial Action Project Site at Grand Junction, Colorado.

The sites were selected on the basis of (1) their representation of a cross section of the DOE complex, (2) recent experience in electrical safety incidents, and (3) EH Site Representative reports indicating potential electrical safety problems. Each Field Office was provided with an advance copy of the Task Group Assessment Guide containing the Lines of Inquiry, tentative field visit schedule, in-briefing agenda, and a list of documents that the team would review. The reviews took approximately 1 week at each site. During site visits, the team (1) reviewed aspects of electrical safety program implementation; (2) interviewed (individually and during inspections) management, supervisory, and worker personnel at each site to determine their level of understanding of electrical safety; and (3) reviewed electrical safety program documents. A list of the Task Group and Field Team members is provided in Appendix A. The Lines of Inquiry are contained in the Task Group Review Guide, which is provided as Appendix E. The list of individuals interviewed is provided in Appendix F. A list of key documents reviewed is provided as Appendix G.

Contractor Self-Assessment

The October 23, 1992, memorandum from the Under Secretary (1) directed the establishment of the Task Group, (2) required DOE contractors to conduct an immediate self-assessment of the electrical safety programs and practices at their respective sites, and (3) stipulated that the results be reported to the cognizant PSO. As suggested, most contractors used the Task Group Lines of Inquiry as guidance for performing the required self-assessments. The Task Group has not had access to a sufficient number of completed contractor self-assessment reports to be able to include a meaningful analysis in this report. The Task Group expects that each PSO will (1) review the self-assessments of contractors under their cognizance, (2) characterize the status of electrical safety programs and practices, and (3) provide conclusions and recommendations, as appropriate, to resolve identified deficiencies and to enhance electrical safety performance. As a followup effort, EH should review the self-assessments to identify additional opportunities for improvement of DOE electrical safety, which would be issued as a supplemental report.

Task Group's Model Electrical Safety Program

Consistent with its Lines of Inquiry, the Task Group has prepared a description of a model electrical safety program based on experience and on regulatory and code requirements. The model is presented below.

The Task Group believes that an electrical safety program for protecting DOE and contractor workers and facilities would be founded firmly on established requirements of DOE 5480.4 and DOE 5483.1A; OSHA electrical safety regulations in 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V; the National Electrical Code (NEC); and applicable state, local, and mine and tunnel safety standards. The program would establish an electrically safe workplace, free from recognized electrical hazards for all DOE and contractor employees. Management would commit to involvement at all levels, based on familiarity with the requirements. Employees would implement effective electrical safety-related work practices, and the installation of electrical systems and equipment would meet all applicable Orders, regulations, and codes.

Management's commitment would be evidenced by consistent policy documents from the PSO level down to and through the contractor organizations, thus projecting a clear understanding of management's expectations for implementing electrical safety requirements (as a component of overall OSH requirements). Sufficient resources, including funding for abatement of electrical safety hazards, would be available and sufficient personnel qualified in electrical safety would be positioned for program implementation. A formal process for periodic self-assessment evaluations of program effectiveness, including necessary recommendations, would ensure a level of safety consistent with DOE and regulatory requirements.

Program managers would recognize that most electrical injuries and fatalities are due to inadequate electrical safety-related work practices and procedures rather than to deteriorating or substandard electrical equipment and installations. Good work practices, as required by OSHA, would be enforced. Electrical safety training would be provided based on risk. Personnel working in the building trades (e.g., electricians, equipment repair personnel, welders, laborers, painters, truck drivers, machine operators, carpenters, and construction workers) are most at risk. At DOE facilities, researchers, engineers, and line crews working near high-voltage installations in accelerators and reactors and in electrical transmission and distribution systems are also at risk. Building trades and employees in general would have a knowledge and awareness of electrical hazards and would have internalized appropriate methods of handling them.

Each site would have designated an Authority Having Jurisdiction (AHJ) for interpreting the electrical requirements of OSHA, NEC, and other standards applicable to the site or its facilities. Qualified electrical workers and all personnel engaged in electrical work (e.g., support trades) would be trained to have a knowledge and understanding of electrically safe work practices, thus avoiding electrical hazards in their work activities. Personal protective and electrical test equipment would be provided, properly maintained, and used to ensure a maximum level of worker protection. All electrical maintenance work packages would contain appropriate safety instructions and precautions for worker protection, including lockout/tagout requirements and adequate schematic diagrams.

Electrical systems and equipment would be installed and maintained to provide workers with electrically safe workplaces. A proactive, state-of-the-art, preventive maintenance and inspection program for electrical systems and equipment would be in place and staffed by qualified electricians. Operations would be conducted by personnel who are qualified on electrical systems, who are knowledgeable of energy sources, and who know the correct methods for isolating such sources in preparation for service and maintenance.

All new electrical installations would be designed and approved by electrical engineers or qualified electrical designers, and configuration control of both high- and low-voltage systems would be maintained. Electrical systems and modifications would be installed in accordance with established requirements. Electrical equipment purchases would meet code and electrical safety requirements, as determined by a nationally recognized testing laboratory or as approved by the AHJ. As indicated in Draft DOE 5483.XX, Occupational and Health Program for DOE Contractor Employees, an electrical safety committee patterned after the DOE Electrical Safety Committee would also be in place. (See Appendix H for the Charter of the DOE Electrical Safety Committee.)

GENERIC ISSUES

The formation of the Task Group on Electrical Safety at Department of Energy Facilities came in response to the Secretary's concern over "a series of recent events involving electrical shock to contractor employees at facilities across the Department of Energy (DOE) complex." The Task Group visited seven DOE sites and found that electrical safety programs are in place and provide for various levels of protection from known electrical hazards. However, these programs do not provide a level of personnel protection that can and should be achieved. These programs need to be updated and improved in a manner that will (1) provide better protection for all personnel, including those workers whose job assignments may expose them to electric shock, and (2) achieve total compliance with recent OSHA requirements stipulated in 29 CFR 1910 and 29 CFR 1926. The Task Group's reviews revealed that efforts to implement OSHA requirements are being constrained to a large degree by management's lack of knowledge of and appreciation for the requirements specified in the regulations. Recognizing the status of the current programs, the Task Group has developed specific recommendations that, when implemented, will achieve an improved electrical safety program and provide a higher level of protection for DOE and contractor employees.

The Task Group reviewed site policies and procedures, interviewed management and other facility personnel, and observed work in process at all seven sites. Generic issues were derived from the site reviews. An issue was deemed to be generic if it was found at more than one site or if it had implications for overall electrical safety. The generic issues are presented as follows:

- Management
    - Electrical Safety Performance
    - Prioritization of Electrical Safety Issues
    - Oversight of Electrical Safety Programs
    - Reporting of Electrical Safety Events
    - Condition of Electrical Infrastructure
    - Electrical Safety Program Requirements
    - EH Site Representative Program Monthly Reports

- Implementation of OSHA Requirements
  - Lockout/Tagout
  - Electrical Safety-Related Work Practices
  - Training
  - Personal Protective Equipment
- Personnel Qualifications
  - Documented Qualifications of Personnel
- Work Control
  - Formal Work Control System
- Evaluation of Incidents/Events
  - Shortcomings in ORPS
  - Incident Investigation Process
- Exemplary Practices

* * *

MANAGEMENT

The Task Group found that DOE and contractor managements are committed to electrical safety. However, management in general must cope with implementing externally imposed new programs, as well as requirements resulting from the efforts of multiple audits and reviews and from upgrading or decommissioning facilities at many sites. Within this context, sufficient knowledge and understanding of requirements necessary to achieve an effective electrical safety program that will meet existing regulatory requirements have not been achieved and therefore were not evident. Although most facilities have had incidents or events that clearly indicate both the opportunity and the need for improvement in electrical safety, the programs remain outdated.

In some instances, individual managers exercised considerable initiative to ensure that their electrical safety program provided adequate protection for their workers. These "islands of excellence" were generally found at the mid-level management positions.

With few exceptions, they were established by individual managers' initiatives and were unique at a given facility.

At all seven facilities visited by the Task Group, interviews and walkthroughs revealed a management commitment to policies, procedures, and programs to ensure adequate protection for workers. Management's commitment was demonstrated by active involvement and participation in workplace activities, including "walking the spaces" and interaction between workers and management during safety committee meetings. This commitment to implement an electrical safety program that includes adherence to the appropriate national electric codes and compliance with OSHA requirements, plus the positive attitude exhibited by site personnel, convinced the Task Group that an improved safety environment is evolving.

From its review of the seven facilities visited, the Task Group formulated several generic issues that relate to management activities: (1) electrical safety performance, (2) prioritization of electrical safety issues, (3) oversight of electrical safety programs, (4) reporting of electrical safety events, (5) conditions of electrical infrastructure, (6) electrical safety program requirements, and (7) EH Site Representative program monthly reports.

Electrical Safety Performance

Policies and procedures do not adequately reflect implementation of improved electrical safe work practices, use of protective equipment, and training in the recognition of electrical hazards -- all in accordance with OSHA requirements. Review of events and incidents associated with electrical safety indicated that many of these occurrences could have been avoided had the electrical safety programs been consistent with existing requirements.

Recent electrical incidents and events, as well as Tiger Team findings and site self-assessments, have indicated the need for improvement in electrical safety across the DOE complex. The Task Group reviewed 68 electrical safety-related occurrence reports from the seven sites visited that had been entered into the ORPS data base since October 1990. Management problems, poor work practices, and personnel errors (including some in the area of lockout/tagout) were indicated by the data. Generally, individual corrective actions focused on the consequences of specific incidents rather than correcting programmatic weaknesses. Lockout/tagout, for example, is a long-standing issue across the complex that has yet to be corrected. The Task Group found systemic problems related to lockout/tagout procedures at all sites, including cases in which (1) current lockout/tagout requirements were not included, (2) several procedures existed at a given site, and (3) a general lack of recognition of the differences existed between maintenance and service requirements on the one hand and administrative requirements for control of out-of-service equipment on the other. In general, the Task Group observed that actions taken to improve performance for electrical safety programs were ineffective or did not fully comply with current requirements.

Policies and procedures reviewed by the Task Group reflected a program that had remained essentially unchanged for several years. Although some attempts were being made to upgrade programs, the policies and procedures generally did not include the current requirements of OSHA regulations for personnel protection. These regulations have been developed from general industry experience and represent those features deemed to improve conditions for worker safety. For example, OSHA prohibits work on energized electrical circuits, except in those cases for which deenergizing is either infeasible or introduces an increased hazard. Traditional attitudes and procedures identified at the sites visited by the Task Group still condoned work on energized circuits without imposing OSHA criteria on the work to be performed. In addition, OSHA requires training for everyone whose work may involve exposure to electrical shock -- not solely for electrical workers. All workers must therefore be trained to recognize electrical hazards encountered during their specific work activities, whether electrical equipment is directly or indirectly involved.

Prioritization of Electrical Safety Issues

> ***Management is unable to prioritize personnel safety programs against audit and review findings and new program requirements. These externally imposed requirements and programmatic demands instituted to improve operations across the DOE complex effectively dominate management time. Appropriate review and responsiveness to emerging internal events are not occurring.***

Interviews with managers consistently revealed frustration, and in some cases discouragement, with the fact that they were unable to respond to their organization's needs. They stated that resources were simply inadequate to do all that needs to be done. Consequently, they prioritize their efforts to ensure compliance with externally imposed requirements. No approved methods are available to evaluate the relative merits of programmatic improvements in electrical safety versus resolution of Tiger Team findings when they cannot do both. The Task Group cannot state whether electrical safety programs would be better had these other program improvements not existed. It can say, however, that the chances for improvement are small in the current environment, unless that improvement is driven by a new set of priorities. A prioritization scheme has been developed and proposed as the risk-assessment methodology in draft DOE 5483.XX, Occupational Safety and Health Program for DOE Contractor Employees.

Oversight of Electrical Safety Programs

Oversight by both DOE and contractor organizations does not ensure that all programmatic requirements for electrical safety are met.

Interviews and reviews of documents at the facilities visited by the Task Group revealed no consistency in the responsibilities for oversight. At some facilities, electrical safety committees were assigned the oversight role; at others, it was assigned to the quality assurance organization. In either case, the Task Group found that the group or organization with responsibility usually lacked priorities, resources, and expertise to perform an assessment against current requirements.

Reporting of Electrical Safety Events

Reporting of electrical events below the threshold of DOE 5000.3A is not consistent. Some safety programs require reporting of events to management that may not be reportable under DOE 5000.3A; at other facilities, policies for such reporting are not stipulated.

Through interviews and discussions conducted at the sites visited, the Task Group learned that deviations from accepted work practices were not always brought to management's attention. For example, some employees receiving minor shocks do not report these events to their supervisors. Also, personnel finding energized circuits that should have been deenergized in preparation for work do not always report such events. Management indicated its desire that all such events be reported. However, even experienced employees were reluctant to admit to such occurrences because of concern for potential embarrassment, censure, or disciplinary action, indicating that line personnel do not fully appreciate the value of lessons-learned programs.

Condition of Electrical Infrastructure

The deteriorating electrical infrastructure of many facilities, often attributable to age, presents hazards to life and property.

Fires or explosions either caused by or involving electrical energy have occurred across the DOE complex, resulting in significant property losses. Failure to include appropriate equipment in preventive maintenance programs and aging or deteriorating equipment are among the general categories of causes found for these events. Without adequate maintenance programs, component failures will occur with increasing frequency, subjecting personnel to ever increasing risks. In addition, many older components have design features that do not and cannot meet existing code requirements, and although their replacement is not required, some present increased risks to exposed personnel. A recent serious shock event at one facility was partly attributable to a "backfeed" design that would not be acceptable under today's codes. In many cases, the older facilities do not have drawings or vendor information to provide for establishment of safe work boundaries. This lack of configuration information necessitates adequate preplanning, including such measures as walkdowns and inspections, before commencement of work.

Electrical Safety Program Requirements

Although line management responsibility for safety is clearly stated and demonstrated, DOE and contractor managements' knowledge of and appreciation for applicable regulations is insufficient to ensure full implementation of the OSHA requirements.

Interviews and reviews of documents conducted by the Task Group revealed a general lack of knowledge of and appreciation for existing requirements at all levels of management. Managers appreciate their obligation to implement OSHA regulations, but they lack sufficient knowledge of the *content* of the regulations to implement them effectively. Many managers were not aware of 29 CFR 1910 or 29 CFR 1926 or had just become informed of these regulations in preparation for the Task Group's visit. Others knew of the regulations but were unfamiliar with their content. Few recognized the impact that the regulations had on their programs. Those managers who were knowledgeable about both the content of the regulations and the commitment requirements represent "islands of excellence," having established exemplary programs for their employees.

EH Site Representative Program Monthly Reports

EH Site Representative Program monthly reports are not being acted on to correct identified programmatic deficiencies in a timely manner.

EH Site Representatives have conducted various performance assessments, including reviews of electrical safety programs for some of the facilities visited by the Task Group. These assessments identified many of the same issues found during the Task Group review, and in some cases, pointed out serious weaknesses in the safety programs. In discussing these reports with some Field Office personnel, the need for additional guidance to ensure prompt action in responding to the findings in these reports was evident. In one instance, the Task Group was told that a report had been transmitted to the site, but no information concerning corrective actions was provided by the PSO. The assessment had been conducted in April 1992, and the report was issued July 2, 1992. The Task Group was at the facility during November 1992.

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IMPLEMENTATION OF OSHA REQUIREMENTS

Implementation of the OSHA electrical safety regulations is incomplete. As a result, the DOE and contractor work force is not realizing the full benefit of an up-to-date electrical safety program. The Task Group found that electrical safety programs focused on what was appropriate and acceptable in the past and on the physical aspects of the facility, rather than on the safe work practices now required by OSHA.

The Task Group found that neither a baseline review nor implementation of 29 CFR 1910 (General Industry), Subpart S (Electrical), and 29 CFR 1926 (Construction), Subparts K (Electrical) and V (Power Transmission and Distribution) has occurred at the DOE sites visited. A baseline review of these regulations would facilitate complete implementation and thereby should reduce the level of electrical related injuries in the complex. Data from the Safety Performance Measurement System (SPMS) at the Idaho National Engineering Laboratory (INEL) indicate that approximately 165 DOE or contractor personnel reported fatalities, shocks, and burns due to contact with electricity in the work place during the period between January 1983 and October 1992. With the potential for fatalities inherent in all such incidents, and with the knowledge that not all shock occurrences are reported, these electrical statistics support the need for full implementation of OSHA's electrical regulations, especially those dealing with electrically safe work practices.

Lockout/Tagout

As evidenced by the Task Group review, there is a pervasive misunderstanding regarding OSHA's intent concerning the Lockout/Tagout regulation (29 CFR 1910.333). In particular, locks/tags designated specifically for personnel protection are widely and incorrectly used for the purpose of protecting equipment.

OSHA's lockout/tagout regulations are specifically designed to provide protection to personnel from hazardous energy sources while equipment is being serviced and maintained. The Task Group found that lockout/tagout programs were written in general accordance with DOE 5480.19, Conduct of Operations Requirements for DOE Facilities; however, not all sites reviewed incorporated the requirements of 29 CFR 1910.147 or 29 CFR 1910.333. Most of the programs attempted to conform to 29 CFR 1910.147, but they did not adequately cover exposure to electrical hazards from work on or near conductors or equipment. The lockout/tagout requirements of 29 CFR 1910.333 can be used with those of 29 CFR 1910.147 as long as the requirements of 29 CFR 1910.333 are implemented.

The concept of one lockout/tagout program incorporating the requirements of 29 CFR 1910.147, 29 CFR 1910.333, and DOE 5480.19 is the preferred method. DOE 5480.19, Chapter IX, states that the lockout/tagout program should be consistent with 29 CFR 1910. Therefore, locks/tags used for purposes other than personnel protection incorporated within the lockout/tagout program must be distinguishable from the personnel protection locks by a different color, shape, or size. The locks/tags used for personnel protection during servicing and maintenance must be singularly identified from those used for equipment protection or for administrative lockout/tagout.

Electrical Safety-Related Work Practices

Evidence exists within the DOE complex that electrical work is being performed on energized circuits that should and can be deenergized before the work commences. This widespread disregard for OSHA requirements is attributable to convenience or traditional electrical worker attitudes.

The Task Group found that electrical work is being performed on energized circuits that should have been deenergized. This poor practice is widely condoned, as evidenced by electrical workers' belief that equipment powered by 110 volts can be serviced in the energized state as safely as in the deenergized state.

The preamble to the OSHA regulations for electrical safety-related work practices emphasizes the following:

> OSHA has not accepted the argument that a qualified employee can work on energized circuits as safely as he or she can work on deenergized circuits. Therefore, OSHA is not leaving it up to the employers discretion as to whether or not to deenergize electrical circuits on the basis of convenience, custom or expediency.

29 CFR 1910.333 requires that before any work can be performed on or near exposed energized parts (50 volts or greater), the equipment must be deenergized and locked out/tagged out in accordance with approved policies and procedure -- unless deenergizing the circuits is either infeasible or increases the hazard, in which case suitable safe work practices for the conditions under which the work is being performed shall be included in the written procedures and shall be strictly enforced. These conditions may include the use of electrical personal protective equipment.

Training

> ***At the DOE sites visited, formal training programs for electrical safety-related work practices do not exist for all employees who work on or near electrical circuits and equipment that expose them to electrical hazards. This condition applies to "qualified," "unqualified," and other employees who may be exposed to electrical hazards. Existing electrical safety training does not satisfy the intent of the OSHA regulations. Thus, total comprehension and understanding of the OSHA training requirements have not been achieved.***

The Task Group found that the sites reviewed have not fully developed a formal training program for electrical safety-related work practices that incorporates all requirements of 29 CFR 1910.332.

All workplaces within the DOE complex, including the general office space occupied by administrative and secretarial personnel, are acknowledged to have some level of electrical hazard. Training in the areas of hazard recognition, appropriate work practices, and knowledge of the working environment can greatly reduce the risk of electrical accidents to employees. (See 29 CFR 1910.333.)

Whether or not an employee is considered to be "qualified" in accordance with the OSHA regulations depends on various circumstances in the workplace. In fact, an individual may be "qualified" with respect to some pieces of equipment, but "unqualified" with respect to others.

The Task Group concluded that a formal training program for electrical safety-related work practices should be developed, based on the exposure to electrical hazards in the workplace by all employees. A graded approach must be used to determine the appropriate level of electrical safety training, and the training content needs to be adapted to the nature of the work being performed, the work environment, and the qualifications of individual employees.

Personal Protective Equipment

Appropriate personal protective equipment is not always provided or used when electric work is performed on or near energized parts. As a result, employees are exposed to potential electrical shock hazards.

Activities on or near energized parts operating at 110 volts are generally considered to be low-risk work within the DOE complex, and personal protective equipment is not necessarily encouraged, used, or required. Leather gloves are used and improperly considered to be adequate protection for work on energized low-voltage circuits. The Task Group observed electrical work performed on energized sources by workers using leather gloves as personal protective equipment. OSHA requires the use of electrical protective equipment when work is performed on or near electrical circuits that operate at 50 volts or greater and that cannot be deenergized. Leather gloves have no recognized insulation quality and are not considered adequate protection for work on live electrical circuits. The appropriate insulated personal protective equipment must be provided and used when work is performed on or near any part energized at greater than 50 volts. (See 29 CFR 1910.335.)

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PERSONNEL QUALIFICATIONS

The Task Group found that personnel qualifications for employees performing work on or near any electrical system presenting a risk of electrical shock were not formally documented. The qualifications of individual employees involved in electrical work activities must be documented by management to ensure that the employee meets minimum requirements to perform the job tasks assigned to that position. For example, the Task Group is concerned that operators' knowledge of and qualifications for operating, switching, and locking/tagging electrical systems may not be sufficient. A review of position descriptions showed that qualification requirements for such activities were not stipulated.

Documented Qualifications of Personnel

Qualifications for personnel who perform work with, on, or near electrical equipment are not documented. Examples of those personnel include electricians, research and development personnel, instrument and control personnel, and operators (stationary engineers) who are required to have detailed knowledge of electrical systems and control of hazardous energy sources (lockout/tagout).

Qualification criteria must be developed and documented for each individual's specific work activities. These criteria can be developed through a task analysis of the work being performed and the environment in which it is performed. Electrical hazards that are inherent to both the task and environment must be addressed when developing the criteria for determining what training, knowledge, and experience is required to be "qualified" for that specific task.

In addition, throughout the DOE sites visited, the Task Group observed a clear lack of understanding with respect to the OSHA requirements for determining "qualified" personnel. The measurement of an employee's qualifications is not in itself the criterion for designating a person as "qualified" for specific work, as determined by OSHA. However, a measurement of an employee's qualifications is the first step in determining what additional training, knowledge, and experience is needed to identify a person as "qualified" for the specific work he or she is to perform.

All personnel working on or near electrical equipment must clearly have the basic training necessary for his or her trade. The absence of this basic training and knowledge cannot be circumvented merely by completing an electrical safety training course, thus making a person "qualified." Conversely, the extensive training received by electricians, usually in the form of an apprenticeship, does not necessarily make a person "qualified" with respect to OSHA. This concept is not well understood throughout the DOE complex.

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WORK CONTROL

Given the lack of configuration control for electrical circuits and equipment, especially in older facilities, the formalization of a work control process is particularly important if electrical work is to be accomplished safely. In order for work to be accomplished safely, job planning should include a structured process that (1) identifies potential electrical hazards, (2) requires walkdowns and/or examination of the job to ensure that configuration knowledge is current, and (3) includes a plan that remediates any identified hazards. It also ensures that the electrical system is installed in accordance with applicable codes and pertinent standards.

Formal Work Control System

> ***No formal work control systems exist to ensure the availability of adequate configuration information needed for performing potentially hazardous activities, such as work conducted on energized circuits, excavation in proximity to buried cables, and drilling through floors and walls where electrical circuits may be located.***

The Task Group found varying degrees of work control and formality at the sites visited and believes that improvements in worker safety can be achieved by implementing formal controls for potentially hazardous work. DOE 4330.4A, Maintenance Management Program, contains guidance for an acceptable work control system. The Task Group recognizes that plans have been approved to implement this Order as late as 1995. The Task Group does not recommend a requirement for earlier implementation. However, an assessment of the facilities' current programs against the Order's guidelines for subsequent improvements in the work control process would provide added assurance that the work is being properly controlled.

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EVALUATION OF INCIDENTS/EVENTS

At the seven sites visited, the Task Group reviewed electrical safety-related incidents and their investigations (1) to obtain information about the causes of incidents, their frequency, and the investigation process and (2) to gain further insight into electrical safety problems. This review was based on three sources: (1) all electrical safety-related incident reports that were included in the Occurrence Reporting and Processing System (ORPS) over the past 2 years; (2) selected reports considered during the field visits for incidents at the sites, inspection of the occurrence scene, and interviews with individuals and the supervisors involved; and (3) review of incidents, and incident reports, for those occurrences recorded just before or during the Task Group visit.

At the sites visited, statistical information obtained from a review of ORPS reports provided (1) information about the nature of electrical safety-related occurrences, (2) the categories to which they belong, and (3) the frequency with which they occurred (by calendar quarter) over the 2 years since ORPS was established. The significance of this information is discussed in the Introduction and Background section of this report.

The Task Group's three-tiered approach to incident review indicated significant shortcomings in both the process for submitting the data to ORPS and in the investigation process, as well as in ascribing "personnel error" or culpability to individuals involved in the occurrence.

Shortcomings in ORPS

The predetermined list of root causes within the Personnel Error category for "occurrence cause" is actually a list of symptoms that serves to preclude or discourage accurate identification of the actual root cause.

"Personnel error" was listed as the root cause in over 41 percent of the ORPS reports reviewed for the sites visited and as a direct or contributing cause in most of the others. Occurrence reports listing personnel errors as the root cause pertained to some of the most serious electrical safety incidents. A predetermined listing of root causes under the Personnel Error category is intended to provide a convenient screening mechanism to characterize the root cause more efficiently. However, the Task Group found the actual effect to be a flawed investigation to determine root cause. Because the listing is really composed of symptoms (e.g., inattention to detail, violation of requirement or procedure, etc.), and not root causes, the incident reports, and the individuals developing the reports, fail to identify the actual root cause. In the case of the Personnel Error category, this information is crucial to the analysis. As a result, the actual data are either lost or never developed and, hence, are unavailable for the lessons-learned process used to preclude recurrence. The Task Group further concluded that this practice led directly to difficulties in delineating the exact cause for personnel errors. Well-established basic causes for personnel errors exhibiting the symptom of "inattention to detail," which could have been subject to management control (e.g., fatigue, distraction, stress, substance abuse, poor attitude, and inadequate training/qualifications), were generally not addressed. Only two notable exceptions were found in the reports reviewed, for which a rigorous human factors analysis was performed to determine the real reason for an unsafe operator action. As a result of this deficiency in the ORPS, corrective actions for personnel errors in these reports tend to be superficial and focus primarily on symptoms.

Revision of choices for the Personnel Error category is needed to replace the current list of broad symptoms with a standard list of specific human factors known to cause personnel errors.

Incident Investigation Process

The incident investigation process used for electrical safety-related occurrences fails to address adequately the crucial area of personnel involvement. This deficiency has resulted in failure to identify true root causes and the inability to take appropriate corrective actions.

In its analysis of incidents that occurred at the sites visited, the Task Group found serious deficiencies in the treatment of personnel errors during the development of root causes for electrical safety-related occurrences. The process of determining why an individual acted as he/she did, thus causing the occurrence, is characterized by a lack of curiosity. Identification of "root causes" (clearly recognizable as symptoms) includes the following examples: (1) the individual failed to contact the supervisor, counter to instructions, before accessing the energized equipment; (2) the individual failed to observe the caution signs located on the access panel; and (3) the individual failed to heed the assistant's warning. Such responses fail to ask the question "why?" The answer to this question is essential if the investigation is to (1) identify the real root cause of the incident, (2) produce more effective corrective action, and (3) identify lessons learned to warn others and preclude recurrence. The Task Group found a definite reluctance to pursue personnel error in greater depth, especially if there was any potential that the corrective action would result in disciplinary action. A definite need exists to adjust the investigative approach and expectations regarding identification of root causes involving personnel errors. Based on the premise that all incidents are ultimately attributed to the failure of a management mechanism once the true root cause of the individual's erroneous actions is determined, the investigation should result in identifying the management mechanism that failed. To illustrate, if the root cause of a personnel error is a long-standing attitude problem on the part of that employee, then the mechanism that failed might well be traced to failure to invoke timely disqualification or dismissal procedures.

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EXEMPLARY PRACTICES

Certain practices observed during the site reviews were considered exemplary by the Task Group, as listed below. These exemplary practices are not acknowledgements of good programs or practices for meeting established electrical safety requirements, which are expected, but rather unique or optimal approaches that further enhance electrical safety performance beyond what might be anticipated from programs designed to satisfy minimum requirements. The Task Group recommends that these practices be made known to at all sites in the DOE complex. The Task Group acknowledges that not all exemplary practices from the sites visited are listed here and recognizes that other exemplary practices exist throughout the complex.

<u>Training and Qualification for High-Voltage Crews</u>

- At INEL, EG&G Idaho high-voltage crews were qualified for both high-voltage and low-voltage work as it pertains to their specific job requirements.

- At INEL, EG&G Idaho has established retraining requirements for the high-voltage crew. These criteria include training at Mesa Hot Line School at 3-year intervals. In addition, crew members are encouraged to obtain state licenses for high-voltage line work.

<u>Equipment Reliability and Monitoring</u>

- At SLAC, preventive maintenance programs have been established for major electrical components. These programs were developed based on the specific needs of the facility and are consistent with or exceed the recommendations of NFPA 70B.

- At SLAC, a formal study has been completed for electrical components to determine the need for replacement or upgrade in order to conform to current OSHA requirements.

Site Training Coordination

- SRS and NTS are multi-contractor sites. At these sites, cooperative efforts exist, through the SRS Training Integration Group and the NTS Contractors Training Council, to address joint intrasite training needs. These processes use a pragmatic approach, integrating physical and personnel resources to develop and produce training material that addresses common needs.

National Electrical Code Compliance

- Westinghouse Hanford Company (WHC) has dedicated one full-time position to interpretation of the National Electrical Code. The Task Group recognizes that this effort by WHC management expedites work processes, assures consistent electrical system compliance, and reduces frustration and confusion for both design and field personnel.

Electrical Safety Committees

- Westinghouse Savannah River Company (WSRC) has developed a Senior Electrical Review Board (SERB). This review board was created to provide a focal point for sitewide exchange of information related to industrial electrical power and control applications. The board publishes pertinent electrical information for dissemination throughout the site. Items in these publications include such things as safety problems and solutions, equipment or components problems, design considerations based on maintenance experience, and other appropriate topics.

- On their own initiative, Hanford employees established the Hanford Inter-Contractor Electrical Board to facilitate interpretation and onsite application of the National Electrical Code and its supplementing requirements. The board responds to requests from across the Hanford Site for decisions about levels of safety intended by the NEC and also serves as an arbitration board for contractors' interpretive authority on the NEC.

Employee Involvement

- At SLAC, the Plant Engineering Department, Electrical Group, developed a Job Site Safety Checklist to provide a means for the employee to perform a pre-job safety review of the work to be done.

- At INEL, communication (e.g., using techniques such as "walking the spaces") between WINCO management and employees regarding personnel safety was exceptional. Based on interviews with WINCO personnel and observations of work in progress, the Task Group found that site personnel have a strong sense of safety awareness.

- At ORNL, a Joint Labor/Management Safety Committee has been established to provide an interface between labor and management concerning safety and health issues, including electrical safety. Labor members on the committee are full-time safety representatives and bring worker recommendations and safety concerns to the committee's attention.

ELECTRICAL SAFETY PROGRAMS AT SELECTED SITES

Before conducting onsite evaluations at the selected DOE sites, several process initiatives took place. Seven DOE sites were chosen to represent a cross section of the Department's electrical safety activities. In addition, sites that had experienced recent incidents or exhibited electrical safety problems reported by EH Site Representative were considered. Lines of Inquiry were developed encompassing pertinent electrical safety issues based on sound management practices and current regulatory requirements. The Task Group was chosen from experts highly cognizant of the different issues reflected in the Lines of Inquiry, DOE Orders, OSHA regulations, and various other standards used as a baseline for the review. Before the Task Group's arrival, each individual site received the Lines of Inquiry and was encouraged to perform a self-assessment based on those Lines of Inquiry.

The Task Group conducted onsite evaluations at the seven DOE sites listed below, using a bottom-up assessment that took into consideration existing facility practices, management awareness, and facility self-assessments:

- Hanford Reservation,
- Idaho National Engineering Laboratory,
- Oak Ridge National Laboratory,
- Nevada Test Site,
- Savannah River Site,
- Stanford Linear Accelerator Center, and
- Uranium Mill Tailings Remedial Action Project (Grand Junction site).

This report highlights departures from the Task Group's model program as well as exemplary practices. The material provides a foundation for the identification of generic issues and the development of the Task Group's principal findings and recommendations which are included in the Executive Summary. In addition, the group evaluated previous occurrence reports of electrical incidents. These events provided insight into facility conditions, management practices, and conduct of operations.

Hanford Reservation

The Hanford Reservation is located immediately north of the towns of Richland, Kennewick, and Pasco, Washington, on the Columbia River. In 1943, Hanford was chosen for the Manhattan Project to produce plutonium for use in the world's first nuclear weapons. Facilities existing on the site range from those constructed during World War II to recently built modern structures. Although defense production has been a prime mission at Hanford for most of its existence, the specific nature of the mission has varied over time. Today, the focus is on activities related to site cleanup and environmental restoration; scientific and environmental research; development and application of radioactive and hazardous waste management technology; and the design, construction, and operation of major energy-related test and development facilities.

The Hanford Reservation is currently under the administration of the Department of Energy's (DOE) Richland Field Office (RL). The lead Program Secretarial Officer (PSO) is the Assistant Secretary for Environmental Restoration and Waste Management (EM-1). RL currently employs four prime contractors at Hanford: Westinghouse Hanford Company (WHC), Kaiser Engineers Hanford Company (KEH), Battelle Memorial Institute's Pacific Northwest Laboratory (PNL), and the Hanford Environmental Health Foundation (HEHF).

WHC is responsible for operations and engineering at Hanford, with Boeing Computer Services - Richland (BCSR) as a major subcontractor. WHC has the leading role in cleanup and environmental restoration activities at Hanford under the Tri-Party Agreement between the Environmental Protection Agency (EPA), the State of Washington, and DOE. Additional responsibilities include operation of the Fast Flux Test Facility (FFTF), chemical processing, defense waste management, decontamination and decommissioning of surplus reactor facilities, engineering development, and space-related testing programs. WHC also manages site support services, including security, fire protection, transportation, materials procurement and distribution, laundry, mail, printing, and facility maintenance and repair. WHC's subcontractor, BCSR, manages site information resources, automated data processing, computer systems, telecommunications, graphics, and photography.

KEH provides architect-engineer and construction services for the Reservation and all labor, materials, and management necessary for construction, maintenance, and repair activities. Support facilities include fabrication shops and nondestructive examination and weld-test laboratories. Other services include environmental monitoring, well drilling, environmental restoration, asbestos abatement, and seismic analysis. KEH also maintains a Quality Training Resource Center for DOE at Hanford and other locations.

PNL operates a multiprogram national laboratory and the research and development center for the Reservation. PNL's missions are to advance science and to facilitate the rapid development and deployment of technology. Its scientific capabilities include physical, biological, chemical, environmental, and computer sciences; whereas its engineering capabilities focus on developing technologies for waste management, environmental restoration, energy conservation, renewable and nuclear energy, and national security. Transferring technology to public and private sector users, developing and operating scientific user facilities, and contributing to science and engineering education are integral components of PNL's mission.

HEHF provides personnel health services in the fields of occupational medicine, behavioral sciences, and environmental health for DOE and its Hanford contractors. It also conducts occupational and epidemiological research for DOE.

The Task Group Field Team reviewed the electrical safety programs used by RL, WHC, and KEH, which by the nature of their functions are assumed to be representative of electrical safety programs and practices throughout the Reservation.

Electrical Safety Program Summary

Management for both WHC and KEH demonstrates a firm commitment to industrial safety programs that provide a safe work environment. KEH line management has developed an orientation program for its construction supervisors based on the requirements of 29 CFR 1926. Major lockout/tagout problems that were identified by WHC a year ago have essentially been resolved by direct management involvement.

Policies and procedures related to electrical safety are already in place. WHC has a job control system (JCS) and KEH has a job safety analysis (JSA) procedure that facilitate improvements in electrical safety through planning and work authorization. In general, configuration control is lacking, although some facilities have as-built drawings in place.

The electrical safety culture and the conduct of operations are consistent with policies and procedures. Interviews conducted by the Task Group revealed that some recently hired personnel have been slow to adjust to site safety practices, which assign priority to safety over production.

The qualifications of personnel performing electrical operations and electrical work are not well documented. Position descriptions lack definitions of responsibilities for electrical safety, knowledge of electrical systems, and lockout/tagout.

Electrical safety training is being conducted, and the WHC core course on this subject has been well received by participants. However, there are many areas related to training that need improvement.

DOE management at Hanford also demonstrates a firm commitment to an effective industrial safety program. RL provides electrical safety training for DOE employees by using the Hanford General Employee Training (HGET) Program, which is administered to all site contractor employees. In addition, graded training is required for DOE employees, depending on their level of involvement in field activities. RL is directly involved in site safety issues, including the resolution of problems associated with lockout/tagout.

Management Role

The requirements of 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V, are not fully understood by either RL or the contractors. RL provides electrical safety training for DOE employees (depending on their level of involvement in onsite field work) through the HGET Program. In the past, the results of EH Site Representative Assessments may not have been addressed in a timely manner, although serious concerns have received immediate consideration. RL recently reached agreement with the PSO to address all findings without awaiting specific guidance from the PSO. RL managers and contractors interviewed by the Task Group demonstrated a firm commitment to a strong industrial safety program that will provide a safe work environment. However, RL has not issued specific policy statements regarding electrical safety either internally or to the contractors. Both DOE and contractor personnel are aware of policy regarding compliance with OSHA requirements.

KEH construction managers have taken the initiative to review and understand the requirements of 29 CFR 1926 and have subsequently compiled an orientation manual based on those requirements. Construction managers and supervisors down through the foreman level have been trained using the new manual. Based on its observations, the Task Group recommends that this training be extended to the working level.

Policy and Procedures

Electrical safety procedures reviewed at Hanford are less than adequate. The procedures are intended to provide clarification and information to facilitate decisions related to the safe conduct of electrical work; however, they do not include all requirements stipulated in 29 CFR 1910.331-335. These procedures should be revised

(1) to establish requirements for deenergizing all electrical equipment and circuits before work is performed on or near them and (2) to include requirements for the use of personal protective equipment. Moreover, procedures for work practices dealing with low voltages are lacking.

The Task Group found evidence that application of the lockout/tagout procedure is not consistent throughout the Hanford facilities. The evidence also indicates that awareness and understanding of the lockout/tagout procedure and its applications are not uniform for all Hanford personnel. However, the new lockout/tagout procedure at Hanford, if properly administered, will meet the OSHA requirements of 29 CFR 1910.147 and 1910.333 and thereby eliminate the inconsistencies identified by the Task Group.

Electrical Safety Culture and Conduct of Operations

The transition to a modern safety culture is not complete at Hanford, as evidenced by statements from some electricians who consider themselves qualified by their trade to work energized circuits without receiving further training. On the basis of the preamble to 29 CFR 1910.331-335, which sets forth OSHA requirements for safe work practices related to electrical safety, the following statement pertains:

> OSHA has not accepted the argument that a qualified employee can work on energized circuits as safely as he or she can work on deenergized circuits. Therefore, OSHA is not leaving it to the employer's discretion as to whether or not to deenergize electric circuits on the basis of convenience, custom, or expediency.

Electricians currently receive extensive training, usually requiring an apprenticeship during the first years of work. This occupational group would require additional training pertaining to electrical work practices covered under this standard.

Work on energized circuits below 600 volts is performed using leather gloves. 29 CFR 1910.335 requires the use of electrical protective equipment; leather gloves, however, do not comply with this criteria. The Task Group found no evidence that the appropriate electrical protective equipment was being provided or used. The evidence also indicated that up-to-date schematics needed for lockout/tagout are not always available.

Electrical workers at Hanford are not receiving training required under 29 CFR 1910.332 for work practices related to electrical safety, including selection and use of equipment and safeguards for personnel protection.

Also, documentation was not available to show that personnel providing inspection, cleaning, and testing services for some electrical protective equipment have received appropriate training. Moreover, documentation of tests performed does not include information about the type and class of gloves worn, the voltage used, and any leakage detected, nor has it been signed by the person conducting the test.

In addition, the Task Group found evidence that operators are reenergizing circuits tripped by safety devices, without the benefit of counsel from a person qualified to conduct tests and inspections to verify that safe conditions have been restored, as required by 29 CFR 1910.331-335.

Post-Tiger Team Corrective Actions

Two findings identified by the Tiger Team (Concerns WS.4-1 and WS.4-5) involved electrical safety practices at WHC and KEH. These findings noted that a contractor working for the team conducted OSHA-type inspections and found noncompliances in several areas, including Subpart S. The Tiger Team identified 547 electrical noncompliances found in WHC facilities and 78 in KEH facilities.

Corrective actions related to both Tiger Team findings on electrical safety are complete. RL has verified closure of the finding ascribed to KEH and in the near future, plans to confirm completion of corrective actions taken in response to the finding ascribed to WHC.

WHC has closed 478 of the 547 OSHA electrical noncompliances. The remaining 69 are the subject of a request for interpretation in which WHC and RL disagree with the Tiger Team's interpretation of OSHA regulations. RL has not yet heard from DOE Headquarters on its request for interpretation. KEH has closed all 78 electrical noncompliances. Because of the large number (1,271) of OSHA-type violations sitewide, RL decided to effect closure on a sample basis by conducting field surveillances. These surveillances are complete, and most noncompliances were corrected within weeks of the Tiger Team Assessment. There has been no need to accelerate completion in response to repetitive events because most of the noncompliances were completed on a short-term basis.

Responsible DOE and contractor line managers are provided periodic reports on the status of Tiger Team corrective actions. The cognizant division director at RL, who must either implement a corrective action or overview contractor corrective actions, is given a monthly status report on all actions that remain open.

Requirements for closeout of corrective actions for Tiger Team findings and other corrective measures related to deficiencies were in place before the arrival of the Tiger Team. As a result of increased attention to corrective action management and a rising level of disapproval for corrective action closeout, RL and the Hanford contractors have developed more indepth expectations for closeout. RL is revising RLP 10-01, "DOE-RL Surveillance Program Procedure," to incorporate more detailed requirements for closeout. In response to requests from site personnel, interim instructions have been included in an RL letter to all contractors (letter from J.J. Keating, "Progress Assessment Team (PAT) Findings," dated July 10, 1992).

Surveillance Program

WHC and KEH provided the Task Group with evidence of a surveillance system that covered most of the key attributes for electrical requirements at facility or construction sites. WHC had conducted a line-by-line programmatic compliance assessment of key DOE safety Orders, but had not conducted similar assessments of 29 CFR and other occupational safety standards. Before the Tiger Team arrived, RL had conducted a major appraisal of electrical safety that resulted in several corrective actions by contractors. No large-scale electrical safety appraisals have since been conducted, but electrical safety as a discipline has been observed during all OSHA-type inspections and Site Representative walkthroughs. None of the surveillance programs implemented by RL, WHC, or KEH covered the full scope of 29 CFR 1910, Subpart S.

All ES&H deficiencies identified at the site are required to be tracked if the deficiency cannot be corrected immediately. RL, WHC, and KEH all provided the Task Group with evidence that tracking systems are in place to document safety deficiencies, including those related to electrical safety.

Site policy at Hanford (e.g., the self-assessment program) requires that findings be prioritized, trended, corrected, and verified as closed. The priority of a corrective action is established by using (1) the Hanford Site Priority Planning Grid and (2) the Hanford Site Graded Approach to Deficiency Tracking and Corrective Action. The Priority Planning Grid is used to assign a risk number for each deficiency. The graded approach then establishes criteria for the level of rigor required for tracking, corrective action, and closeout based on the assigned grid number. Regardless of the risk number, all findings must be tracked to closure. This system is currently being implemented across the site and shows promise as a tool for allocating resources among the thousands of deficiencies that remain open.

Programmatic changes have been implemented based on oversight findings and the frequency with which incidents occur. The development of a sitewide lock-and-tag manual provides but one example of these changes.

Neither RL nor the contractor organizations regard the level of staffing as adequate to conduct frequent oversight of the full range of electrical safety activities at Hanford. Current oversight is conducted using available staff and based on past concerns, incidents, time expired since the last oversight in the area, or guidance by management. WHC demonstrated a methodology for assigning an industrial safety hazard level to each facility in order to prioritize more than 1,000 facilities that are subject to oversight activities.

Although RL and the contractor organizations are conducting electrical safety oversight, the current level of staffing does not permit them to monitor the full range of electrical safety requirements at all levels without diverting resources from other activities. Consequently, numerous noncompliances with 29 CFR have probably not yet been identified.

Expertise/Qualifications of Electrical Safety Personnel

The qualifications of electrical workers at Hanford are not formally documented. Such documentation is necessary to help establish the minimum requirements of and training needed for electrical workers. The Task Group found no evidence of "well-defined" qualifications for electrical safety personnel.

WHC was found to employ personnel dedicated to oversight and interpretation of the National Electrical Code. One person's credentials include two certifications in NEC interpretation from the International Association of Electrical Inspectors (IAEI). This individual has 20 years of experience in the electrical construction industry, has experience as an NEC trainer for the International Brotherhood of Electrical Workers (IBEW), and serves on the DOE Electrical Safety Advisory Committee. The qualifications of another individual include several years as a high-voltage lineman. This person is assigned to the WHC High-Voltage Group.

Electrical Safety Training

Electrical safety training is being conducted at the Hanford Site. This training, however, is usually fragmented and is not under a specific electrical safety training program. In most cases, the coursework for training does not comply fully with CFR 29 1910, Subpart S. All contractors reviewed at Hanford are currently developing a more defined process to remedy this problem. Cooperative efforts between the various safety groups at the site will enhance the quality of training. An appropriate training curriculum is being developed, but it has not been effectively delivered or administered.

Not all employees at Hanford are receiving electrical safety training based on the graded approach (e.g., training for painters as required in Table S-4 of CFR 29 1910.332). A complete review of the OSHA regulations and the application of the graded approach would help remedy this problem.

All training conducted at the Hanford Site has been recorded into independent contractor and DOE data bases. Only DOE and KEH, however, have identified core training requirements for specific job descriptions. These requirements are not entirely up-to-date in the area of electrical safety. WHC has not developed a training matrix establishing core requirements and identifying particular needs for electrical safety. Doing so would allow management to identify what training must be provided. A cooperative initiative between first-line management and the training and safety organization will expedite this effort.

A line-by-line review of CFR 29 1910.331-335 indicates that coursework currently being offered does not fully comply with OSHA requirements. In most cases, however, relatively minor modification would correct this problem.

The use of "subject matter experts" at Hanford as trainers is a positive part of the training process. The fact that these individuals receive "Train-the-Trainer" courses taught at the Hanford Quality Training Resource Center adds credibility to the training effort. Good, competent trainers are employed by all site organizations, and electrical safety training is being upgraded constantly. Efforts are under way to overcome the Task Group's misgivings about the existing electrical safety training program.

The High-Risk Electrical Safety training course developed this year by WHC is extremely successful and has been well received. Its 100 participants to date have made very positive comments about the quality of and need for this course.

Electrical Safety Incidents

RL, WHC, and KEH have implemented procedures and training and possess experience in handling reportable incidents as specified in DOE 5000.3A. Policies and procedures have been developed to transmit requirements from DOE 5000.3A to facility managers and representatives. Like DOE 5000.3A, Hanford's policies and procedures are strong in the area of reporting, but their expectations for investigating incidents are weak. Investigations are occurring, and many are conducted by qualified and experienced individuals. For example, at the request of DOE Headquarters, the Task Group reviewed an event (RL--WHC-WHC200EM-1992-0068) that was investigated under a manager who is an experienced investigator for Hanford and a veteran of the Nuclear Navy. The Task Group found that the incident had been thoroughly and professionally investigated. Without well-defined requirements, however, investigations of some incidents may not be adequate.

Expectations for the conduct of investigations of nonreportable events have not been established by DOE 5000.3A or by Hanford policies and procedures. Although the Task Group found no evidence of inadequate incident investigation, the conduct of investigations is an activity that clearly affects quality. As such, it should be covered by procedure and performed by trained personnel. The use of critiques by resident or external experts for incident investigations should also be considered.

Post-Incident Response

Facility emergency procedures are in place at Hanford to provide for securing the event scene and ensuring the availability of medical assistance. The WHC electrical utilities organization provided the Task Group with a specific example of instructions containing detailed instructions to staff for recovering from electrical incidents.

Neither RL, WHC, nor KEH currently requires that critiques (noninvestigative inquiries) of events be conducted. (WHC had such a requirement at one time.) Critiques are sometimes conducted by all three organizations, but this practice is left to the discretion of cognizant line managers. Critiques in the area of electrical safety do not include input from affected personnel.

A policy is in place for conducting root cause assessments at Hanford. Consistent with DOE 5000.3A, all incidents must be followed by a root cause assessment. Incidents leading to the identification of deficiencies result in the application of the Hanford corrective action matrix, which defines the level of training required for the root cause analyzer. Specific requirements do not exist for what techniques should be used or how root cause assessments should be conducted. One- and 4-day root cause training courses are offered by the Hanford Quality Training and Resource Center. RL has frequently used award fee assessments as a means of evaluating the quality of root cause analyses conducted by contractors. The Task Group conducted a detailed review of a November 19, 1992, incident and found that WHC had identified the root cause to be inadequate training. The Task Group found it curious, however, that disciplinary action was proposed for individuals who were not adequately trained. In fairness, these findings and recommendations were contained in a draft document, and several extenuating circumstances may have led to the disciplinary action.

Generic Lessons Learned

KEH conducts an adequately detailed organization-wide trending of events. WHC trends incidents using causal codes, but this does not generally include enough detail to identify subtle problems. The trending of lockout/tagout incidents represents an exception to this observation. This particular trending effort has been highly productive in effecting a new sitewide lockout/tagout procedure. As indicated by their response to past problems (e.g., lock and tag), trends involving major deficiencies are usually identified by both WHC and KEH. RL generally trends only the information required by the Computerized Accident/Incident Reporting System (CAIRS). The Field Office has no formal trending or lessons-learned program for incidents of any kind.

At KEH, lessons learned are disseminated in a weekly staff newsletter. WHC, which is larger, is more selective about the contents of its newsletter for employees; consequently, its level of coverage is less comprehensive. WHC has been reviewing outside lessons learned from NRC and other industry sources and provides similar information to other contractors on request. RL has no formal lessons-learned program, although letters outlining lessons learned and requesting followup information are frequently sent to contractors. RL also formally distributes all Headquarters documents concerning lessons learned to contractors at Hanford.

Idaho National Engineering Laboratory

The Idaho National Engineering Laboratory (INEL) covers 890-square-miles and is located approximately 40 miles west of Idaho Falls, Idaho. It includes a complex of laboratories and offices in Idaho Falls.

INEL is a multiprogram laboratory whose primary mission includes the disciplines of reactor physics, materials, heat transfer, waste management, advanced test reactor technology, nuclear technology, materials safeguards, strategic materials, electric vehicle technology, geothermal technology, hydroelectric technology, and energy conservation technology. In addition, research, development, and testing activities (as applied to reactor safety) are conducted, including code development and verification as well as advanced concepts. Engineering and construction services and related support functions are also provided.

Five primary contractors manage specific operations at areas around the site: Argonne National Laboratory-West (ANL-W); EG&G Idaho, Inc.; Westinghouse Idaho Nuclear Company (WINCO); Westinghouse Electric Corporation; and Babcock & Wilcox Idaho, Inc. Two other contractors provide special services: Protection Technology of Idaho, Inc., provides site protection services, and Morrison Knudsen-Ferguson of Idaho Company (MK-FIC) provides construction and construction management of projects, as directed by DOE.

The management of INEL is assigned to the DOE Idaho Field Office (ID) for all activities except those at ANL-W and the Naval Reactors Facility. ANL-W is assigned to the DOE Chicago Field Office (CH). The Lead Program Secretarial Office (PSO) for INEL is the Office of Nuclear Energy (NE).

The Task Group reviewed electrical safety programs for ID, EG&G Idaho, WINCO, and MK-FIC. These organizations were selected to facilitate review of the broadest possible range of electrical safety programs at INEL. These organizations were considered to be representative of electrical safety practices and programs throughout INEL.

Electrical Safety Program Summary

Full implementation of OSHA requirements, as defined in 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V, has not yet been achieved by the electrical safety programs at INEL. Until these requirements are implemented, program deficiencies will continue to exist in safe work practices, training, and use of protective equipment. A number of external and self-assessments have identified deficiencies in such areas as electrical design and compliance with installation codes; however, corrective action plans have been implemented to minimize worker exposure to the hazards created by these deficiencies.

EG&G Idaho, WINCO, and MK-FIC are the principal site contractors at INEL. Management organizations for all three of these contractors are appropriately involved with their respective safety programs. However, complexity within the various contractor organizations and numerous interfaces between contractors have complicated the formulation of consistent and effective procedures for lockout/tagout. As a result, ID has determined the need to exercise a strong leadership role in establishing sitewide requirements for a consistent lockout/tagout system. On the other hand, both DOE and contractor management initiatives have resulted in an exemplary program (1) for high-voltage electrical work and (2) for monitoring major electrical equipment to detect deterioration that could potentially lead to catastrophic failure.

Policies and procedures related to electrical safety are in place. In general, however, they do not fully implement the OSHA requirements. Moreover, up-to-date, as-built key electrical drawings are not in place for all INEL facilities.

This has led to instances in which the wrong equipment has been locked and tagged in preparation for maintenance, which causes concern about the caution being used by personnel responsible for establishing work boundaries. The common use of electrical proximity devices in lieu of meters specifically designed for a given electrical measurement could result in (1) erroneous information regarding energized circuits, and (2) increased potential for electric shock.

All three principal INEL contractors are implementing effective surveillance practices to include both programmatic and quality checks of electrical safety measures.

With the exception of the EG&G Idaho Power Management Group, low-voltage (i.e., less than 600 volts) training is not being addressed adequately at INEL.

Documentation, investigation, and followup concerning electrical safety incidents required by DOE 5000.3A is adequate across INEL, subject to the general comments on incident investigations in the Generic Issues section of this report. Formal reporting and followup for near-miss electrical safety incidents are not routinely performed within some contractor organizations, primarily because of misunderstandings on the part of workers with regard to contractor and ID policies.

One manager at EG&G Idaho is implementing methods to reduce incidents caused by unsafe acts through the following activities:

- Enforcing rigorous root cause analysis and associated corrective actions;

- Instituting behavior modification training of workers based on lessons learned from occurrences; and

- Implementing awareness training for employees to create an environment that will (1) allow workers to point out unsafe or potentially unsafe acts without embarrassment or ill feelings and (2) ensure that policies for reporting near-misses are clearly understood and followed.

ID has been recently reorganized to provide line accountability for programs at INEL. Progress is being made toward issuance of a safety manual that will include electrical safety requirements. In addition, procedures and policies will be revised to reflect current requirements. ID management has recognized the need to provide an electrical safety program for all ID personnel, but such a program has not yet been implemented. However, ID field personnel do attend contractor training courses on electrical safety on an as-needed basis to support their activities at the various sites.

In general, ID and contractor management are fully committed to improving electrical safety at INEL and are making aggressive efforts to enhance the safety culture.

Management Role

Specific policy statements regarding electrical safety have not been issued by DOE either to contractors or within the DOE Field Office. An ID safety manual, which will include information related to electrical safety, is being drafted and is scheduled for issuance in mid-1993. Within DOE, there is a general lack of awareness about OSHA requirements for electrical safety contained in 29 CFR 1910, Subpart S. ID has not initiated enough audits or surveillances for the implementation of DOE Orders for OSHA compliance. Before the Task Force review, the ID oversight organization had not recognized the scope of these OSHA requirements, and the Field Office is now concerned that it may not have qualified personnel to conduct effective audits on electrical safety. ID has not established priorities that would determine the schedule for auditing contractor compliance with OSHA requirements.

All three contractors (WINCO, EG&G Idaho, and MK-FIC) reviewed by the Task Group have issued electrical safety requirements in the form of safety manuals. The documents reviewed, however, did not address all requirements of 29 CFR 1910, Subpart S, or 29 CFR 1926, Subparts K and V. The principal construction contractor, MK-FIC, is working directly with subcontractors to ensure that they are knowledgeable about electrical safety requirements before they begin to perform work at the site. MK-FIC has developed a Safe Work Index System to evaluate subcontractor performance. All three contractors have experienced numerous organizational changes involving an influx of new employees and reassignment of existing personnel. As a result, few audits or surveillances, if any, have been undertaken in the area of electrical safety. Most contractor organizations have tended to assume that correction of deficiencies identified by the Tiger Team would bring their activities into compliance with all relevant requirements.

Recent events indicate that worker safety may not be assured by EG&G's lockout/tagout procedures. Serious concerns were raised in December 1991 by the EH Site Representative regarding these procedures. However, EG&G has recently written a new procedure, which was in the process of being implemented at the time of this review.

Management actively participates in and supports safety programs. Senior management committees, labor management committees, proper analysis of incidents, and senior management review of occurrence reports all provide positive contributions to a modern safety culture. The Task Group found that WINCO's safety attitude was consistent across the organization, from top management down through the workplace. Use of the Safety Training Observation Program (STOP), safety observers, and committees that include representatives of labor all appear to be contributing positively to the safety culture.

Policy and Procedures

Overall, electrical safety measures at INEL are less than adequate in that they do not all fulfill the requirements of 29 CFR 1910.331-335. For example, electrical safety procedures and personal protective equipment for energized low-voltage work are deficient.

At EG&G Idaho, policies and procedures concerning electrical safety have been issued. (Some, like those for lockout/tagout, have recently been rewritten.) Their weakness, however, lies in the fact that they are not being fully implemented in the workplace. Most significantly, the Task Group noted that lockout/tagout procedures currently in place at EG&G Idaho have caused confusion. In addition, although much effort has gone into updating electrical drawings and schematics, up-to-date (as-built) drawings and schematics are still unavailable.

At WINCO, new lockout/tagout procedures are being written, but the one currently in use is not being properly or completely implemented. The current procedure does not meet the requirements for lockout/tagout stipulated in 29 CFR 1910.147 and 1910.333. This problem has been identified in several reports over the past 18 months. The Task Group found evidence that the current lockout/tagout procedure is not generally known and understood across the organization. Actual systems that have been locked and tagged show that the lockout/tagout system is being used extensively for administrative control of shutdown systems. Systems for lockout/tagout, logbooks, master control sheets, and tag numbering are in place and followed. The new lockout/tagout procedure at WINCO has the potential to meet the OSHA requirements of 29 CFR 1910.147 and 1910.333 and thereby to eliminate problems that have already been identified.

At MK-FIC, adequate policies and procedures concerning electrical safety are already in place or are being developed. Many required procedures, including lockout/tagout, are being rewritten.

More generally, the Task Group found evidence that electricians across the site are using electrical proximity devices to test circuits in lieu of using meters designed for electrical measurements. This practice could contribute to dangerous conditions, including an increased potential for electrical shock.

Electrical Safety Culture and Conduct of Operations

Implementation of DOE 5480.19, Conduct of Operations Requirements for DOE Facilities, is being accomplished at INEL on a priority basis. A clear commitment to the new safety culture is evident at all levels.

MK-FIC is characterized by a positive electrical safety attitude that is integrated into the entire program structure. For example, employees are encouraged to develop a high level of competence in their areas of specialization and are issued competence cards identifying them as resource experts in those areas (e.g., electrical safety, ladders, etc.).

WINCO employees exhibited positive attitudes toward electrical safety requirements. Accountability for electrical safety is evident throughout the work force. WINCO has been especially effective in involving workers in electrical safety surveillances. EG&G Idaho's upper and middle managers, supervisors, and workers also demonstrated excellent attitudes toward electrical safety requirements.

ID is committed to achieving full implementation of the new Conduct of Operations Order (DOE 5480.19) and the new safety culture as quickly as possible at INEL and is actively monitoring progress through various ID line management and oversight groups.

Post-Tiger Team Corrective Actions

The overall Tiger Team followup and closure process for ID and its contractors uses an effective tracking and risk-based prioritization approach for responding to electrical safety findings. The evolving Compliance Management System and associated trending efforts should ensure that future electrical safety concerns and findings, such as those generated by this review, are appropriately managed. The Task Group is concerned, however, that the validation process for "objective evidence" to support completion of milestones established in the Tiger Team Action Plan (TTAP), and subsequent closure of corrective actions, is based largely on the judgment of individual "findings managers." Guidance documents define objective evidence as "any formal document that provides information, or that records the results of a direct observation, that an activity has been completed." In order to evaluate the INEL validation and closure process for electrical safety findings, the Task Group evaluated two Category II Corrective Action Plans (CAPs): one pertaining to 29 CFR 1910, Subpart S, at EG&G Idaho and the other to 29 CFR 1926, Subpart K at MK-FIC. Neither plan has been formally closed. However, concerns were identified related to contractor closure of milestones for both CAPs. In a number of instances, the closure of milestones was based exclusively on local validation within the performing organization, which is inconsistent with the requirement for "objective evidence."

The Task Group conducted a spot check of the closure of milestones for Category III Tiger Team findings related to specific OSHA electrical deficiencies. Closures were generally based on quality assurance records or work package sign-offs, which do meet the requirement.

The DOE findings managers do not concur on closure until all milestone actions have been completed and the CAPs have been submitted to ID. Although the closure process had not been completed for the two Category II findings evaluated herein, actions to date for Category III findings suggest that the closure process by some ID findings managers may be disproportionately based on documentation provided by the performing organization rather than on observations by Site Representatives or physical inspections by the findings managers.

The milestones for closure of Tiger Team finding EG&G/WS.4-5 mandated the development of local procedures for implementation of 29 CFR 1910, Subpart S. The resultant actions were all carried out by the same "performing department," which did not arrange either for an independent review by EG&G Idaho's cognizant safety professionals responsible for the corporate electrical safety manual or for a field verification to demonstrate successful implementation of the new requirements.

Also, despite MK-FIC closure for milestones related to MK-FIC/WS.5-4 (failure to comply with 29 CFR 1926, Subpart K), training for nine construction engineers did not fully comply with Subpart K. Validation efforts focused on completion of training related to Subpart K was conducted by Environcon, Inc., which did not include requirements for company-specific implementation.

Concurrence in TTAP closures by DOE findings managers must be based on objective evidence that has been validated and that will fully satisfy the intent of the requirements.

Surveillance Program

ID, EG&G Idaho, WINCO, and MK-FIC are all clearly committed to conducting effective electrical safety surveillance programs. All have programs in place that include some level of tracking, trending, and feedback of lessons learned. The quality of these programs varied within each organization.

In many cases, assigned electrical safety surveillances were broad in scope or general in nature. The Task Group observed a common tendency to conduct electrical safety surveillances that consist of unfocused spot checks of general material conditions or of work in progress. Comprehensive monitoring of work procedures for electrical safety practices and efforts to focus on specific material requirements are not routinely included in many programs at INEL.

With some exceptions, actual training to conduct effective electrical safety surveillances is lacking. INEL personnel do not generally recognize that conducting surveillances is a learned skill that requires training and supervised practice.

In some contractor organizations, the work force has not been involved in electrical safety surveillances.

The Task Group noted several exemplary practices relative to surveillances at INEL:

- WINCO has instituted a safety observer program implemented by volunteers from the work force. The program has been well received and features training in surveillance skills as well as awards and incentives for good performance as a safety observer.

- The EG&G Idaho Power Reactors Program has retained an individual with extensive experience in surveillance programs to upgrade the quality and efficiency of the EG&G Idaho safety surveillance program.

- MK-FIC has created an impressive program for tracking and trending safety deficiencies. The program can be loaded on a standard computer terminal and uses company-generated data on safety deficiencies, plus safety inputs from a variety of other sources, to generate safety bulletins and training materials in a timely and highly efficient manner.

- EG&G Idaho has an impressive surveillance program that monitors major electrical equipment for the high-voltage power grid at INEL to prevent catastrophic failures.

Expertise/Qualifications of Electrical Safety Personnel

Personnel with responsibilities for electrical safety for all three major contractors possess the necessary expertise to meet electrical safety standards. However, on a sitewide basis, electrical workers (e.g., electricians, technicians, and welders) do not have formally documented qualifications that comply with the requirements of 29 CFR 1910.331-335.

The qualifications of personnel assigned to the EG&G Idaho Power Management Group are very good, and the people are very knowledgeable about electrical safety requirements. These personnel are tested by the company and are being certified by the State of Idaho.

WINCO's quality assurance electrical inspectors are well qualified and contribute significantly to the effort to ensure that electrical work is performed in accordance with 29 CFR 1910, Subpart S.

Electrical Safety Training

ID lacks an electrical safety training program that is administered to all employees, although Site Representatives and other staff who frequently visit INEL receive the site access training required by the contractors.

The contractor organizations schedule documented electrical safety training classes for all employees. Training records are maintained in a computer data base as well as in traditional hard-copy format.

With the exception of the EG&G Idaho Power Management Group, no adequate training for low-voltage circuits is provided for either EG&G Idaho or WINCO electrical workers, nor is adequate electrical safety training being provided for non-electrical workers.

For both EG&G Idaho and WINCO, training in the proper use of voltage proximity devices is inadequate. Many workers use these devices to check for energized circuits in lieu of using meters designed for electrical measurements.

EG&G Idaho does not have a program that incorporates all OSHA requirements into its electrical safety training courses. There is a general misconception that any requirement cited in the National Electrical Code (NFPA 70) meets OSHA requirements. The EG&G Idaho Power Management Group has implemented outstanding high-voltage training from both within EG&G and from external sources. It is particularly exemplary that outside high-voltage training has been provided by subcontractors to assist lineman in obtaining state licenses.

MK-FIC has an effective electrical safety training program that is risk-based and incorporates OSHA (29 CFR) requirements. The training identifies an electrical safety element and then relates the element to the OSHA requirement. The program defines long-range training goals and assigns training requirements to subcontractors. One subcontractor interviewed by the Task Group conducted safety meetings periodically for his workers, as validated by training records for a variety of electrical safety topics required by OSHA. The subcontractor supervisor was knowledgeable of his responsibilities related to electrical safety training for workers.

The effectiveness of sitewide lockout/tagout training is significantly degraded by the lack of a standard procedure for the site. This is especially true for EG&G Idaho, where several different systems exist. EG&G Idaho has recently completed a new standard lockout/tagout procedure that is being implemented on a high-priority basis.

Electrical Safety Incidents

The requirements of DOE 5000.3A are understood and implemented for reportable occurrences at INEL. In addition, management has made a strong commitment to ensure that adequate, formal critiques are conducted for those electrical safety incidents reportable under DOE 5000.3A and to identify and correct root causes.

The Task Group noted that one EG&G department is using the following methods to reduce the number of occurrences caused by unsafe acts:

- Planned worker behavior modification training is based on lessons learned from occurrences.

- Training sessions to encourage employees are used to create an environment that will allow workers to identify unsafe or potentially unsafe acts without embarrassment or ill feeling.

Post-Incident Response

Response by ID and contractors to electrical safety incidents reported under DOE 5000.3A is adequate. All contractors have policies intended to encourage reporting and followup of near-miss incidents reportable under DOE 5000.3A, as well as for those that may not be considered reportable. In addition, the policy of the ID managers is that aggressive reporting and followup by contractors on all safety-related incidents will not reduce Cost Plus Award Fee (CPAF) determinations and, in fact, could increase the award.

On the other hand, the Task Group found evidence of a general failure to communicate these policies on near-miss incidents to all levels of the affected organizations. The Task Group noted that workers and first-line supervisors in many contractor organizations are reluctant to file formal reports and investigate near-misses. This reluctance can usually be traced to one or more of the following factors: (1) concern about embarrassing one's self or a co-worker, (2) the perception that it is not important or necessary to report incidents in which no damage or injury occurred, (3) the belief that informal followup conducted on-the-spot is adequate, and (4) concern about disciplinary action. As a result, with some notable exceptions, formal reporting and followup for near-miss electrical safety incidents do not routinely occur in many organizations at INEL.

The Task Group identified two noteworthy good practices in the areas of near-miss reporting and followup at INEL:

- MK-FIC has established an effective awareness program that encourages employees to report near-misses. This program is based on training and education of the employees.

- One EG&G Idaho department is implementing a program to encourage employees to report and follow up on near-misses. These goals are being accomplished through the personal involvement of the department manager. As part of this effort, the program encourages employees to seek out unsafe or potentially unsafe conditions in the workplace without fear of embarrassment or ill feelings.

Generic Lessons Learned

The Laboratory Operations Department conducted a review of incidents occurring within EG&G Idaho over the past several years. An analysis of results of the review indicated that most root causes can be traced to careless unsafe acts by individuals rather that deliberate or knowing noncompliance with standards. As a result, this department has implemented (1) monthly meetings of the Safety Committee, (2) review of each incident, (3) additional root cause analysis, and (4) development of behavior modification training.

Nevada Test Site

The Nevada Test Site (NTS), located some 65 miles northwest of Las Vegas, Nevada, is currently used to conduct all U.S. nuclear weapons tests. These tests are conducted underground (either in vertical holes or horizontal tunnels) for containment of the detonation products. NTS was selected in 1950 to provide a continental proving ground for nuclear weapons testing in order to reduce the expense and logistical problems of testing in the Pacific. The site was initially operated for a few months each year by the Test Division of the DOE Albuquerque Field Office (AL). In 1962, the Nevada Field Office (NV) was created and assumed responsibility for operations and programs at NTS. Nuclear weapons testing at NTS then became a year-round effort.

To date, 697 tests have been performed at NTS, including 27 Plowshare tests designed to develop peaceful uses for nuclear explosives. Atmospheric testing was discontinued in 1958. The NTS is also used for the storage and disposal of low-level and transuranic wastes from DOE nuclear weapons laboratories and production facilities. This mission began in the 1960s, and expansion plans include the continued disposal of low-level and transuranic wastes, plus future disposal of mixed (radioactive and hazardous) wastes.

NV provides support services for the three DOE weapons design laboratories and directs all weapons testing through a senior manager appointed as Test Controller. Operations at the NTS are monitored by the DOE Nevada Test Site Office (NTSO), which is subordinate to NV. The design laboratories are Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories. NV also provides support services for the Defense Nuclear Agency (DNA) through weapons effects testing in the tunnels. The technical adequacy and readiness for these tests are the responsibility of the national laboratories and DNA, but NV is responsible for conducting all tests.

Four principal contractors provide support services at NTS:

- Reynolds Electrical & Engineering Company, Inc. (REECo), is the prime support contractor at NTS. REECo supports the NTS in construction, large diameter drilling and tunneling, food services, housing, industrial safety, medical services, purchasing, fire protection, warehousing, transportation, radiation monitoring, and engineering services.

- EG&G Energy Measurements, Inc. (EG&G/EM), provides electronics and instrumentation support to the Nuclear Weapons Development Program.

- Raytheon Services Nevada (RSN) provides architect-engineering support for NTS and provides engineering services for drilling and mining activities.

- Wackenhut Services, Inc., provides security services at NTS and other DOE facilities in the Las Vegas area.

In addition to weapon testing facilities, NTS contains the Liquified Gaseous Fuels Spill Test Facility and a repository for defense low-level wastes. The Yucca Mountain Project, a nearby characterization program for a repository for spent nuclear fuels and other high-level wastes, is administered by the DOE Office of Civilian Radioactive Waste Management (RW).

The Task Group reviewed aspects of the electrical safety programs of NV, NTSO, REECo, EG&G/EM, and RSN, which are presumed by the nature of their functions to be representative of the electrical safety programs and practices throughout NTS.

Electrical Safety Program Summary

NV and contractor management is aware of and provides support to their safety programs. The Task Group determined that a positive safety culture exists at NTS. Committees are in place to deal with safety issues and to conduct root cause analyses. Safety issues are defined for individual jobs, including those for jobs at the working level, and performance reviews for craft personnel include evaluation of employees safety records.

NV, NTSO, review and contractor management dedicates appropriate resources for correction of electrical safety deficiencies. Deficiencies are prioritized and corrective action planning is based on safety significance and near-term site operational and budgetary considerations.

NV and contractor site management have articulated their policies regarding the importance of electrical safety. Safety compliance requirements for subcontractors are included in contracts and are audited by the REECo Occupational Safety and Fire Protection group. They have also established several committees to address electrical safety issues. One committee is the REECo Labor-Management Electrical Safety Committee (Blue Ribbon Committee), which effectively fosters open discussions on electrical safety, identifies concerns, and resolves issues through an electrical safety subcommittee.

NTSO personnel also chair two electrical committees. They chair the Electrical Power Management Committee, which (1) reviews standards, (2) ensures compliance with standards, (3) performs design reviews, and (4) revises site standards. They also chair the Nevada Test Site Electrical Safety Committee, which (1) ensures that DOE and other requirements and standards are uniformly implemented, (2) prioritizes electrical safety projects, and (3) develops responses to DOE and OSHA assessment findings.

Procedures need to be improved in several areas. Preventive maintenance procedures do not always contain such essential information as vendor data, material needed, or safety requirements. Administrative procedures that implement management policies are sometimes vague and do not reflect certain elements of the electrical safety program as practiced. Finally, some REECo operating procedures, occupational safety codes, and the Electrical Safe Work Practices Manual do not adequately incorporate the electrical safety requirements of 29 CFR 1910.331-335.

The Task Group found that the Equipment Grounding Conductor Test Program (assured grounding) implemented at the Area-12 Tunnel by REECo was excellent. This program warrants special attention and provides a model that could be adopted by other DOE sites.

In both the low- and high-voltage programs, documentation has not kept pace with actual program activities. Also, work crews are sometimes sent to their job sites without work packages containing electrical design and installation information.

The efficient and reliable operation and excellent documentation of instrument calibration at NTS is noteworthy. Nearly 6,000 instruments listed in the inventory are tracked by computer and calibrated at required intervals. Many of these are electrical test instruments. Instrument users are notified of the need for calibration, and instruments are identified using bar codes. Calibration standards are traceable to primary standards. Calibration staff training is well documented to assure proficiency in calibration procedures.

NTSO performs audits of the implementation of DOE and OSHA electrical safety requirements and conducts a comprehensive "baseline" OSHA compliance assessment. The findings are then validated, weighted for safety significance, prioritized, and categorized. Finally, root causes are determined, action plans are developed, and cost estimates for the implementation of corrective actions are performed. Throughout this process, the status of corrective actions is tracked, and final closure is verified. The scope and methods used in the assessment process provide the basis for future planned electrical safety assessments. A trending program will be initiated as soon as a historical record of deficiencies has been compiled.

Contractor site management is aware of all electrical safety deficiencies identified by the Task Group and has implemented a system to track, prioritize, correct, and verify closure of deficiencies. The computer tracking system is being modified to facilitate trending of electrical safety deficiencies. Some trending has been performed manually.

A review of the NV training programs revealed a well-run operation that may warrant designation as a noteworthy practice. These programs include a "Train-the-Trainer" component, have a contractor training counsel, are actively involved in the contractor's performance award fee process, and practice good documentation and tracking of training. However, the electrical safety aspects of the training program need enhancement.

Electrical safety training conducted in association with the graded approach is not being given its appropriate level of importance by most contractors at NTS. Most contractor training organizations are currently being restructured, indicating their awareness that such electrical safety training is required. The Task Group was shown documented evidence that plans exist to secure and deliver electrical safety training. The functions of the NTS Contractors Training Council is a joint effort by all contractors and is exemplary.

All contractor training programs at NTS have adopted the intent of DOE 5480.18 regarding design and development of instructional programs. The need for trainer qualifications, validation of learning, and performance-based training are recognized principles at NTS. A training effort is needed for the crafts on reporting electrical shock incidents and near-miss incidents.

A program is in place for investigating incidents, determining lessons learned, and identifying generic electrical safety issues. A root cause analysis system is being developed, and courses are being administered to upgrade staff expertise in this area. A need exists for the introduction of electrical safety expertise into the investigation process to interpret OSHA and NEC requirements.

The requirements for investigating near-miss incidents are obscured by the lack of clarity of the occurrence reporting system. New procedures to be implemented in early 1993 will correct this deficiency. Although the existing procedures for investigation of near-miss incidents are vague, the actual process being used to investigate individual incidents was thorough and adequate. However, no sitewide program is available for trending near-miss incidents. Procedures should be updated to reflect reality.

The contractors' electrical safety oversight programs at NTS need improvement. The current oversight organizations consist of personnel experienced in OSHA compliance, although not in the area of electrical safety. This deficiency is recognized by REECo, whose management is currently attempting to recruit an electrical safety professional.

Management Role

NV, NTSO, and contractor managements have issued clear policy statements on the importance of (1) electrical safety, (2) line management and worker safety responsibilities, and (3) safety oversight responsibilities. For example, draft DOE electrical safety guidelines have recently been issued for trial use at NV facilities. In addition, electrical safety is included in general occupational safety policy statements. One NV employee is directly involved in the development of safety standards.

REECo has two separate documents dealing primarily with safety and with organization and management, respectively. The REECo Safety Manual and REECo Policy and Organization Manual specify policies applicable to occupational safety. Electrical safety requirements, the importance of safety, and safety responsibilities and accountabilities are explicitly described in the Safety Manual. The Policy and Organization Manual is much more vague, but it does mention safety as a generic job responsibility. Together, these manuals adequately describe the requisite accountability and scope of responsibility for electrical safety management and oversight.

The unique relationship between NTS management (both DOE and contractor) and NTS users has led to unacceptable electrical installations and inadequate oversight by the user organizations of their own activities. REECo constructs and maintains the facilities at NTS. However, users install their own electrical and electronic equipment for experiments. These installations are not always inspected by REECo to assure compliance with the requirements of the REECo electrical safety program. Improvement is needed in establishing effective control over user activities at the site. The Task Group believes that DOE and other user/sponsor Federal agencies (e.g., DNA) need to ensure that electrical safety requirements are being enforced.

NV, NTSO, and contractor line management actively identify, track, correct, and verify the corrections of electrical deficiencies. Deficiency trending is not currently performed. However, when implemented, planned modifications to the data-handling software will allow trending.

Contractor oversight of electrical safety needs to be clearly defined and formalized into procedures. Currently, no set of explicit criteria exists for defining the scope and level of detail of electrical safety surveillances performed by the REECo Occupational Safety and Fire Protection (OS&FP) Department. Rather, occupational safety specialists rely on their experience and knowledge of electrical safety requirements when observing work activities.

OS&FP performs surveillances of conditions and work activities on a continuing basis, but detailed audits are not performed by the contractor. REECo supervisors conduct weekly self-inspections. Management reports on the status of corrective actions are published, and resources are dedicated to correct prioritized deficiencies. The REECo Safety Code A-6 checklist used for this purpose contains a very brief electrical section. The REECo Safety Inspection Checklist for 29 CFR 1910, still undergoing review, is specific to electrical safety and will be used in conjunction with the supervisors' weekly checklist to provide sufficient detail. REECo has a system to track both self-identified and DOE-identified deficiencies, which are prioritized, corrected, and verified as closed. Trending is not performed.

NV, NTSO, and contractor managements actively participate in electrical safety programs through several committees that monitor the site electrical safety programs and through support of supervisor/craft safety meetings.

NV, NTSO, and contractor managements demonstrate support of electrical safety by prioritizing deficiencies, planning corrections, and dedicating the appropriate level of resources to correction. However, long-range planning should be provided to facilitate effective evaluation of the need for electrical system upgrades in older facilities to comply with current industry codes and standards.

Policy and Procedures

Policy level documents are generally clear and concise and incorporate appropriate DOE and OSHA electrical safety requirements. However, some administrative procedures that implement policies are vague and do not adequately describe elements of the electrical safety program as currently practiced at the NTS. For example, electrical safety oversight program procedures do not prescribe the scope and frequency of electrical safety audits currently performed by the REECo OS&FP Department. The contractor recognizes the need to improve the electrical safety of its operations. REECo OS&FP is currently attempting to recruit an electrical safety specialist, who will be responsible for upgrading oversight procedures and performing electrical safety oversight functions.

Calibration procedures incorporate all appropriate electrical safety requirements. EG&G/EM calibrates nearly 6,000 pieces of test equipment, many of which are electrical. For FY 1992, this organization maintained over 95 percent of the test instruments within calibration standards. Instruments are identified using bar codes and are tracked by computer. Detailed calibration records are maintained, and calibration personnel are well trained. Manufacturer recommendations for calibration of their equipment are followed, including appropriate electrical safety precautions. However, the Task Group is concerned about the fact that the calibration staff lacks specific electrical safety training. Training records for individuals are maintained back through high school.

NTSO stated that P-Tunnel design documents address applicable requirements stipulated in 29 CFR 1910, 29 CFR 1926, and the National Electric Code. Modifications to existing electrical systems for the P-Tunnel are in progress.

REECo has recently revised Occupational Safety Code C-12, "Electrical Safe Work Practices." This procedure addresses the work practices and protective measures that must be taken to work in the vicinity of energized and deenergized electric equipment. C-12 was revised using 29 CFR 1910.331-335 (Electrical Safety-Related Work Practices) as a guideline. However, C-12 does not meet the minimum requirements of these regulations. For example, C-12 (2) states that minimum approach distances listed in Table 1 are to be observed if deenergization is not possible. This table (S-5) was taken from 29 CFR 1910.333(c)(3) and applies to overhead lines. C-12 should be revised to reflect that these approach distances are for qualified employees working in the vicinity of energized overhead lines. 29 CFR 1910.333 requires the use of electrical protective equipment and insulated tools whenever an employee is working on or near exposed energized parts operating at 50 volts or greater. 29 CFR 1910.333 defines troubleshooting activities as energized work and thereby requires that suitable safe work practices be followed, but C-12 (2)(d) only requires the use of protective equipment when troubleshooting is performed on energized circuits in excess of 300 volts (i.e., taking voltage measurements and current readings). C-12 (6) states that "voltage testing or testing for the presence of voltage shall not be considered working on equipment"; however, contact with metering probes or tools *is* considered working on the equipment and requires appropriate protective measures. Electrical work on energized circuits is being performed without using the electrical protective equipment required by 29 CFR 1910.331-335. Although all electrical workers are issued Class O gloves (low voltage), they are not required to use the gloves when troubleshooting circuits energized at less than 300 volts.

C-12 is generic and does not contain requirements for approval to work on or near energized equipment. The Task Group determined that the procedure should be modified to include responsibilities of managers who supervise the performance of electrical work. C-12 should also contain requirements for establishing formal procedures for all "hot work," and approval of such work should be based on a process that includes a thorough analysis of the hazards of each job.

REECo Occupational Safety Code C-8, "Lock and Tagout Requirements," is also generic and does not include all pertinent requirements of 29 CFR 1910.147 and 1910.333. REECo recognizes this deficiency and is currently revising its lockout/tagout procedure.

Operating procedures for the REECo site maintenance department do not provide all necessary instructions and appropriate electrical safety requirements. Many maintenance procedures were last issued or revised in 1988 and do not contain the safety requirements of 29 CFR 1910.331-335, issued December 1991. Procedures should be updated to include the safety measures and protective equipment requirements stipulated in 29 CFR 1910.331-335 and other safety standards. These procedures should also contain the vendor data needed to perform manufacturer-recommended maintenance activities. For example, procedures should not simply state that electrical connections should be tightened; they should list the torque values recommended by the manufacture.

Procedures should also stipulate (1) safety precautions necessary to perform the job; (2) special tools, materials and equipment needed to perform the job; (3) job task instructions; (4) estimated time to perform the job; (5) appropriate references to technical manuals and vendor data; and (6) areas requiring special attention based on previous maintenance activities.

REECo's work control systems need to be enhanced. At present, documentation for planning and organizing electrical work activities is minimal, especially for high-voltage work activities. Interviews with high-voltage personnel indicated that work is usually planned by the foremen in the field, or by the linemen themselves, and that written work procedures are rarely used.

REECo recognizes this deficiency and has developed a procedure to establish an integrated work control program. The procedure will apply to all personnel and activities involved in the conduct of work, including the subcontractors who prepare and approve work packages. This procedure will provide information related to the preparation, review, and approval of work packages, as well as instructions for change requests. Once the procedure is implemented and the system is fully staffed, the work control process at REECo should be greatly enhanced.

The REECo Electrical Safe Work Practices Manual was developed to address electrical safety items that are common to both electricians and lineman. Part 2 of this manual includes safety requirements for electricians performing low-voltage work. However, the manual does not specifically address safety hazards associated with electrical work or contain information about personnel protective equipment. Part 1 of the manual covers general safety procedures for all electrical work. However, it does not meet the minimum requirements of 29 CFR 1910.331-335. For example, page 1.1.11 does not require the use of electrical protective equipment for work involving voltages below 440 volts; whereas 29 CFR 1910.333 requires electrical protective equipment to be used with voltages above 50 volts. The manual was published in 1990, before the issuance of 29 CFR 1910.331-355, and should be revised to reflect OSHA requirements concerning electrical safety-related work practices.

Electrical maintenance procedures are often incorporated into company procedures. This practice complicates procedure modification because each company procedure must be signed by the plant's General Manager, which can cause a significant delay in the modification process. Under these circumstances, inaccuracies in procedures could remain uncorrected for an excessive period of time.

Electrical Safety Culture and Conduct of Operations

NTS has responded positively to the establishment of an enhanced safety culture. NV, NTSO, and contractor managements support the concept of continual safety improvement and participate actively in electrical safety programs. In particular, management has fostered an environment in which (1) electrical safety deficiencies are identified and resources allocated for prompt remediation; (2) safety goals are established, progress is monitored, and supervisors are held accountable for meeting those goals; (3) committees have been established to identify and resolve electrical safety concerns raised by labor and management; and (4) employee performance reviews include evaluations of safety performance.

NV 11XA.1, "Organization and Functions," Chapter III, Part A, "Nevada Test Site Office," addresses line responsibilities and accountabilities, but is vague about electrical safety. Chapter IV, Part B, "Safety and Health," clearly stipulates the oversight role of NV and NTS contractors and requires the implementation of DOE programs and policies regarding electrical safety.

Several committees have been established at NTS to focus on electrical safety as it relates to design, installation, and work practices. NV, NTSO, and the contractor organizations participate actively in the deliberations of these committees.

Interviews conducted by the Task Group indicated that management (1) is aware of the importance of electrical safety, (2) is supportive of efforts to implement work practices that are consistent with safety requirements, and (3) encourages the identification and correction of deficiencies. Management is interested in continual safety improvement and is setting and monitoring safety goals.

REECo electrical workers are well informed about the safety requirements of Occupational Safety Code C-12, "Electrical Safe Work Practices," and each electrician is issued a pair of low-voltage gloves each month. However, personnel who work on or near exposed energized circuits have not received all required training. All employees whose work brings them close to exposed energized parts operating at 50 volts or greater must be trained in the safety-related work practices required by 29 CFR 1910.331-335. Employees who have not received this training are not formally "qualified" to perform "energized work."

Wiremen, electricians, and power system workers were found to have a good understanding of electrical safety and the OSHA requirements in 29 CFR 1910.331-335. However, the high-voltage program suffers from a high turnover in personnel, which DOE and contractor management attributed to noncompetitive pay scales. Opinions were expressed that this condition creates a safety problem in that adequate training in safe work practices is not assured for all site high-voltage personnel.

Personnel protective grounding methods and the use and care of personnel protective grounds are less than adequate. The Task Group observed personnel working on deenergized high-voltage lines that were not grounded. Inspections of personnel protective grounds revealed that connections were frayed, improper cable supports were used, and supporting ferrules were missing. In one instance, grounding sets were improperly stored on the back of a bucket truck, where they could easily be damaged.

All electrical safety deficiencies identified by the Task Group had already been identified during a Power Operations Evaluation performed by NV during the summer of 1992. This evaluation was conducted in the wake of two separate incidents in which booms on line trucks made contact with energized power lines. The resulting report identified numerous deficiencies, including (1) the site's inability to retain knowledgeable, trained personnel; (2) insufficient technical training on specific equipment and procedures; (3) inadequate and inaccurate procedures; (4) inadequate inspection and certification program for critical safety equipment; and (5) inadequate engineering and management support.

REECo management is very concerned about electrical safety; however, improvement is needed for electrical systems. These improvements should begin with the revision of all applicable procedures, including those for work planning and scheduling and for work package documentation. REECo has developed a draft action plan to correct these deficiencies.

Post-Tiger Team Corrective Actions

NV has tracked and assisted in prioritizing corrective actions related to Tiger Team findings. Corrective action plans for these findings have been approved, and completion of actions has been verified by NV. Contractor resources have been dedicated to the correction of deficiencies, in a manner that is consistent with both safety and resource availability. Near-term actions have been tracked and closed. Longer term actions (e.g., a clearing time study for low-voltage service circuits) have been scheduled, including milestones for completion.

NV, NTSO, and contractor oversight organizations have audited closure of post-Tiger Team electrical safety corrective actions, and management is aware of the status of post-Tiger Team electrical safety corrective actions, including all outstanding actions that must be completed before closure can be achieved.

Surveillance Program

NV 11XA.1, "Organization and Functions," establishes the scope and responsibilities relative to oversight of contractor electrical safety programs.

The REECo Policy and Organization Manual clearly establishes the scope and responsibilities of safety oversight. REECo oversight activities are conducted by employees in the OS&FP Department who are experienced in OSHA activities. Although the contractor performs some safety surveillances, the full scope of electrical safety activities is not routinely performed. Self-inspections conducted by REECo supervisors include electrical hazards. OS&FP is charged with responsibility for oversight of electrical safety but does not have specific technical procedural guidance for inspection criteria. OS&FP is currently attempting to recruit an electrical safety specialist with the capability to define and perform electrical safety surveillance. OS&FP oversight responsibilities extend to electrical work activities in the field.

NV conducts routine, scheduled appraisals of electrical safety. NTSO conducts surveillances of the implementation of electrical safety requirements, evaluates standard utility practices for applicability to the NTS, and forwards action items to REECo for implementation. NV has performed comprehensive baseline electrical audits of their facilities. Periodic audits by NV are scheduled to begin in January 1993. NTSO participates in these audits. NV also performs audit reviews of work-related conditions and activities. Identified deficiencies are tracked, prioritized, and corrected, and closure of corrective actions is verified. Deficiencies are grouped into general categories, but trending is not performed.

NV and contractor electrical safety oversight programs have all applicable DOE and OSHA requirements as their basis. Findings are documented, prioritized, and validated for closure. The findings may be analyzed to identify problem areas (a labor-intensive, manual process), but not to identify trends. Modifications to the tracking program are under way to allow computerized trending in the future.

The combination effect of NV, NTSO, and REECo oversight activities approach the appropriate level of oversight. The Task Group anticipates that the addition of a qualified and trained electrical safety specialist to REECo's OS&FP Department will enhance its capability sufficiently to enable an effective and thorough oversight effort.

Expertise/Qualifications of Electrical Safety Personnel

NV, NTSO, EG&G/EM, and REECo have approved job positions for electrical safety personnel. The positions are filled for NV, NTSO, and EG&G/EM, and the job opening at REECo is currently being advertised. The requisition for this job specifies a safety professional with electrical safety experience.

DOE personnel are well qualified by education and training, as well as by experience. They are highly visible on site and at the Nevada Field Office, and they deal with electrical safety issues on a day-to-day basis, interacting extensively with site contractors.

The EG&G/EM electrical safety engineer is based at the North Las Vegas office of EG&G/EM. This individual has well-documented expertise in this field and interacts continually with line organizations within the safety organization and with other NTS contractors. The Training Department relies on this individual to provide expertise for the electrical safety training administered at EG&G/EM. The function is well defined, well communicated to the line organizations, and well implemented by EG&G/EM.

Electrical Safety Training

Electrical safety training conducted in association with the graded approach is not being assigned an appropriate level of importance by most contractors at NTS. However, most of the training organizations are currently being restructured, indicating management's awareness that electrical safety training is required. Formal plans have been documented to implement electrical safety training.

The nature and content of compliance training varies from contractor to contractor. These inconsistencies could be resolved within the Contractors Training Council at NTS. This council provided the Task Group with its most convincing evidence that training is a priority issue at NTS and that efforts are under way to implement a quality program for electrical safety training.

For the most part, NTS personnel have not received the level of electrical safety training mandated by OSHA regulations. Identification of the need for training appears in the training matrix used by NTS contractors. Records documented by respective employers identify personnel who have received this level of training.

Training for lineman is less than adequate, and because of the high turnover rate, some management personnel expressed concern that new employees do not always receive adequate electrical safety training to perform their assigned duties. Technical training is generally conducted for management personnel, who in turn provide similar training to craftsmen under their supervision; however, such training has not reached the working level at NTS.

Training of electrical workers and support personnel at NTS is deficient in the area of NEC requirements for wiring on the low-voltage side of incoming line distribution transformers, as well as the National Electrical Safety Code requirements for the high-voltage side of transformers (work performed by linemen). The site also appears to be deficient in providing welders with the specialized electrical training required for work related to electrical, pipe-fitter, and sheet-metal crafts. Further, the site is deficient in providing OSHA electrical safety-related work practice training for other crafts, such as painters, riggers, crane operators, and laborers. Training can assist in the effort to get the electrical worker to appreciate the value of reporting all shocks and near-misses.

In response to Tiger Team findings, NV, EG&G/EM, REECo, and Wackenhut have personnel in place who are skilled in providing performance-based training. (RSN was not questioned about this issue.) At NTS, the use of this process and the graded application of the Training Accreditation Program by DOE at NTS has strengthened electrical safety training in general.

Use of the Contractors Training Council will enable the group of contractors at NTS to allocate resources effectively for training in all personnel programs. This system is unquestionably a noteworthy practice, and the concept should be considered for application throughout the DOE complex.

Electrical Safety Incidents

REECo has established a program to investigate electrical safety incidents. This program is implemented by the Labor-Management Electrical Safety Committee, which was chartered in March 1992. This committee is a subcommittee of the Blue Ribbon Safety Committee and, as the name implies, deals specifically with electrical problems. The committee is composed of representatives from the crafts and from the safety, management, and engineering organizations. The charter defines the conduct of meetings, management and committee responsibility, and methods for resolving issues. The establishment of this committee reflected a commitment by management to establish a safe workplace and may serve as a model for other DOE facilities across the complex.

REECo personnel are now being trained in root cause analytical techniques, as governed by REECo Procedure No. 1.11.14. A program that actually performs root cause analysis has not been implemented, but as soon as more personnel have been trained, REECo will be in a position to execute a root cause analysis program and actively identify causes, prepare effective dispositions, and verify that corrective actions have been taken.

REECo has established an effective electrical safety program that has successfully held electrical incidents to a minimum. Once the root cause analysis program has been fully implemented, the number of electrical incidents can be expected to decrease and the root causes of incidents will be more effectively identified and corrected. Until personnel are properly trained, however, this program will not be fully implemented.

The REECo program for identifying, investigating, and documenting near-miss incidents, including those relative to electrical safety, is described in Occupational Safety Code A-10, "Occurrence Reporting," of the REECo Safety Manual. Occupational Safety Code A-10 indicates that all REECo employees are responsible for immediately reporting near-miss incidents to their supervisors, and it further states that the supervisor shall evaluate occurrences, initiate corrective actions as necessary, and assure that occurrences are promptly reported to the OS&FP Department and documented. However, near-miss incidents are not defined. In its current form, Occupational Safety Code A-10 is relatively weak with respect to establishing the importance to safety of evaluating near-miss incidents. A-10 is in the process of being revised to emphasize the importance of reporting near-miss incidents. OS&FP anticipates approval of the revision for incorporation in the REECo Safety Manual in early 1993.

Despite the lack of clear guidance, the OS&FP review process for individual near-miss events is appropriate and thorough, and it far exceeds what would be expected based on Internal Procedure 2.1.9, which governs the review of near-misses. A comprehensive analysis of near-misses currently does not exist to identify trends or patterns indicative of problem areas that warrant increased management attention or corrective actions across the site. OS&FP personnel recognize the benefits of a program that extends beyond individual departments and indicated that one of their initiatives for FY 1993 (as stated, to "improve lessons learned through analysis of injuries/illnesses/occurrence reports/near-misses") is to implement a sitewide trending program.

REECo personnel interviewed by the Task Group expressed the opinion that near-miss events that do not involve property damage or injury are likely to go unreported. This is particularly true where carelessness, shortcuts to established practices or procedures, or other human errors are involved and might lead to fixing blame. Discussions with craft personnel and supervisors indicated that, in the past, negative feedback has resulted from reporting near-misses and that near-miss incidents involving electric shock have not been reported uniformly.

Post-Incident Response

REECo has an effective program implemented by the Electrical Safety Committee for responding to electrical incidents. The committee is composed of electrical craft workers, engineers, safety professionals, and management and is structured to react to a broad spectrum of situations. During an incident, this committee should have the capability to resolve complex issues in areas such as medical response, facility restoration, and procurement of equipment needed to return the facility to a safe condition.

Once root cause analysis training has been completed, root causes for electrical incidents should be readily identified. The Electrical Safety Committee will conduct most, if not all, post-incident response critiques, working in conjunction with personnel involved in an electrical incident.

The Electrical Safety Committee has a program in place to investigate and critique electrical safety incidents. The site also has safety professionals at its disposal to conduct preliminary investigations, as well as OSHA compliance officers to provide support in any electrical incident investigation. However, there is general concern about the lack of expertise in NFPA 70 (National Electrical Code) and ANSI C2 (National Electrical Safety Code) at NTS.

At present, an electrical safety expert is not available to serve as an expert on code requirements. Electrical safety and code compliance would be well served if a facility had an Authority Having Jurisdiction (AHJ), as defined in NFPA 70, available to provide code interpretations from NFPA 70, ANSI-C2, 29 CFR 1910, and 29 CFR 1926.

Generic Lessons Learned

NV and REECo have identified four generic lessons learned from their operations. First, multiple lockout/tagout programs are in effect at the site (between low-voltage and high-voltage personnel, as well as between construction and maintenance personnel). Also, lockout/tagout programs do not fully meet OSHA requirements.

Second, near-miss reporting and trending for electrical and other activities related to worker safety do not occur. Although occurrences are reported under DOE 5000.3A, no special categorization is available within the ORPS system for electrical occurrences, making trending difficult. NTS near-misses are handled under a wholly separate system that has not recently been emphasized by management. The rigid formality (and bulk) of ORPS makes it unacceptable for near-miss reporting.

Third, electrical training is not receiving the appropriate level of emphasis within the "graded approach." This is true for OSHA-required training as well as for training related to specialized electrical tasks (e.g., breaker maintenance, differential/control circuits, etc.). At NTS, the high turnover of personnel specializing in high-voltage work hampers the ability to maintain an adequately trained electrical work force. This high turnover makes specialized training and qualification essential.

Finally, work packages for maintenance activities, including job hazard analyses and identification of safety and environmental concerns, are not generally being provided as required by DOE 4330.4A. This problem is being actively pursued in conjunction with other implementation issues related to DOE 4330.4A, but the Task Group recognizes that full compliance may not occur for several years.

Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL), located in Oak Ridge, Tennessee, is managed by Martin Marietta Energy Systems, Inc. (MMES), for the DOE. From its origin as a weapons research and development (R&D) laboratory and radiochemical processing facility during the Manhattan Project, ORNL has evolved into DOE's largest nondefense, multiprogram R&D laboratory and is operated under the cognizance of the Director of the Office of Energy Research (ER-1). Its activities now span a broad spectrum of energy-related scientific fields, including R&D in the environmental, physical, and life sciences. The DOE Oak Ridge Field Office (OR) provides contracting authority over ORNL.

ORNL and the Oak Ridge complex present unique ES&H challenges. The site includes a broad range of medium- and high-hazard facilities, reactors, high-energy physics devices, fusion research machines, and chemical and radiological processing facilities. ORNL derives support from almost all DOE Program Secretarial Offices and about 150 external customers. It accommodates a resident staff of about 5,000, plus a guest population of approximately 2,000 from universities, industry, Federal agencies, and foreign institutions. The site contains areas with extensive radiological and chemical contamination, as well as several decommissioned facilities and waste sites.

The Task Group reviewed electrical safety programs operated by OR, MMES, and MK-Ferguson at ORNL.

Electrical Safety Program Summary

Implementation of OSHA requirements, as defined in 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V, has not yet been achieved by the electrical safety program at Oak Ridge National Laboratory. Until these requirements are implemented, program deficiencies will continue to exist in such areas as safe work practices, training, and use of protective equipment. A number of assessments have identified deficiencies related to electrical design and installation code compliance; however, corrective action plans already in place will minimize worker exposure to these hazards.

Management is actively involved in the electrical safety program at ORNL, especially in the Plant and Equipment Division. Management and staff alike have an acute awareness of the absence of as-built configuration management for some facilities and the hazards inherent in older equipment. Consequently, ORNL personnel exercise considerable caution when performing work around these facilities and their equipment.

Policies and procedures related to electrical safety are in place. In general, however, they are out-of-date and sometimes conflict with OSHA requirements (e.g., high-voltage glove testing; see IS-5.1 1986 Electrical Safety Guide). Work control and planning consistent with DOE 4330.4A, Maintenance Management Program, are needed for electrical work. However, the Maintenance Implementation Plan (MIP) submitted to DOE indicates that immediate implementation is not planned.

The electrical safety culture and conduct of operations at ORNL are based on existing policies and procedures. The lockout/tagout procedure protects workers adequately, but it needs to address the specific requirements of 29 CFR 1910, Subpart S. High-voltage electrical work is conducted by well-trained personnel, using electrical drawings that reflect as-built configuration.

Surveillance programs are in place to identify electrical deficiencies at ORNL. Improvements are needed in the oversight of safe work practices, training, and use of protective equipment.

Management and line personnel are trained and well qualified in the skills required for electrical work. Routine safety meetings and management involvement encourage a positive safety attitude. However, additional training is needed to implement OSHA requirements fully.

Electrical safety incidents are reported through the occurrence reporting system. Potentially unsafe conditions or concerns expressed by electrical workers in the Plant and Equipment Division can be reported via several channels, including a peer reporting system.

In the view of the Task Group, it would be beneficial if the DOE Site Office would increase its oversight of and involvement in the ORNL electrical safety program. Resources have recently been added to provide electrical oversight, but the emphasis is on code compliance. Personnel safety through implementation of work practices, training, and use of protective equipment receives less attention. An electrical safety program is not yet in place for DOE personnel.

Management Role

Laboratory management is actively involved in the safety program. A definite progression of workplace involvement exists from top management down. The Laboratory Director participates in random site visits and bimonthly luncheon meetings with employees. The Deputy Director is responsible for chairing the weekly meetings of the ES&H coordination committee, which are attended by Associate Directors, Division Directors, and other managers. The Deputy Director's technical assistant devotes considerable time to developing the agenda for and attending these meetings. Reports related to DOE 5000.3A requirements are reviewed by management on a daily basis.

ORNL management has developed a realistic awareness of the work environment at the Laboratory. Observation training for senior managers has effectively sensitized them to the safety culture. Although not all OSHA requirements have been implemented, management has provided an electrical safety program that (1) addresses hazardous electrical conditions, (2) provides training for electrical workers, and (3) establishes procedures for the conduct of electrical work. Although no serious deficiencies were identified during this review, improvements are needed in a number of areas.

ORNL policy statements on electrical safety do not adequately emphasize safety programs. IS-S.1, "Electrical Safety Guidelines," was last revised in 1986. No other policy or implementing documents have been issued that fully address the requirements 29 CFR 1910, Subpart S. Oversight of the electrical safety program has been delegated to the Electrical Safety Review Committee. To date, reviews have focused on the material condition of Laboratory facilities. To be effective, the committee charter and its activities should be expanded to accomplish the following:

- Develop specific criteria to review safe work practices, training, and code requirements;
- Conduct program reviews; and
- Consider representation by DOE and crafts personnel.

ORNL has established an OSHA compliance data base to prioritize and track electrical deficiencies. According to MMES, the closure of approximately 9,000 electrical deficiencies has been limited by resource availability. Managers participate in existing safety programs and frequently "walk the spaces."

The Plant and Equipment Division electricians participate in safety-oriented committees that freely communicate concerns and opinions to management either through personal interaction or through other bargaining-unit employees. Managers expressed concern that their resources are limited to the extent that such activities as updating the safety manuals, training instrument and control personnel, and dispositioning deficiencies are not aggressively pursued.

The Task Group is somewhat concerned about whether contractor oversight responsibilities are fully and consistently met. Because oversight activities are a recent addition to the MMES contract, field implementation of these responsibilities is still at an early stage.

Mid-level managers are becoming increasingly familiar with the work spaces under their cognizance. Awareness of conditions, including deficiencies, is obviously a result of walkthroughs, joint labor meetings addressing safety issues, participation in incident reviews, and involvement in the safety committee. Responsibility for electrical safety is focused at lower management levels and encompasses operations, maintenance, and construction related to safety. Assignment of a technical representative to serve as ORNL's NEC Authority Having Jurisdiction also supplements this area of responsibility.

The Task Group noted that safety issues are rarely, if ever, raised from the employee level to that of top management. This is a result of middle management's responsiveness to employee concerns. The 1992 Communications Survey conducted by ORNL reflected that a high percentage of employees are aware of job hazards (86 percent) and believe that safety concerns can be raised to their immediate supervisors without fear of retribution (88 percent).

With respect to electrical safety, MMES has a program in place to inspect a fixed number of electrical jobs each month in order to verify that work is performed in compliance with NFPA 70. A standard should be developed to describe how the program will be implemented, what percentage of the work will be inspected, the qualifications and training of inspectors, and so forth. This program has the potential to serve as a model for other components of the DOE complex.

DOE line management has established an organizational structure and an onsite presence at the ORNL plant to enhance the DOE/contractor relationship and DOE's management oversight. The ORNL Site Office has been assigned organizational and specific assignment responsibilities related to safety and facility surveillance. Top management of the DOE Program Office meets regularly with top ORNL management, and the Department's "safety- first" philosophy has been communicated during these meetings and through the award fee process. DOE's site managers have committed to conduct weekly walkthroughs of the Laboratory facilities.

The Site Office was established approximately 3 years ago. Since that time, DOE site management has not issued specific policy statements regarding electrical safety to either the contractor or to DOE employees. Specific audits of the implementation of DOE and OSHA electrical safety requirements related to specific facilities, safe work practices, and training have not been conducted, nor is a schedule in evidence indicating that such audits are to be performed in the near future. There is some question as to whether DOE site personnel are sufficiently qualified to carry out all electrical safety oversight functions.

Despite limitations on funding and staff resources, representatives of the Site Office should be more involved in ORNL's electrical safety and training programs and should spend more time in the workplace. In addition, the Site Office should establish safety training requirements for workers exposed to electrical hazards. The Task Group was concerned that the facility representatives did not have written guidance for criteria concerning facility surveillances, closeout of findings, training requirements, and so forth. The Site Office recognized this shortcoming and has prepared a draft guidance document, reviewed by the Task Group, intended to correct this situation.

DOE management has been aware of electrical safety deficiencies identified by MMES and the Tiger Team. The DOE Office has yet to develop formal criteria for the closeout of Tiger Team findings, and the contractor's tracking system is used to determine the status of identified deficiencies. Closure is based on an ad hoc review of contractor activities. The Task Group found no documented evidence of Site Office involvement in electrical safety program activities either at the contractor level or within its own organization. Formal procedures are not used by DOE facility representatives for appraisals and surveillances.

The Task Group was also concerned about the fact that 25 DOE facility representatives are responsible for approximately 600 facilities at ORNL. Because each representative has numerous assignments, as well as other job responsibilities, site management has used a graded approach to ensure that facility surveillances are conducted at facilities determined to have a high priority, based on the essential nature of facility activities. Additional resources have been requested.

In addition to routine surveillances conducted by facility representatives, the Site Office uses support from the DOE safety and health organization, EH Site Representatives, Nuclear Facility Safety Representatives, and other technical reviews to facilitate identification of safety issues. Written guidance for facility representatives, training, field surveillances, and OSHA closeouts is currently under development.

Policy and Procedures

ORNL needs to incorporate fully the requirements of 29 CFR Part 1910, Subpart S, into its procedures and safety manual and otherwise bring these documents up-to-date. ORNL safety procedures incorporate most DOE and OSHA requirements. For example, the procedure governing lockout/tagout of electrical equipment requires additional review and explanation. At present, the contractor has one lockout/tagout procedure (IS-8.1, "Lockout/Tagout of Hazardous Energy Sources") to serve all energy systems. 29 CFR 1910.333(b)(2), Lockout and Tagging, specifically requires a procedure for electrical systems. Development of an energy system-specific lockout/tagout procedure for electrical equipment should resolve this issue.

Operations procedures in place at ORNL include requirements related to electrical safety. Supervisors are responsible for providing individual workers with direction concerning safety, even when these workers have received training, are journeyman electricians or apprentices, and are aware of electrical work hazards.

Configuration management for low-voltage (50-600 volts) distribution systems does not exist. As a result, an effective lockout/tagout procedure and appropriate protective equipment are needed to protect against possible dual feeds and electrical sneak circuits. The high-voltage distribution system at ORNL is adequately configured.

The Task Group did not have an opportunity to review maintenance procedures because work activities are assigned by the supervisor. Once work packages are documented by the shop planner, safety procedures will need to be incorporated into each individual work package.

The Task Group reviewed a calibration procedure associated with testing high-voltage rubber gloves used by electrical line workers. The review indicated that calibration was being performed consciously; however, the test itself was conducted in a manner that was in conflict with ASTM 496.

Moreover, interpretations and innovations had been implemented that were counterproductive to safety. For example, Class 2 gloves were tested at 15,000 volts for use at a voltage of 13,500 AC; ASTM requires that Class 2 gloves be tested at a voltage of 20,000 AC.

The locally produced unit used to test high-voltage protective equipment and hot-line tools is not listed or approved. The Task Group could find no fault with the testing unit but recognizes that the system should be reviewed, approved, and documented within the ORNL procedure system.

Plant and Equipment Division Procedure E-2.3, "Electrical Safety Standards," excludes "troubleshooting" on energized circuits from its "hot work" rules. 29 CFR 1910.333 allows troubleshooting on energized circuits only if protective equipment is used and the requirements set forth in 29 CFR 1910.333(c) and 1910.335 are enforced.

The responsibility of the construction contractor and subcontractor for the electrical safety program seems to be well defined. The subcontractor/prime contractor relationship is clearly defined in a written procedure. The procedures have not been implemented and will need to be reviewed once the contractor begins training subcontractor personnel.

More positively, the Industrial Safety Department's review of modifications and projects provides input to design procedures for worker safety. The program to inspect eight electrical jobs per month should also be encouraged, although its activities should be formalized.

Electrical Safety Culture and Conduct of Operations

The electrical safety culture and conduct of operations at ORNL are based on existing policies and procedures. The lockout/tagout procedure protects workers adequately, but it needs to address the specific requirements of 29 CFR 1910, Subpart S. High-voltage electrical work is conducted by well-trained personnel.

ORNL has established an effective electrical safety program, particularly for high-voltage work (600 volts and above). However, activities conducted on energized low-voltage systems are considered to be low-risk work. The rules for conducting low-voltage work at ORNL are less than adequate.

Oversight of electrical work is the responsibility of the electrical crew supervisor. Tasks are planned by the electrical workforce supervisor, with scheduling and materials ordered by the shop planner and estimator. This system seems to work well, and supervisors were found to have adequate control over the work being performed.

The Task Group noted a deficiency involving the lack of direct input from electrical workers to the Electrical Safety Committee. The committee is composed of representatives from the safety, engineering, and operations organizations and has proven to be an effective means for addressing electrical safety issues. The participation of electrical workers would provide the committee with the insights of individuals who work with these issues on a daily basis. That is, participation by electrical workers would provide the Electrical Safety Committee with a worker perspective, adding another dimension to the committee's scope. Members of the electrical work force voice their concerns through interface with supervisors, participation in union activities, and access to higher management. The Electrical Safety Committee concept can be an effective means to control a safety program and is a practice that could be emulated by other

DOE facilities. The breadth of the committee could be enhanced through inclusion of DOE and craft representation.

Electrical craft supervisors at ORNL are committed to providing a safe work environment for all electrical workers. Safety meetings are conducted each Monday morning, and topics discussed are often related to electrical safety and lessons learned. However, the Task Group found no evidence that the ORNL safety organization provides oversight of the electrical safety program. Such oversight would ensure that all applicable regulations are incorporated into procedures and appropriately implemented. Whenever personnel work on or near an energized circuit, the potential exists for accidental contact with energized parts. Other hazards include misapplication of testing equipment, faulty testing equipment, faulty insulation, and loose terminals. 29 CFR 1910.331-335, Electrical Safety-Related Work Practices, addresses work procedures and protective equipment required to protect employees working on or near exposed parts of energized and deenergized electric equipment. ORNL has not fully implemented these requirements into its procedures, and some electricians interviewed were not aware of safety requirements prescribed by 29 CFR 1910.331-335. (Required training for 29 CFR 1910.332 describes these criteria.) Electrical protective equipment that complies with 29 CFR 1910.335 is not being provided for low-voltage technicians. 29 CFR 1910.331-335 became effective on December 4, 1990, and requires that suitable safe work practices be followed when work is performed on or near exposed energized parts. (See CFR 1910.333(c) and 1910.335.)

Plant and Equipment Division Procedure E-2.3, "Electrical Safety Standard," provides guidelines for the safe conduct of electrical work at ORNL. The latest revision of this procedure is dated November 10, 1992, based on 29 CFR 1910.331-335 and other guidance. E-2.3 contains requirements for working on energized equipment, but it does not require that these rules apply to troubleshooting on energized systems. 29 CFR 1910.333 specifies that all electrical parts and equipment with the potential to result in electrical shock or burns to personnel must be deenergized during the conduct of work in the vicinity of that equipment.

29 CFR 19190.333 allows troubleshooting on energized circuits only if the work rules and protective equipment specified in 29 CFR 1910.333(c) and 1910.335 are enforced. During interviews with management and craft personnel, the Task Group found the widespread view that leather gloves are acceptable for low-voltage work. Other reasons for not providing protective equipment include the cost of purchasing the equipment and the requirement for periodic testing. Throughout general industry, many incidents involving electric shock and burns have occurred while work was performed on or near electrical circuits that were known to be energized.

Because ORNL does not classify troubleshooting as energized work, electrical workers are not provided with appropriate personal protective equipment for troubleshooting energized equipment. E-2.3 requires that gloves be used while performing hot work. Leather gloves do not have any recognized insulating value and should not be considered adequate protective equipment for working on energized circuits.

Inspections of the temporary grounding sets used on deenergized electric power lines and equipment indicated that these sets were built using "hot-line taps." These taps are intended for use on high-voltage lines and are not approved for use on temporary grounding systems. Hot-line taps are not designed to withstand the fault current that would be imposed on the clamp if the system were to become inadvertently energized. Cable terminations were also lacking the required cable supports or cable supporting ferrule to prevent damage to the grounding cable at the point where the cable attaches to the clamp. These temporary grounding sets do not meet the requirements of ASTM F 855 and may not withstand the fault current should the circuit become energized.

Post-Tiger Team Corrective Actions

In general, the Task Group found that the corrective action plan for Tiger Team findings was acceptable. All corrective actions related to Tiger Team findings have been tracked, trended, and prioritized. ORNL's tracking system is not fully developed. At present, ORNL does not audit closure of corrective actions; however, efforts are under way to facilitate this function. ORNL's Quality Assurance Office verified completion for 9 of 11 corrective action items related to one Tiger Team finding (Concern WS.4-4). Completion of the remaining two items is not due until later. All six corrective action items under another Tiger Team finding (Concern RP.3-3) have been verified by the Quality Assurance Office; however, some were overdue by as much as 8 months.

Post-Tiger Team corrective actions related to electrical safety have been completed or are scheduled for completion within a timeframe commensurate with the potential hazard level. Because no repetitive events have occurred since the Tiger Team Assessment was conducted, an accelerated completion schedule has not been followed.

DOE and contractor management are aware of the status of post-Tiger Team corrective actions related to electrical safety. ORNL provides the ORNL Site Office with pictures of the physical condition of the work site before and after the corrective action is completed, along with other appropriate documents. The Site Office verifies closure of a finding only after all corrective actions associated with that finding are complete.

Surveillance Program

ORNL has a surveillance program in place to perform periodic inspections of its own work. The most recent surveillance of the full range of electrical safety activities at the Laboratory was performed in 1990, in advance of the Tiger Team Assessment. Surveillance of lockout/tagout procedures is scheduled for the third quarter of FY 1993. Surveillance findings are being placed into a tracking system.

Technical nonconformances identified in high-priority buildings were corrected by ORNL as of February 4, 1992. Other corrections are currently under way. The inspection procedure consists of selecting eight projects per month to be inspected by an electrical engineer. The Task Group observed that the system works well; however, the contractor should document the qualifications of the inspector (especially in the area of training) and the procedures used to conduct inspections. Training plans should be documented and should meet all requirements set forth in 29 CFR 1910.332. At a minimum, inspectors should also be knowledgeable of NFPA 70 (NEC) and ANSI C2 (National Electrical Safety Code). Qualifications for inspectors should be accredited by an outside organization (e.g., a professional engineer's license from the state, or its equivalent).

The Task Group noted several positive findings related to ORNL's surveillance program:

- A find-it/fix-it team has been established;
- The Quality Assurance Office has established an audit process; and
- A self-assessment plan has been established.

The ORNL Site Office, however, should improve its knowledge of facility conditions and enhance its oversight of electrical safety. In addition, a trend analysis process should be initiated and programmatic assessments should be conducted. The Site Office should also close multiaction findings on an item-by-item basis instead of waiting until all actions have been completed. These weaknesses are the result of inadequate resources, a situation that is recognized by OR. The Site Office currently uses consultants to assist with routine operations, although consultants cannot be regarded as cognizant personnel.

Expertise/Qualifications of Electrical Safety Personnel

The Task Group found that electrical workers at ORNL were well qualified to perform their duties. The contractor recognizes the need for designating an individual as an Authority Having Jurisdiction to interpret codes and regulations. However, no one at the ORNL Site Office is fully qualified to carry out electrical safety oversight functions. Further, the Site Office lacks an appropriate set of criteria to oversee the contractor's electrical safety program. Finally, the Site Office must currently rely on consultants to perform routine tasks and thus lacks the personnel resources necessary for accomplishing effective oversight.

Electrical Safety Training

As stated above, the Task Group found that electrical workers at ORNL are well qualified to perform their duties. The contractor recognizes the need for designating an individual as an Authority Having Jurisdiction to interpret codes and regulations.

The electrical safety training received by workers in the Plant and Equipment Division is good. However, electrical workers receive safety training only for high-voltage (above 600 volts) work. The training program should be expanded to include low-voltage work activities (50-600 volts), as required by 29 CFR 1910.332.

Comprehensive electrical safety training has not been provided to ORNL electrical welders as required by 29 CFR 1910.332. The training module, "National Electrical Code Training for Plant and Equipment Division Electrical Workers," contains information that is misquoted from Table S-4 of 29 CFR 1910.332(c).

The six-member Electrical Safety Committee at ORNL recommends implementation of a system to ensure that electrical work is conducted safely. The roles and responsibilities of the Electrical Safety Committee include informing workers about important electrical safety issues. The committee does routinely review and update all training documents related to electrical safety.

Personnel assigned to the ORNL Site Office have limited electrical safety oversight functions, and criteria for conducting oversight of the contractor's electrical safety program are lacking. In addition, the Site Office does not have either a formal electrical safety training program related to oversight or a system to evaluate the effectiveness of the ORNL program. Resource limitations contribute significantly to these conditions.

Electrical Safety Incidents

ORNL's program for the investigation and documentation of safety incidents is defined in accordance with IS-1.4, "Recordable Injury and Illness Investigation," dated June 1991.

The contractor has an active program for the investigation of electrical safety incidents. Such incidents are reviewed and documented, and the site's occurrence reporting system is being expanded to include near-miss incidents.

Potentially unsafe conditions or concerns identified by electrical workers in the Plant and Equipment Division are reported via several mechanisms, including a peer reporting system.

On a DOE-wide basis, root causes of electrical incidents are determined (or limited) by judgments based on the experience and knowledge of the personnel conducting the reviews and not by a rigorous analytic process. Until an effective root cause analysis process is in place, solutions to remedy electrical safety incidents may not be sufficiently effective. The need to have more individuals trained in the area of root cause analysis is recognized by both DOE and contractor managements.

Post-Incident Response

ORNL accident reports are maintained by the Industrial Safety Division. Accident investigations are conducted by appropriate personnel and organizations, including the Electrical Safety Committee. Recommendations identify parties responsible for implementation and projected milestones.

MMES follows IS-1.4, an internal procedure for investigating electrical safety incidents. These investigations are performed by an appropriate cross section of personnel from areas at the site. The team generally includes representatives from the safety organization, the relevant division safety officer, craft representatives, and other personnel. In at least one instance, the investigation team also included members of the Electrical Safety Committee. These reviews result in documented findings, recommendations, specific assignments for followup action, identification of responsible parties, and projected dates for completion of corrective actions. The Plant and Equipment Division Director and the Industrial Safety Department Manager review all investigation reports.

Generic Lessons Learned

The Task Group identified several lessons-learned processes currently in effect at ORNL. These processes result in an appropriate level of employee and management involvement in such areas as incident review, documentation, dissemination of information, and tracking and trending of accidents and inspection findings. The investigation and review process relative to electrical safety incidents is inherently sound. Employees who are routinely involved in these activities participate directly in the diagnosis of safety breakdowns and corrective actions.

In order to provide appropriate information to cognizant personnel at MMES and DOE, incidents are communicated as "yellow alerts" on the MMES/DOE electronic mail network. The alert identifies the lesson learned and provides a brief discussion of the situation. References to DOE occurrence reports are included when pertinent. The Industrial Safety Department tracks and reports trends of recordable injuries.

OSHA findings are tracked in a data base maintained by the OSHA Program Manager. Trend information is then made available for audit followups and management status reports. The data base is currently being updated. Consolidation of findings related to DOE Orders and ORNL procedures with those related to OSHA requirements has also been proposed. Such an expanded data base would enhance its usefulness as a source of lessons learned.

Savannah River Site

The Savannah River Site (SRS), located near Aiken, South Carolina, was constructed to produce the basic materials used in the fabrication of nuclear weapons, primarily tritium and plutonium-239. The site consists of three operational nuclear materials production reactors (K, L, and P); one reactor (C) in cold standby status; one reactor (R) in shutdown status; two separations areas (F and H) for processing irradiated materials; a closed (and dismantled) heavy water extraction plant and a heavy water rework plant (D); a fuel and target fabrication facility (M); and the Savannah River Technology Center (SRTC), a research and process development laboratory supporting production and cleanup operations.

Located in an agricultural area, SRS also serves as a lumber and forestry research center managed by the U.S. Forest Service. The site houses the Savannah River Ecology Laboratory (SREL), an environmental research center operated for the Department of Energy (DOE) by the University of Georgia.

During the course of its review, the Task Group contacted management and staff of the DOE Savannah River Field Office (SR), Westinghouse Savannah River Company (WSRC), Bechtel Savannah River Incorporated (BSRI), and Wackenhut Services Incorporated.

Electrical Safety Program Summary

Safety audits by DOE and WSRC produced a comprehensive 2-year OSHA compliance baseline of all site areas. Electrical safety deficiencies were identified, and appropriate corrective actions are being taken. DOE and contractor deficiencies should be consolidated into a common data base to identify positive and negative trends more clearly.

DOE and site management demonstrates support for safety by (1) dedicating adequate resources for identifying and correcting deficiencies; (2) establishment of monthly employee safety meetings and the Safety Observer program; (3) inclusion of safety in employee evaluations; (4) the Quality Improvement Safety Suggestion program; and (5) cooperative interaction on technically complex or contentious electrical safety issues.

Current contractor safety policies are well structured, clear, and concise and stipulate the safety responsibilities of WSRC and BSRI managers, the Policy Review Committee, the Industrial Safety Section, and site employees. In addition, the recently developed Basic Electrical Safety Awareness policy is near publication and has been widely reviewed by contractor supervisors.

The Task Group found that the transmission and distribution line crews at Savannah River are knowledgeable and that they exercise safe practices. No energized work is conducted, and the lockout/tagout program for transmission and distribution was found to be satisfactory. The Task Group identified deficiencies in the low-voltage lockout/tagout program. Records from quarterly audits of the lockout/tagout program in general plant areas revealed problems related to incorrectly completed lockouts and post-lockout clearances. The records show that a significant number of lockouts are unaccounted for or missing, and others were not completed properly. Errors documented in the records included missing tags, missing signatures, and clearance requests filled out improperly. Review of the glove-testing program revealed a lack of testing documentation and the apparent lack of formal operator training in test procedures. Personnel protective grounding sets were found to have improper connections, as well as frayed or broken strands.

The Tiger Team reported few electrical safety findings, which may reflect a lack of electrical expertise on the Tiger Team rather than the absence of electrical safety problems. This fact is evident by the large number of electrical safety findings in the DOE and WSRC surveillance program audits conducted since the Tiger Team Assessment. On the other hand, verification and closure of Tiger Team findings are being handled well.

SR has active surveillance, documentation, tracking, and closeout programs for all tenant activities. Due to the large size of the site and the small SR staff assigned to surveillance (nine personnel), support contractors are used for this purpose. About 50 percent of electrical findings from 1989 to 1991 and 35 percent of current findings have been verified and closed out. DOE recognizes the weakness in its closeout process and has initiated corrective actions.

WSRC has a proactive OSHA surveillance program that documents, tracks, prioritizes, and verifies closure. A 2-year audit of over 2,500 buildings and facilities resulted in more that 12,000 findings. Approximately 42 percent of these findings were electrical in nature, of which approximately 75 percent either have been verified as closed out or have work orders pending.

The Task Group found no dedicated DOE or contractor staff or person responsible for electrical safety at SRS. Electrical safety expertise is evident on site in groups such as the Senior Electrical Safety Review Board (SERB), but these individuals are not specifically assigned to this task. In the Task Group's view, the large worker population and physical expanse of SRS justifies assigning dedicated staff to electrical safety.

With the exception of training for qualified workers, the WSRC electrical safety training program is in an early stage of development; furthermore, electrical safety training is fragmented from organization to organization. This situation is being addressed by the formation of the SRS Training Integration Group; however, the new organization needs guidance from an electrical safety expert. The guidance provided by SERB does not include focused expertise. The Task Group views efforts by the Site Services training staff to "walk the spaces" and confer with electrical workers (in order to determine their training needs) to be a noteworthy practice.

Safety Review Committees for each Program Management Team (PMT) area and a Site Safety Review Committee investigate electrical incidents. The procedures of identification and review of near-miss incidents are not clear. Root causes are identified in the occurrence reports, but data bases for tracking corrective actions are not fully developed. Little evidence exists that a formalized sitewide lessons-learned program is in place.

Management Role

DOE and contractor managements demonstrate support for safety through a variety of actions (including policy statements and visible goals that emphasize occupational and industrial safety) and through proactive safety programs that emphasize participation by employees and safety specialists. Management support also includes (1) safety audits and surveillances of existing conditions, work activities, and safety programs and (2) dedication of resources to identify and correct deficiencies.

Although policy statements regarding the importance of electrical safety per se were not observed, contractor management has issued policy statements regarding the importance of safety. The policy statements are concise, with responsibilities clearly defined. The written policies state that all safety requirements apply to both WSRC and BSRI, plus their subcontractors. However, there is currently no document defining sitewide electrical safety requirements, except for the general policy on the applicability of all DOE and OSHA requirements. Site management is aware of the need to provide explicit definitions of responsibilities and requirements for electrical safety apart from general occupational safety. In a partial response to this need, Procedure 8Q-25, "Basic

Electrical Safety Awareness," has been developed and is nearing implementation. The Task Group notes that the requirements of this procedure have received wide, thorough, and active review at the site.

The requirements have already been incorporated in planned employee training and safety awareness meetings, demonstrating a specific management commitment to electrical safety. In addition, the contractor is consolidating and revising policy-level procedures related to electrical safety into one manual -- specifically, Electrical Safety Manual (18Q). Goals for safety performance, safety monitoring and oversight, and safety program development and implementation are an integral part of the appraisals that determine the contractor award fee. These measurable goals are highly visible at SRS and strongly supported by management.

Contractor safety programs emphasize applying safety principles to all activities in the workplace. These programs include the Field Safety Engineers program, Safety Observer Program, monthly employee safety meetings, senior management safety audits, and employee performance reviews that evaluate safety performance as well as job performance.

DOE and contractors alike perform safety audits and surveillance using OSHA requirements as acceptance criteria. Identified deficiencies are tracked and corrected, and in most cases, the corrections are verified. Trending is still in a very early stage of development; however, a variety of systems are in place to track similar types of deficiencies in different contractor and DOE line management organizations. To provide meaningful trend analysis of audit and surveillance data, these systems should, at a minimum, be able to recognize redundant items. A common basis for deficiencies already exists (e.g., OSHA compliance requirements), which is being used by the parties performing audits and surveillance.

DOE and contractor management support is evident for most aspects of the safety program, especially in the area of prompt correction of identified deficiencies. Management has also demonstrated support for identifying deficiencies by establishing programs for raising the safety consciousness of management, supervisors, and workers and for establishing lines of communication to safety experts.

SR management periodically conducts audits of industrial safety using matrixed safety professionals from the SR Safety Division, Industrial Safety Branch (ISB). Electrical safety requirements form a portion of acceptance criteria for the general industrial safety audit. The ISB provides safety specialists in a matrixed fashion to other SR line organizations for the performance of safety audits, surveillances, and technical reviews. The ISB also has line responsibility for the SRS Fire and Medical Departments and primary oversight responsibility for the WSRC Occupational Safety and Hygiene (OS&H) Department. The ISB is the primary SR resource for guidance on interpreting, implementing, and monitoring industrial safety requirements.

WSRC construction subcontractor safety programs are reviewed for compliance with DOE and WSRC safety policies. In addition, contractor safety representatives perform documented safety inspections of subcontractor work activities. Progress on corrective actions formulated in response to findings are tracked, and after correction, a percentage of the findings is verified closed by the safety representatives. Day-to-day safety management and monitoring of subcontractors is the responsibility of the contractor's Subcontract Technical Representative.

The WSRC Occupational Safety and Hygiene Department is nearing completion of a comprehensive baseline OSHA compliance audit. This 2-year effort will give way to periodic audits beginning in January 1993. Preliminary information has shown that the highest incidence of noncompliance arises in the electrical area. Based on these findings, the contractor's periodic audit program for 1993 will emphasize the electrical issues in upcoming audits.

SR management is aware of electrical safety deficiencies identified through DOE safety surveillances and has a system to track, trend, prioritize, and verify correction of those deficiencies. SR is also aware, in a general sense, of the magnitude and type of deficiencies identified through contractor oversight organizations, and SR ISB provides oversight of contractor efforts to identify and correct safety deficiencies.

WSRC management is aware of electrical safety deficiencies. The WSRC OS&H group is charged with oversight of occupational safety. Deficiencies identified by this group are tracked, grouped, and prioritized and corrections are verified. Trending capabilities will be established as a historical data base is developed. Management reports on corrective action status and deficiency classification are issued periodically.

Participation in safety programs by DOE, WSRC, and BSRI is high. Subcontractor management is required by policy and contract to implement an acceptable safety program and to respond to contractor and DOE oversight of safety program implementation. Subcontractors are also encouraged to request assistance from WSRC safety engineers. Subcontractor participation in safety programs was not directly observed by the Task Group. However, interviews with WSRC and DOE personnel indicate that subcontractor implementation of safety programs is monitored.

Management support is evident in most aspects of the safety program. Areas where support is high include the prompt correction of identified deficiencies. Management has also demonstrated support for identifying deficiencies by establishing programs for raising the safety consciousness of management, supervisors, and workers and for establishing lines of communication to safety experts. However, the utilization of Field Safety Engineers (the primary safety resource for area activities) should be enhanced to enable more effective use of this resource. The Task Group noted two specific examples of inefficiency in this area. First, clerical and administrative responsibilities and activities detract from the primary function of the Field Safety Engineers. Second, because of the small number of Field Safety Engineers, multiple facility responsibilities, and the significant distance between those facilities, travel consumes an inordinate portion of potentially productive time.

Policy and Procedures

Current contractor safety policies are clear and concise in defining the responsibilities of WSRC and BSRI managers, management committees, oversight organizations, employees, and subcontractors. A specific Basic Electrical Safety Awareness policy is in draft form, has been widely reviewed, and is expected to be approved and implemented soon. In addition, the contractor is consolidating and revising policy-level procedures related to electrical safety into one manual, the Electrical Safety Manual.

Oversight responsibilities of the SR ISB are clearly defined in policy and planning documents. Accountability for implementation of DOE guidance is established in contractor performance appraisal criteria for the award fee appraisal process. These measurable goals are highly visible within the contractor organization.

Interviews with D-Area Power Plant personnel indicated that electrical operations (e.g., breaker, disconnect, and fuses) require the attendance of a WSRC Electrical and Instruments Department technician. Operations procedures were briefly reviewed and, although no general electrical safety precautions appeared in the body of the procedure, these precautions were outlined in a separate section of the Operating Manual (8Q4 series procedures).

Responsibility for the contractor safety program and accountability for program implementation are clearly established. The principal mechanism observed is the award fee appraisal process in which explicit, measurable goals are periodically established and agreed upon between the contractor and DOE. These goals are highly visible within contractor management.

A pervasive program exists for inspecting all electrical extension cords, portable tool cords, and appliance cords on site. (See 8Q5-S9509, "Safety Inspection of Electrical Cords, Appliances, and Other Electrical Equipment.") Inspection tape is applied to the cords to indicate the expiration date. This program has been largely effective. However, on a walkthrough of the Defense Waste Processing Facility, the Task Group noted an expired and illegal extension cord and a duplex outlet box assembly in the same work area with portable electric tools. The WSRC inspection apparently missed this item. Further, BSRI's "Safety Task Assignment (STA) Guidelines" does not contain a precaution to check current inspection tape before use. If the illegal assembly observed by the Task Group had been presented for inspection, it would have been removed from use. Finally, the Task Group notes that 8Q-25, "Basic Electrical Safety Awareness," cautions workers to inspect each extension cord for a current inspection sticker.

Procedure S-9501, "Safe Practices Near Electrical Conductors," is a well-written, comprehensive procedure for working on or near exposed energized equipment. However, S-9501 allows the use of leather gloves as electrical protective equipment when work is performed on or near energized conductors of 50-150 volts. 29 CFR 1910.335 requires the use of electrical protective equipment when work is performed on or near energized parts of 50 volts or greater. Leather gloves have no recognized insulation value and are not considered adequate as protection from electric shock when work is conducted on exposed energized parts. This procedure should be revised to include all requirements stipulated in 29 CFR 1910.331-335. WSRC management has recognized this problem and is in the process of resolving the issue.

Electrical Safety Culture and Conduct of Operations

SRS has made preparations for the development of a pervasive and participative safety culture. Programmatic elements are in place and functioning. Employee safety awareness programs are highly developed, and management demonstrates support for these programs. Electrical safety, as an important subset of occupational safety, is gaining the attention that it deserves. Program implementation is showing positive gains toward an increased safety awareness among employees. With sustained management support and continued stewardship of programs by their current managers, the safety culture should continue to grow in an acceptable manner.

SRS has a program established to inspect personnel protective grounding sets on a periodic basis. All grounding sets inspected were marked and had been recently inspected. However, some of these grounding sets were found to have been built using improper clamps and connectors and did not have connection ferrules. Some of the grounding cables inspected had broken and frayed stands. Personnel protective grounding sets need to be constructed in accordance with the requirements of ASTM F 855-90 because grounding sets improperly constructed may not be able to carry the available fault current safely that the circuit is inadvertently reenergized. Grounding sets could melt, or blow off without operating the overcurrent devices, exposing personnel to shocks and burns. SRS personnel who build and inspect grounding sets need to be trained in the requirements of ASTM F 855-90 and the proper construction of personnel protective grounds. Any grounding sets found to have improper connectors, clamps, or broken or frayed conductor strands should be immediately removed from service and repaired.

Interviews with electrical craft personnel indicated that SRS craft personnel are very familiar with the requirements for working on energized systems and with the WSRC lockout/tagout procedure. However, during its review of periodic inspection records for the lockout/tagout program, the Task Group found numerous violations of the procedure. Quarterly and yearly audits of lockout/tagout conducted by the power work control supervisor for G-Area indicate that there are problems with personnel completing lockouts and clearances incorrectly. Records show that a large number of lockouts are unaccounted for or missing. Personnel are repeatedly completing improper lockouts. Errors include missing tags, missing signatures, clearance requests, filled out improperly and improper independent verification.

SRS is currently performing inhouse inspection and testing of its rubber protective equipment. The Task Group found that all rubber protective equipment had been inspected and tested within the time limits prescribed by ASTM F 496-90. However, SRS does not provide any documentation of the testing performed on its protective equipment. All electrical protective equipment should be inspected, tested, and stored in accordance with ASTM F 496-90. In order to establish a history of this electrical protective equipment testing, and to provide documentation that the tests were performed, records must be kept. The person currently performing the inspection and testing of electrical protective equipment has not been given any formal training for inspecting and testing this equipment. He also has not received any training or certification on the proper operation of the testing apparatus.

Post-Tiger Team Corrective Actions

The Lines of Inquiry used by the Task Group concerning post-Tiger Team corrective actions are specific with regard to corrective actions for findings related to electrical safety. However, the Tiger Team reviews at Savannah River did not focus on electrical safety; consequently, there were no Tiger Team findings or resultant corrective actions that specifically addressed electrical safety. There were, however, several general findings that addressed overall safety issues such as OSHA compliance programs. In these cases, electrical safety violations were cited along with those in other areas to support specific findings. However, corrective actions tracked for closure would involve development of procedures or programs to ensure OSHA compliance, not to correct the specific examples cited to support broader overall findings.

The Occupational Safety Programs and Assessments (OSP&A) Department of the WSRC Division of Environment, Safety, Health and Quality Assurance (ESH&QA) is the SRS organization primarily responsible for addressing electrical safety issues. OSP&A is performing OSHA compliance baseline audits that include facility walkdowns to identify noncompliances with requirements such as those stipulated by 29 CFR 1910, Subpart S. This sitewide effort includes all facilities. More than 12,000 noncompliances have been identified, roughly 42 percent of which involve electrical safety issues.

To date, the baseline audits have taken approximately 2 years and the dedicated support of four full-time field engineers, and they were over 95 percent complete as this report was being prepared. The audits include documentation and tracking of all findings, require written responses concerning implementation of corrective actions, include scheduled verifications of implementation of corrective actions, and are scheduled for completion in early 1993. This program is the primary means for identifying and correcting electrical safety issues at the SRS. Closures of Tiger Team findings are relatively meaningless with respect to electrical safety because of the disparity between the lack of electrical safety findings by the Tiger Team and the large number of findings identified during the WSRC self-assessment.

Surveillance Program

DOE has active surveillance programs, with appropriate documentation, tracking, and closeout components. This surveillance provides oversight for all tenant activities at SRS. Due to the large size of the site and the small SR staff (nine personnel) assigned to surveillance, support contractors are used for this purpose. Should specialized expertise in electrical safety be needed, it will be obtained from support contractors. As discussed above, about 50 percent of electrical findings from 1989 to 1991 and 35 percent of current findings have been verified and closed out. DOE recognizes the weakness in its closeout process and has initiated corrective actions.

WSRC has a proactive OSHA surveillance program that documents, tracks, prioritizes, and verifies closure. A 2-year audit of over 2,500 buildings and facilities resulted in more that 12,000 findings. Approximately 42 percent of these findings were electrical in nature, of which approximately 75 percent either have been verified as closed out or have work orders pending. Trending of these data should be accomplished. The surveillance staff appears to be adequate in number, but it lacks the indepth expertise on electrical safety needed to respond to the large number of electrical safety findings and the continued need for electrical safety program development.

Expertise/Qualifications of Electrical Safety Personnel

Neither DOE nor the contractor has a staff or person dedicated exclusively to electrical safety. Hence, the Task Group could not assess qualifications of electrical staff personnel. The fact that expertise in electrical safety exists at the site is evident; however, as discussed above, individuals are not assigned directly to the task of electrical safety. The worker population and the physical expanse of the site would justify such assignments.

WSRC's electrical safety expertise resides primarily in the SERB. An electrical safety liaison function between different groups (e.g., SERB, Safety, Training, line organizations, and other site contractors) would be well served by such an individual. Electrical safety expertise at SR is provided by a support contractor on an as-needed basis.

Electrical Safety Training

Electrical workers are receiving electrical safety training at SRS. However, specific electrical safety training requirements mandated by OSHA for other trades personnel (e.g., pipe fitters, welders, and painters) have not been satisfied. Matrixed employee training required by job description has not been fully achieved, although it is being addressed relative to electrical safety training.

The general employee training program for electrical safety at SRS is in an early stage of development as far as being a stand-alone program. The recognition of electrical safety as a separate safety concern with an autonomous support function has not been achieved. Efforts are in motion to raise the awareness of electrical safety hazards as a primary concern at SRS. This effort is being pursued in part through several training initiatives, which include revisions to (1) the General Employee Training Program, placing more emphasis on electrical safety, and (2) electrical safety procedure S-9501 and the method used to incorporate S-9501 into several training matrices. Additional initiatives include WSRC's development of a sitewide Electrical Safety Manual (18Q) and its integration among the other prime operating contractors, plus joint efforts by the Training

Integration Group to bring together contractor training organizations in order to identify common goals that are needed to meet DOE and OSHA training requirements.

Training programs throughout SRS apply a consistent effort toward implementing the requirements of DOE 5480.18. Where the Order does not directly apply, its principles are being integrated according to a "graded approach," with recognition that the concept of performance-based training represents the most pragmatic approach to course development and delivery.

Electrical Safety Incidents

The site has a good program for the investigation of all reported accidents, including those involving electrical energy. The reporting of electrical accidents is required by DOE Orders, as is reporting of all accidents, but nothing differentiates them formally for tracking and trending. An advisory committee, the SERB, becomes informally involved in investigations because many of its members are from the plant divisions where the accidents occur. Currently, the site is addressing criteria for defining reporting requirements for "near-miss" incidents because their self-audit identified this as a concern. Investigations cannot be performed on near-misses if they are not reported on a consistent basis.

The Task Group examined several occurrence reports and found that root causes had been identified. Lockout/tagout problems were noted in association with several of the occurrences reported in 1991 and with a number in 1992. The reduction in the number of lockout/tagout incidents in 1992 demonstrates the site's ability to recognize and correct root causes for this problem. A formal methodology to resolve root causes of electrical incidents that are less visible than lockout/tagout violations is not in evidence.

Post-Incident Response

SRS has a program for responding to incidents; however, formalization and documentation of the process is not apparent. Electrical incident responses are part of the program, but they are not emphasized in any special way. Typically, once an incident is reported, it is reviewed by the Site Central Safety Committee, which includes members from support organizations such as Industrial Safety. The Site Safety Committee also reviews the incident. This committee is primarily composed of personnel from the PMTs and the operations organization.

The Central Committee reviews oversight of performance and monitoring; whereas the Site Committee resolves the issues causing the incident. In addition, there is a Senior Management Review Board to which the Site and Central Committees report. The Review Board is charged with resolving policy questions. The SR ISB would benefit in the electrical safety incident investigation and response activities by having a trained electrical safety expert available either through support contractors or full-time staff.

Root cause analysis is performed using a graded approach that requires indepth analysis of more severe incidents. However, as identified by the SRS self-assessment, followup activities associated with incidents have not been proceduralized.

Generic Lessons Learned

SRS has a data base, the Site Item Reportability and Issues Management (SIRIM), structured to meet the requirements of DOE 5000.3A. A subset (Impacts) of SIRIM is used to track the status of corrective actions. The requirements for this data base are defined in Manual 1B, MRPs 4.08 and 4.09. SIRIM is not fully implemented, and its value is not recognized across the site. The Industrial Safety group indicated that it does not routinely monitor the data base, a practice that could assist in identifying safety issues. Also, the Reactor Division has developed its own tracking data base, the Master Tracking System. The Task Group believes that other divisions may also have their own data bases; however, within the timeframe of this review, no other divisions could be examined.

The Facility Safety Evaluation Section (FSES) is responsible for generating lessons learned at the site. FSES issues lessons-learned bulletins and a weekly newsletter that focuses on major issues across the DOE complex and the nuclear industry. The FSES organization addresses only those lessons learned that are of major importance. For example, when the Task Group asked whether a lesson learned would typically be generated from an electrical shock incident, FSES indicated that, as a matter of policy, this would not occur unless several similar electrical shock incidents were reported, thereby establishing a trend.

Essentially, a deficiency exists in the lessons-learned program as it relates to electrical safety. How lessons learned would be addressed for a serious electrical incident is not clear. A formalized process does not exist across the site to generate lessons learned on electrical safety. The SERB is the focal point for electrical lessons learned that are based on the board's own experience and initiatives. Although the SERB is only an advisory body, it plays a key role in the area of electrical safety. However, no formal responsibility is defined for many of the board's support activities. Without such a formal charter, the impact of the support role of the SERB is inappropriately diminished.

Stanford Linear Accelerator Center

The Stanford Linear Accelerator Center (SLAC) is a single-purpose laboratory located in Palo Alto, California. SLAC is dedicated to experimental and theoretical research in elementary particle physics and to the development of new techniques for high-energy accelerators and elementary particle detectors. The Stanford Synchrotron Radiation Laboratory (SSRL) is dedicated to research in atomic and solid-state physics, chemistry, biology, and medicine. SLAC is operated for DOE by the Leland Stanford, Jr., University in accordance with a not-for-profit management and operations (M&O) contract. Organizationally, SLAC is operated under the purview of DOE's Assistant Secretary for Energy Research (ER). DOE's San Francisco Field Office (SF) provides an onsite presence and daily oversight of operations at the laboratory through the DOE Stanford Site Office (SSO).

The SLAC site comprises 426 acres of land owned by Stanford University and has been in continuous use for over 25 years in a national research program that has made major contributions to the natural sciences. The SLAC FY 1993 budget is $164.8 M (including $19.1 M for SSRL). SLAC has a staff of, 1574 (including 149 for SSRL) and is one of the few laboratories in the world that conducts original research related to the basic constituents of matter. The Task Group reviewed the electrical safety programs of SSO and SLAC, including a limited review of programs at SSRL.

Electrical Safety Program Summary

The electrical safety program currently has the active support and involvement of management. The Director of SLAC has established committees to assist in managing programs and addressing issues related to safety. Problems associated with an old and deteriorating electrical infrastructure are known to exist, and a detailed study to replace this equipment has been performed.

Implementation of OSHA requirements, as defined in 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V, has not yet been achieved by the electrical safety program at SLAC. Until these requirements are implemented, program deficiencies will continue to exist in the areas of safe work practices, training, and the use of protective equipment. A number of assessments have identified deficiencies in electrical design and lack of compliance with the installation codes; however, when implemented, corrective action plans already in place should minimize worker exposure to these hazards.

Policies and procedures related to electrical safety are in place. In general, however, they do not reflect OSHA requirements and, in some cases, are in conflict with those requirements. Work control and planning consistent with DOE 4330.4A, Maintenance Management Program, are needed for electrical work, but implementation is not planned before 1995.

The electrical safety culture and conduct of operations at SLAC are inconsistent across the organization. For example, some research groups maintain that their education and experience exempt them from formal training to recognize and avoid electrical hazards in the workplace. SLAC's safety meetings to discuss electrical safety issues are scheduled and routinely held in only one area of the organization. These meetings can be used to obtain important information concerning electrical safety and could facilitate dissemination of information throughout the Laboratory. Management and staff participation in such meetings on a routine basis could result in significant benefit for the laboratory.

Management has established procedures to monitor electrical equipment for deterioration in order to prevent catastrophic failure. The surveillance program for electrical safety consists primarily of annual audits and surveillance inspections conducted by the SLAC Environment, Safety, and Health (ES&H) Division, plus self-assessments and quarterly walkthroughs performed by line management. SLAC management's first audit of the Electrical Safety Program is scheduled for February 1993.

Formally documented qualifications are not in place for electrical workers. Such qualifications are needed to ensure that the requirements of 29 CFR 1910, Subpart S, are met. Management has recognized the need to have more individuals trained in the process of root cause analysis. A formal root cause analysis process will ensure that effective solutions are found for issues affecting electrical safety at the facility.

The Task Group concluded that SLAC will remain vulnerable to electrical safety incidents until the lockout/tagout system is fully implemented and verified. The system is currently ineffective because of inconsistent application. In addition, all personnel must receive training pertinent to electrical safety and fully compliant with OSHA regulations.

Management Role

Management at SLAC is knowledgeable about electrical deficiencies and is particularly concerned about the deteriorating electrical infrastructure and the burden it places on worker safety. Management is aware of electrical safety incidents involving personnel and equipment. A disciplined approach for ensuring that DOE Orders and OSHA requirements are properly assessed and that detailed implementation plans are prepared is currently being pursued.

SLAC lacks appropriate policy documents and implementing procedures for key elements of 29 CFR 1910, Subpart S, Electrical. Neither the Environmental, Safety and Health Manual (ESH-100) nor other documents fully implement these requirements. In some cases, the ES&H Manual directly conflicts with OSHA requirements. In addition, the lack of upper tier documents results in incomplete or confusing implementation at lower levels of the organization. Safety-related elements, including training, selection and use of work practices, use of equipment, and safeguards for personnel protection, are not consistently implemented across the organization. The Quality Assurance and Compliance Department is responsible for internal independent oversight of the electrical safety program and has scheduled a program review for 1993.

Management involvement is accomplished through the Environmental, Health, and Safety Coordinating Council, which is composed of senior managers and reports to the SLAC Director. In addition, an Electrical Safety Review Committee has been established to review major new projects for electrical safety and to conduct periodic inspections. However, the committee is not chartered for oversight responsibility. SLAC has implemented a plan that tracks, trends, and prioritizes corrective actions designed to close out deficiencies identified by the Tiger Team Assessment and other external and internal appraisals. The self-assessment performed by SLAC before the arrival of the Tiger Team included a site survey that revealed numerous electrical deficiencies as well as a programmatic appraisal. The specific deficiencies are incorporated in the corrective action management system and are being tracked to closure. However, the Task Groups determined that programmatic findings identified in the self-assessment and not related to Tiger Team findings were not entered into the tracking system and have not been evaluated for priority relative to other findings.

SLAC management is prominently involved in the safety program. For example, the Director visits work sites as his schedule permits. He established the Environmental, Health, and Safety Coordinating Council to focus on safety issues, and he is in the process of initiating a disciplined approach to the implementation of OSHA requirements throughout the organization. Recognizing that older electrical equipment presents additional challenges to worker safety, the Director recently took a very personal interest in a serious electrical shock incident. The Associate Director, Technical, visits the workplace several times a week. His subsequent reports are intended to ensure a safe work environment for employees and to disseminate information about hazardous conditions.

The availability of resources is an important issue in resolving electrical deficiencies. For example, implementation of the recommendations of the Conceptual Design Report (prepared to define electrical equipment upgrades in order to reach compliance with the requirements of 29 CFR 1910, Subpart S, and to reduce hazards inherent in maintaining older equipment) will require additional resources. Implementation of DOE 4330.4A is currently scheduled for 1995. Early implementation of certain elements of the Order related to planning and work authorization would improve safety; however, additional resources would be required. Finally, formal configuration management for electrical systems does not exist at SLAC, and resources to establish such a program are not available.

The DOE Site Office has not issued policy statements concerning electrical safety for either the contractor or DOE employees. SSO is still in the process of establishing and obtaining agreement concerning its oversight responsibilities at SLAC. As yet, no specific audits of electrical safety have been conducted or scheduled. Recent functional appraisals, the Tiger Team, and SLAC self-assessments have identified numerous electrical code deficiencies that are being tracked to closure. During April 1992, a performance assessment was conducted by Site Representatives from the DOE Office of Environment, Safety and Health (EH). The assessment evaluated the effectiveness of the DOE San Francisco Field Office (SF) at SLAC and identified specific and programmatic issues related to electrical safety. To date, SSO has not received any instruction from the PSO on correction of these deficiencies.

Policy and Procedures

There is a general lack of policy documents and implementation of procedures for key elements of 29 CFR, Subpart S. These procedures should provide clarification and information to assist in decisions for the safe conduct of electrical work and should be included in the requirements of 29 CFR 1910.331-335. Procedures for worker practices dealing with low voltage are lacking. Only a limited number of draft procedures are in place to ensure safe lockout/tagout practices.

The lockout/tagout procedure at SLAC has the potential to meet the OSHA requirements of 29 CFR 1910.147 and 1910.333, but because of inconsistent application of the procedure, it is currently ineffective. Personnel working in the field apply the procedure with little or no guidance or training on its application. This situation has resulted in confusion about how and when the procedure should be applied and could potentially create an unsafe work environment.

Electrical Safety Culture and Conduct of Operations

The transition to a modern safety culture is not complete at SLAC and was found to be advancing slowly. This is evident from the interviews conducted by members of the Task Group, which included opinions expressed by some employees that their advanced education and training or their special qualifications should result in exemption from electrical safety training. Regardless of this position, the OSHA regulations clearly require all employees to be trained according to their risk of exposure to electrical shock.

Electricians currently receive extensive training, usually requiring an apprenticeship during the first years of work. This occupational group would require additional training pertaining to electrical work practices covered under this regulation.

At SLAC, workers use leather gloves to service and maintain circuits energized at less than 600 volts using 29 CFR 1910.335 specifies the use of electrical protective equipment, and leather gloves do not meet the requirements for energized low-voltage work. No evidence was found to indicate that the appropriate electrical protective equipment was being provided or used. Some supervisors also expressed the view that they need not receive the same level of training required of their subordinates. In addition, electrical workers at SLAC are not receiving training that is required by 29 CFR 1910.332 for electrical safety-related work practices, including selection and use of equipment and safeguards for personnel protection. Nonetheless, some workers evidenced a positive attitude toward the requirements of a modern safety culture.

Safety meetings to discuss electrical safety issues are scheduled and routinely held in only one area of the SLAC organization. These meetings can be used to obtain important information concerning electrical safety and could facilitate the dissemination of information throughout the laboratory. Management and staff participation in such meetings on a routine basis could result in significant benefits for SLAC.

Equipment monitoring to preclude catastrophic failures is currently in place. Transformer gas and oil analysis, infrared surveys, and equipment monitoring will provide indications of incipient problems before they result in equipment failures that could compromise worker safety. SLAC management recognizes that full compliance with 29 CFR 1910, Subpart S, is a requirement for onsite electrical work being performed by outside contractors.

Post-Tiger Team Corrective Actions

Corrective actions related to electrical safety have been prioritized and are being tracked by the ES&H Division. Corrective action for the primary electrical safety finding (Tiger Team Concern WS-4.4) has not yet been completed. This finding has been prioritized as No. 17 of 206 findings and is scheduled for completion on March 1, 1993. Although the task for the primary finding will be completed on time, procedures and processes will remain under development.

Although monthly status reports are provided to DOE and SLAC management, they are not sufficiently detailed to determine the status of ongoing corrective actions. This is the case for all corrective actions, not just those related to electrical safety. A corrective action running behind schedule might not be recognized as such until the month before its scheduled completion. Management does not need to know the status of all tasks associated with each corrective action; however, it does need to know the status of high-priority items. The ES&H Division is working on preparing more detailed reports to resolve this problem.

Some self-assessment corrective actions (i.e., those not picked up as part of the Tiger Team corrective action plan) have not been entered into an action plan. Milestones for corrective actions related to electrical safety have been completed on time or are ahead of schedule. The auditing system established by the Quality Assurance and Compliance Department is effectively closing out corrective actions within the SLAC organization. SSO has developed draft procedures for validating and closing out Tiger Team corrective actions. To date, however, none of these actions have been closed.

Surveillance Program

SLAC's surveillance program for electrical safety consists primarily of annual audits and surveillance inspections conducted by the ES&H Division and self-assessments and quarterly walkthroughs performed by line management. The ES&H Division has scheduled the first audit of the Electrical Safety Program for February 1993 and will provide management with summaries of its findings. In the interim, surveillance inspections of various aspects of electrical safety are being conducted. Surveillance inspections are generally narrower in scope than audits.

In a memorandum concerning the execution of safety responsibilities, the Director of SLAC tasked line managers to conduct safety walkthroughs of the work spaces under their supervision, using a checklist developed by the ES&H Division. The checklist includes only one paragraph (four lines referring to codes and regulations) on electrical installations. Unless line managers are trained on these various codes and regulations, the walkthroughs they conduct will likely be superficial. This absence of training was a concern that was identified in the SLAC self-assessment conducted in September 1991. The finding from the self-assessment does not appear in a corrective action plan; consequently, its correction may or may not be accomplished.

SLAC was found to have an appropriate level of staffing to provide oversight of electrical safety activities. However, the laboratory's line managers were not shown to have received the appropriate training to conduct self-assessments and walkthroughs related to electrical safety.

Findings from audits and self-assessments are currently tracked on different systems. This situation could lead to confusion in the effort to ensure that all corrective actions are being implemented. More positively, SLAC is in the process of consolidating findings from audits and self-assessments into a single tracking system. Such a consolidation will facilitate prioritizing and trending the implementation of corrective actions. Findings related to electrical safety identified by various audits and assessments should be grouped under the same category, with cross-references included as appropriate. Also, a self-assessment program, including electrical safety under OSHA, is being implemented.

SSO personnel have had basic OSHA training and rely on the SF Environment and Safety Support Division (ESS) for specific electrical safety support. For functional appraisals, reviews, and oversight, SSO depends on ESS for specific ES&H technical support. Electrical safety represents only one aspect of an OSHA review. The SSO should consider initiating additional site-specific electrical safety training and should conduct separate electrical safety reviews.

Expertise/Qualifications of Electrical Safety Personnel

The qualifications of electrical personnel (e.g., electricians, technicians, researchers, and welders) are not formally documented. Such documentation is necessary to help establish the minimum qualification for electrical workers and the training required for qualification according to 29 CFR 1910.331-335.

As indicated previously, some electrical work is being performed by scientific professionals who may not be qualified under OSHA regulations 29 CFR 1910.331-335.

Electrical Safety Training

Although some electrical safety training for less than 600 volts is being taught at SLAC, it must be supplemented with the requirements of 29 CFR 1910.332, as they relate to their respective job requirements, to satisfy the regulation fully. A system is not in place to ensure that all employees who require electrical training are identified throughout the laboratory. SLAC policy stipulates that individual supervisors are primarily responsible for identifying and providing appropriate electrical training. Although this approach may have worked effectively in the past, SLAC should consider a system to ensure that all personnel receive the appropriate electrical training required by 29 CFR 1910, Subpart S.

Electrical workers at SLAC do not receive all training that is required under 29 CFR 1910.332. The Task Group found evidence that employees whose work involves potential exposure to energized parts at operations of 50 volts or greater are not always trained in safety-related work practices required by 29 CFR 1910.331-335.

Electrical workers do not always use the correct personal protective equipment when performing work on or near energized low-voltage equipment (including troubleshooting and testing of circuits) as required by 29 CFR 1910.331-335. 29 CFR 1910.333 specifically classifies troubleshooting as energized work and requires that suitable safe work practices be followed.

Some employees believe that, because they are electricians or researchers, training in work practices related to electrical safety is not needed. 29 CFR 1910.332 does not exempt any of these individuals from training if they are exposed to electrical hazards.

Electrical Safety Incidents

SLAC does not appear to have a formal, documented program for investigating electrical safety incidents. Although investigations of incidents have been conducted, their thoroughness is questionable. For example, the report on an accident occurring at Substation 507 on October 16, 1992, does not include root causes analysis. Further, the report found that both the injured electrician and the contract electrician at the scene failed to read the warning signs posted on the switch cabinet door. The report did not address the question of why these individuals failed to read the signs. The circumstances surrounding other findings also needed more indepth inquiry. SF reached this conclusion after conducting a review of the accident report and notified SLAC accordingly. The SF Manager did not accept the initial accident report as complete. After an internal review conducted on December 2, 1992, SF requested that the Accident Investigation Committee consider additional issues and root causes not covered in the report. On December 18, 1992, the committee provided an updated accident report, as requested, including the additional information requested and a root cause analysis. This updated report was found acceptable to SF.

The quality of root cause analyses for electrical incidents is determined (or limited) by the experience and knowledge of the personnel who conduct the reviews and not by the rigor of the process. Until an effective root cause analysis process is in place, solutions to remedy electrical safety incidents may not be sufficiently effective. Management recognizes the need to have more individuals trained in the area of root cause analysis.

Post-Incident Response

SLAC does not have a fully documented program for responding to electrical safety incidents. For example, the part of the program that emphasizes correcting personnel hazards and restoring the facility and equipment to a safe condition is not documented. The program does, however, ensure the availability of medical assistance as needed, a policy that is documented in ES&H Bulletin Nos. 06 and 07. These two bulletins describe procedures for handling worker injuries for non-SLAC and SLAC personnel, respectively, a description of available medical assistance is included.

The site has a program for investigating and critiquing all electrical safety incidents, but the Task Group found no evidence that the program is documented. Root causes are not promptly identified, but lessons learned are developed from electrical safety incidents. Some lessons learned result in the preparation of ES&H bulletins. Lessons learned are also published in the form of memoranda from the SLAC Director to managers and supervisors.

SLAC does not have a documented program ensuring that personnel hazards are corrected or that facilities and equipment are restored to a safe condition after an incident occurs. Although these issues may be addressed in most or all instances, appropriate responses cannot be assured in the absence of a more formal process. As indicated above, root causes for electrical safety incidents are neither completely nor promptly identified at SLAC.

Generic Lessons Learned

SLAC has a program for investigating and critiquing all electrical safety incidents, but the Task Group found no evidence that the program is documented. Safety meetings to discuss electrical safety issues are scheduled and routinely held in only one area of the SLAC organization. Management and staff participation in such meetings on a routine basis could result in significant benefits for the laboratory. Root causes are not promptly identified.

Lessons learned are developed from electrical safety incidents. Some lessons learned result in the preparation of ES&H bulletins. The SLAC Director has initiated a lessons-learned bulletin system to disseminate information on serious accidents and near-misses. In addition, lessons learned are published in the form of memoranda from the SLAC Director to managers and supervisors.

Uranium Mill Tailings Remedial Action Project

The Uranium Mill Tailings Remedial Action Project (UMTRA) is a remediation and environmental protection program operated by the DOE. UMTRA's Congressionally mandated mission is to clean up and control residual radioactive materials from designated inactive uranium processing sites and to eliminate existing and future environmental health hazards caused by those materials. UMTRA's primary focus of operations is at several sites located in the western part of the United States.

On November 11-12, 1992, the Task Group visited the UMTRA Site at Grand Junction, Colorado. The site visited is small, but important, because it houses the activities of a non-GOCO contractor operation. Representatives from UMTRA management, as well as the technical assistance and remedial action contractors and subcontractors, were present during the review.

Organizations and contractors that were contacted include the DOE's Project Manager for UMTRA and staff from the Albuquerque Field Office (AL); MK-Ferguson Company, the remedial action contractor (RAC); and Jacobs Engineering Group, Roy F. Weston Company, Sergent, Hauskins, and Beckwith, and Geraghty and Miller, the technical assistance contractors (TACs). The ICC Corporation, the prime subcontractor to the RAC, was also contacted by the Task Group during the visit.

Electrical Safety Program Summary

The Task Group's major findings centered around (1) the need for expertise in the area of electrical safety on the part of DOE and its contractors, (2) professionally prepared design and as-built drawings depicting electrical systems, and (3) oversight processes for electrical safety. The DOE Headquarters Office of Environmental Restoration and Management (EM) has limited involvement in conducting oversight of, or in providing electrical safety technical support to, UMTRA. General expertise related to environment, safety, and health (ES&H) is available through DOE, MK-Ferguson, Weston, and several of the subcontractors at the Grand Junction site. However, UMTRA does not have access to adequate specialized expertise in electrical safety. An electrical safety program that implements the requirements of 29 CFR 1910, Subpart S, and 29 CFR 1926, Subparts K and V, does not exist.

The DOE project management staff is small and therefore must rely primarily on the RAC and TACs for expertise related to safety, including their very limited expertise in electrical safety. At present, these contractors provide limited onsite capabilities in the areas of electrical safety. The TACs are responsible for assisting DOE with safety audits of RAC operations, including electrical safety. The UMTRA staff oversees the TAC. This oversight chain has limited expertise in the discipline of electrical safety. DOE and contractor management is aware of this problem and is in the process of correcting it. One of three new TAC safety positions has been reserved for an individual with electrical safety qualifications. UMTRA will also schedule additional electrical safety training for DOE and contractor staff through the DOE Electrical Safety Committee. DOE and contractor staff will be scheduled to receive electrical safety training as soon as it becomes available.

Most UMTRA activities are characterized as "temporary" and little effort is given to maintaining design and as-built plans and drawings. This makes determination of circuit loadings and layout difficult. Electrical installation schematics are committed to the memories of electricians, not to paper. Moreover, electricians, not design engineers, make decisions about the design and specifications of electrical installations. Although as-built drawings are not yet being prepared by the RAC and electrical subcontractor, plans do exist for developing these documents in the near future.

Tracking and closing of incidents and identified deficiencies by the RAC is timely and complete, but DOE is not involved. A DOE issue tracking system is currently under development. Trending of identified deficiencies is not performed.

The RAC has few procedures in place for its electrical activities, including lockout/tagout and safe conduct of electrical work. Revised procedures will be developed in conjunction with the above-discussed effort to increase the project's level of expertise and training in electrical safety.

UMTRA reports directly to EM-AL and receives programmatic guidance from the EM Office of Southwestern Area Programs (EM-45). However, the reporting relationship to EM is for management, not for technical support in such areas as occupational safety and health. Consequently, EM and AL provide neither expertise nor oversight for electrical safety.

Existing safety policies and procedures cover lockout/tagout, but a work practices program for electrical safety and training for both "qualified" and "unqualified" personnel (as defined by OSHA 1910.331-335) has not been provided. In addition, the UMTRA organization uses an assured equipment grounding conductor program, but this program does not include all elements required by OSHA, such as testing for continuity and implementation by qualified personnel. This program needs revision with respect to both implementation and administration in order to comply with the OSHA standards.

UMTRA and contractor personnel were very helpful and cooperative during the Task Group review, and they expressed a willingness to implement improvements for the electrical safety program as quickly as possible.

Management Role

Two major contractor activities are accomplished through UMTRA: (1) the TAC provides technical support and oversight functions, and (2) the RAC performs the physical work associated with site cleanup and restoration and oversees work performed by its subcontractors (e.g., ICC, and their subtier Westran, Inc.). UMTRA project management and staff direct the activities of these contractors. Because the size of its occupational safety and health staff is limited, UMTRA must rely on the RAC and TAC to exercise most of its day-to-day influence at remediation sites.

The RAC has recently demonstrated its support of electrical safety through increased corporate attention in the areas of policies, procedures, and personnel qualifications. There is also a growing emphasis on site contractor and subcontractor management involvement in electrical safety programs. RAC management participates in weekly site surveillance, tool box safety meetings, and subcontractor coordination activities, all of which are part of the safety program. The DOE UMTRA Project Office does not actively participate in these activities.

UMTRA site management is aware of electrical safety deficiencies identified through DOE and contractor (RAC and TAC) audits. Such deficiencies are tracked, and their correction is verified. The RAC provides information on electrical and other safety issues/findings to all project sites and incorporates appropriate issues into the "lessons learned manual." However, a program is not currently in place to trend deficiencies, and the responsibility for resolving contractor-identified deficiencies has not been assigned to specific organizations. The size of the UMTRA staff is not adequate to focus on electrical safety deficiencies. The RAC has recently added ES&H site managers to its support network for these safety programs, an action that was intended to facilitate the prompt correction of most deficiencies.

Policy and Procedures

In general, all policies for UMTRA sites are developed by the UMTRA Project Office, which has developed an ES&H plan that comprises UMTRA policies and goals. The plan references appropriate DOE, OSHA, and NEC requirements and standards for electrical safety but does not include the requirements of 29 CFR 1910.331-335.

As stated in the ES&H plan, the UMTRA Project Office and the TACs are responsible for auditing the activities of the RAC. The plan also calls for the RAC to provide oversight of their subcontractors and requires the subcontractors to perform self-assessments. Electrical safety is addressed as part of the general category of safety and health during these oversight activities.

The RAC's safety policies and implementing procedures are currently being developed. The Safe Conduct of Electrical Work policy and the lockout/tagout procedure, however, have been promulgated down to the RAC subcontractors. The RAC is strengthening its ES&H organization at both the RAC-Albuquerque Project Office and the Grand Junction site to formulate and implement policy more effectively and to develop related electrical safety procedures. This process includes strengthening the onsite ES&H staff in the area of electrical safety.

The RAC's oversight program currently incorporates most of the OSHA requirements of 29 CFR 1926; however, 29 CFR 1910, Subpart S, and DOE requirements have not been comprehensively addressed. The RAC is aware of these deficiencies and is developing comprehensive electrical safety procedures to satisfy these requirements, as well as specific calibration procedures for activities involving electrical hazards. The RAC is also developing specific responsibilities in the area of electrical safety for electrical subcontractors as part of its revisions of their Safe Conduct of Electrical Work procedure.

Electrical Safety Culture and Conduct of Operations

The responsibilities of DOE and contractor line management for electrical safety have been clearly defined in UMTRA's ES&H plan. Electrical safety is considered an integral part of general safety and health for the project. The UMTRA Site Manager's responsibility and authority for safety are clearly defined in the position description. UMTRA site management does not actively participate in the electric safety program.

RAC management participates in weekly site surveillance, tool box safety meetings, and subcontractor coordination activities, all of which are part of the safety program. RAC responsibilities and accountabilities for electrical safety are detailed in their Safe Conduct of Electrical Work procedure.

Design modifications affecting electrical systems are rarely performed at UMTRA sites. Most facilities are either as-built designs or temporary installations. The RAC does not have prescriptive requirements for verification of electrical schematics. Also, the RAC does not implement an electrical work control system (i.e., safe work permits) to address the electrical safety requirements, training, procedures, and personal protective equipment for all electrical work conducted. Electrical work at the site is usually performed by subcontracted electricians who are utilized on an as-needed basis, and not by workers routinely assigned to the site.

All electrical personnel used on site have been trained to follow the RAC lockout/tagout procedure. Although this procedure addresses isolation of electrical equipment before work is commenced on that equipment, the Task Group views the procedure as inadequate because it does not meet the requirements of OSHA regulations.

Electrical interlocks are not available on UMTRA sites, and specific procedures are not provided for employees working on or near exposed energized circuits. The RAC does not allow work on energized circuits to date, and if necessary, a specific exemption can be requested and may be granted.

The procedure also requires subcontractors to use qualified, licensed electricians, but it does not include requirements for the specific electrical training in 29 CFR 1910.332. The definition of "qualified," as established in the new Safe Conduct of Electrical Work procedure, must include this requirement.

Safe approach distances and clearance to overhead lines are described by OSHA and in the new RAC Safe Conduct of Electrical Work procedure. The RAC does not define insulation requirements for electrical work in its ES&H program for construction. However, the RAC is developing criteria that will require subcontractors to have procedures for such activities as overhead line monitoring.

The RAC does not issue electrical personal protective equipmant but does require that nonconductive head protection be worn on site at all times. Subcontractor electricians are required to provide their own appropriate equipment, supplies, and materials and to ensure that they are in good working order. The RAC also oversees activities to ensure that adequate protection is maintained, although no specific procedure is available to address these activities and no prescriptive requirements are stipulated that electrical equipment be approved by a nationally recognized or alternate testing laboratory.

Post-Tiger Team Corrective Actions

UMTRA was not the subject of a Tiger Team Assessment and is not required to develop a post-Tiger Team action plan.

Surveillance Program

Oversight by DOE in the area of electrical safety, is superficial. One TAC (Roy F. Weston Company) is responsible for performing this function, although it lacks the expertise to conduct comprehensive surveillances of electrical safety. Electrical safety surveillances performed by the RAC are also superficial.

A comprehensive surveillance of the electrical system has recently been performed for all UMTRA sites by a RAC electrical engineer. In addition, the RAC has drafted a comprehensive electrical safety system surveillance checklist for implementation in the near term. However, the Task Group is concerned that the volume of the items to be checked may hinder effective implementation. In other words, the checklist should not be viewed as a substitute for surveillance conducted by a qualified electrical safety expert.

Periodic audits are conducted by the TAC supporting the UMTRA Project Office. Each active UMTRA site is audited at least once per construction season. However, expertise in important aspects of electrical safety is lacking.

Electrical safety findings identified by the TAC are tracked and prioritized and completion of corrective actions is verified. The RAC corrective action system includes items and deficiencies identified by its surveillance activities, those performed by the TAC, and other assessments conducted by UMTRA. The TAC currently tracks only those items identified by its and UMTRA's oversight activities, not those identified by RAC surveillances.

The RAC performs weekly site surveillances that include review of electrical safety against the OSHA requirements of 29 CFR 1926 and, more recently, 29 CFR 1910. However, expertise in important aspects of electrical safety is lacking. RAC personnel also document and track deficiencies and ensure that corrective actions are completed. In addition, the results of all other audits are tracked to completion. Currently, neither the RAC nor the TACs have a program to trend or perform trend analyses of identified deficiencies.

The general safety staff at the Grand Junction site recognizes the need for a safety expert with a stronger electrical background. The RAC is currently seeking to fill this void and recently used electrical staff from their INEL project to perform surveillance on the electrical systems on UMTRA sites. The resulting report, issued in October 1992, contained readily identifiable code and regulatory system violations but did not deal with any system characteristics, engineering standards, programmatic issues, or electrical safety-related work practices.

Expertise/Qualifications of Electrical Safety Personnel

General ES&H expertise is available to the UMTRA Project Office at AL through the RAC and TAC. However, these organizations do not have access to specific qualifications and expertise in the area of electrical safety. The general safety staff at the UMTRA site in Grand Junction recognizes the need to acquire the services of an electrical safety expert, and the RAC is currently seeking qualified applicants.

Personnel from the TACs conduct ES&H compliance inspections periodically on the UMTRA project, but these deal only with such highly visible issues as GFCI requirements and testing. Further training is scheduled for the TAC personnel that will include the requirements of 29 CFR 1910.331-335. The need to acquire electrical safety expertise for UMTRA is necessary to maintain an electrically safe work site.

Electrical Safety Training

Training records exist and training programs are in place at UMTRA sites; however, neither the training records nor the training programs have the depth to meet the OSHA requirements for electrical safety training for all employees. The Task Group found no documentary evidence verifying that this topic had been considered indepth. The RAC did indicate that electrical issues have been discussed at "tailgate" safety meetings.

Electrical safety training at the UMTRA site in Grand Junction is a small part of a 4-hour general safety course administered to personnel working at the UMTRA sites. The course is taught by members of the RAC staff, and participation is recorded in employee files. Very little emphasis can be placed on electrical safety within the framework of such a brief course that is dedicated primarily to radiation safety. Successful completion of this course indicates that the employee is trained within corporate safety guidelines, with limited emphasis on electrical safety. The Task Group found no evidence that participants internalize the material presented.

Training in the use of the test equipment used for the "assured grounding program" is virtually nonexistent. An interview with the individual responsible for training indicated that only a "few minutes" of training took place. Moreover, the trainer had very little background in the use of the testers. Documentation in the form of training procedures and records were not kept.

The Task Group found no evidence that subcontractor electricians working on site are trained to recognize specific UMTRA site electrical hazards. These craftsmen were accepted as "qualified" based on their completion of the above-cited 4-hour safety course.

The electrical subcontractor acknowledged that the only documented qualifications for these employees are their licenses as Journeyman Electricians, issued by the State of Colorado.

Incorporation of the new RAC Safe Conduct of Electrical Work policy into the training program will enhance electrical safety at UMTRA. However, specific training in the electrical safety-related work practices, as mandated in OSHA 29 CFR 1910.332, will be required.

Electrical Safety Incidents

The DOE UMTRA Project Office and the TAC do not have a formal process for investigating incidents of an electrical nature and do not address post-incident response and generic lessons learned. The RAC has an Accident Investigation Procedure (MORT), root cause-trained personnel, and a lessons-learned procedure, all of which have been used for post-incident response. The highly mobile nature of UMTRA activities and the small DOE UMTRA Project Office management staff present special problems in this area.

APPENDIX A

TASK GROUP MEMBERSHIP AND FIELD TEAM COMPOSITION

APPENDIX A

TASK GROUP MEMBERSHIP AND FIELD TEAM COMPOSITION*

TASK GROUP MEMBERS

Oliver D.T. Lynch, Jr.	Director, Office of Performance Assessment; Office of Environment, Safety and Health (EH-32); Task Group Chairman; Team Leader, Field Team 1 (ORNL, SLAC, INEL, Hanford)
John W. Teske	Director, Performance and Quality Verification Division; Office of Performance Assessment, Office of Environment, Safety and Health (EH-32.2); Task Group Deputy Chairman; Team Leader, Field Team 2 (UMTRA, NTS, SRS)
Omer F. Goktepe	Office of High Energy and Nuclear Physics, Office of Energy Research (ER-22) (ORNL, SLAC)
Rick Kendall	Safety Diagnostic Division, Office of Self-Assessment, Office of Defense Programs (DP-9.1) (NTS, SRS)
Louis McGee	Regulatory Compliance Division, Office of Program Support, Office of Environmental Restoration and Waste Management (EM-331) (UMTRA, Hanford)
Lawrence E. Miller	Office of Facilities, Fuel Cycle, and Test Programs; Office of Nuclear Energy (NE-47) (INEL)

TECHNICAL SUPPORT AND FIELD TEAM

Patrick H. Tran	Policy and Standards Division; Office of Occupational Safety, Office of Environment, Safety and Health (EH-31.3) (ORNL, SLAC)

*Sites visited by these individuals are indicated within parentheses.

John Anderson	Savannah River Field Office, U.S. Department of Energy (SRS)
Gene H. Carr	Oak Ridge Field Office, U.S. Department of Energy (ORNL)
Al Chernoff	Albuquerque Field Office, U.S. Department of Energy (UMTRA)
John Gonzales	San Francisco Field Office, U.S. Department of Energy (SLAC)
Richard A. Holten	Richland Field Office, U.S. Department of Energy (Hanford)
John Martin	Idaho Field Office, U.S. Department of Energy (INEL)
James D. Ross	Nevada Field Office, U.S. Department of Energy (NTS)
Herbert L. Abercrombie	Senior Consultant, Nuclear Engineers and Consultants, Inc. (ORNL, SLAC, INEL, Hanford)
William Anderson	Principal Engineer, Fire Protection Programs, Westinghouse Hanford Company (ORNL, NTS, INEL)
Mike W. Bahr	Engineering Specialist/Electrical Safety, Idaho National Engineering Laboratory (ORNL, NTS, SRS, Hanford)
C. Bryan Drennan	Electrical Safety/Training Specialist, Sandia National Laboratory (UMTRA, NTS, SRS, Hanford)
Leo Flores	Assistant O&M Division Manager, Reynolds Electrical and Engineering Company (SLAC, INEL)
Eric Meils	Consultant, Nuclear Engineers and Consultants, Inc. (UMTRA NTS, SRS)

Larry A. McDonald	Engineering Project Manager, Martin Marietta Energy Systems (SRS)
Larry D. Perkins	OSHA Project Manager, Martin Marietta Energy Systems (UMTRA, SLAC, INEL, Hanford)
	ADMINISTRATIVE SUPPORT
Leon H. Meyer	Technical Writer, The LHM Corporation
Darla Treat Courtney	Technical Editor, Environmental Management Associates

APPENDIX B

THE UNDER SECRETARY'S TASKING MEMORANDUM

The Under Secretary of Energy
Washington, DC 20585

October 23, 1992

MEMORANDUM FOR ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY
ASSISTANT SECRETARY FOR DEFENSE PROGRAMS
ASSISTANT SECRETARY FOR FOSSIL ENERGY
ASSISTANT SECRETARY FOR NUCLEAR ENERGY
ASSISTANT SECRETARY FOR ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT
ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH
DIRECTOR, OFFICE OF ENERGY RESEARCH

SUBJECT: FORMATION OF TASK GROUP--ELECTRICAL SAFETY AT DEPARTMENT OF ENERGY FACILITIES

We have had a series of recent events involving electrical shock to contractor employees at facilities across the Department of Energy (DOE) complex. Some of these could have easily resulted in fatalities. These recent and recurring events, together with overall deficiencies in electrical safety practices identified by the Tiger Team Assessment program, concern me.

The Secretary's March 1991 Occupational Safety and Health initiatives are directed at strengthening line management's accountability for assuring programs are in place to protect our work force from such hazards. While we are making progress in correcting the backlog of electrical deficiencies at our facilities, these continuing incidents indicate that more effort is warranted. As a first step, all operating contractors are to immediately conduct a self-assessment of electrical safety programs and practices at their respective sites. These assessments are to be documented and reported to the cognizant Program Secretarial Officer.

In addition, I am directing the Assistant Secretary for Environment, Safety and Health to take the lead in establishing a task group to immediately review electrical safety programs and practices across the complex to identify measures to improve and ensure the electrical safety of DOE and contractor employees. A written report is to be prepared outlining the task group's findings, including recommendations for addressing these concerns.

In recognition of the urgency in which I view this matter, I am waiving the 60-day minimum notification requirement contained in DOE Notice 2321.1, so that the task group may begin its field work as soon as possible. DOE and contractor line management are asked to participate in this review, as appropriate, to ensure that lessons learned and needed changes in practice are disseminated to all programs within the Department. A status report and preliminary findings are to be provided to me by November 30, 1992, on the group's progress.

The actions required by this memorandum do not apply to the Naval Reactors Program.

Hugo Pomrehn

APPENDIX C

29 CFR 1910.147 THE CONTROL OF HAZARDOUS ENERGY (LOCKOUT/TAGOUT)

AND 29 CFR 1910, SUBPART S - ELECTRICAL

Appendix B to § 1910.145(f)—References for Further Information

The following references provide information which can be helpful in understanding the requirements contained in various sections of the standard:

1. Bresnahan, Thomas F., and Bryk, Joseph, "The Hazard Association Values of Accident Prevention Signs", *Journal of American Society of Safety Engineers;* January 1975.

2. Dreyfuss, H., *Symbol Sourcebook,* McGraw Hill; New York, NY, 1972.

3. Glass, R.A. and others, *Some Criteria for Colors and Signs in Workplaces,* National Bureau of Standards, Washington DC, 1983.

4. *Graphic Symbols for Public Areas and Occupational Environments,* Treasury Board of Canada, Ottawa, Canada, July 1980.

5. Howett, G.L., *Size of Letters Required for Visibility as a Function of Viewing Distance and Observer Acuity,* National Bureau of Standards, Washington DC, July 1983.

6. Lerner, N.D. and Collins, B.L., *The Assessment of Safety Symbol Understandability by Different Testing Methods,* National Bureau of Standards, Washington DC, 1980.

7. Lerner, N.D. and Collins, B.L., *Workplace Safety Symbols,* National Bureau of Standards, Washington DC, 1980.

8. Modley, R. and Meyers, W.R., *Handbook of Pictorial Symbols,* Dover Publication, New York, NY, 1976.

9. *Product Safety Signs and Labels,* FMC Corporation, Santa Clara, CA, 1978.

10. *Safety Color Coding for Marking Physical Hazards,* Z53.1, American National Standards Institute, New York, NY, 1979.

11. *Signs and Symbols for the Occupational Environment, Can. 3-Z-321-77,* Canadian Standards Association, Ottawa, September 1977.

12. *Symbols for Industrial Safety,* National Bureau of Standards, Washington DC, April 1982.

13. *Symbol Signs,* U.S. Department of Transportation, Washington DC, November 1974.

[39 FR 23502, June 27, 1974, as amended at 43 FR 49749, Oct. 24, 1978; 43 FR 51759, Nov. 7, 1978; 49 FR 5322, Feb. 10, 1984; 51 FR 33260, Sept. 19, 1986]

§ 1910.146 [Reserved]

§ 1910.147 The control of hazardous energy (lockout/tagout).

(a) *Scope, application and purpose*—(1) *Scope.* (i) This standard covers the servicing and maintenance of machines and equipment in which the *unexpected* energization or start up of the machines or equipment, or release of stored energy could cause injury to employees. This standard establishes minimum performance requirements for the control of such hazardous energy.

(ii) This standard does not cover the following:

(A) Construction, agriculture and maritime employment;

(B) Installations under the exclusive control of electric utilities for the purpose of power generation, transmission and distribution, including related equipment for communication or metering; and

(C) Exposure to electrical hazards from work on, near, or with conductors or equipment in electric utilization installations, which is covered by subpart S of this part; and

(D) Oil and gas well drilling and servicing.

(2) *Application.* (i) This standard applies to the control of energy during servicing and/or maintenance of machines and equipment.

(ii) Normal production operations are not covered by this standard (See subpart 0 of this part). Servicing and/or maintenance which takes place during normal production operations is covered by this standard only if;:

(A) An employee is required to remove or bypass a guard or other safety device; or

(B) An employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation) or where an associated danger zone exists during a machine operating cycle.

Note: *Exception to paragraph (a)(2)(ii):* Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection (See subpart 0 of this part).

(iii) This standard does not apply to the following.

(A) Work on cord and plug connected electric equipment for which exposure to the hazards of unexpected energization or start up of the equipment is controlled by the unplugging of the equipment from the energy source and by the plug being under the exclusive control of the employee performing the servicing or maintenance.

(B) Hot tap operations involving transmission and distribution systems for substances such as gas, steam, water or petroleum products when they are performed on pressurized pipelines, provided that the employer demonstrates that (*1*) continuity of service is essential; (*2*) shutdown of the system is impractical; and (*3*) documented procedures are followed, and special equipment is used which will provide proven effective protection for employees.

(3) *Purpose.* (i) This section requires employers to establish a program and utilize procedures for affixing appropriate lockout devices or tagout devices to energy isolating devices, and to otherwise disable machines or equipment to prevent unexpected energization, start-up or release of stored energy in order to prevent injury to employees.

(ii) When other standards in this part require the use of lockout or tagout, they shall be used and supplemented by the procedural and training requirements of this section.

(b) *Definitions applicable to this section.*

Affected employee. An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

Authorized employee. A person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

Capable of being locked out. An energy isolating device is capable of being locked out if it has a hasp or other means of attachment to which, or through which, a lock can be affixed, or it has a locking mechanism built into it. Other energy isolating devices are capable of being locked out, if lockout can be achieved without the need to dismantle, rebuild, or replace the energy isolating device or permanently alter its energy control capability.

Energized. Connected to an energy source or containing residual or stored energy.

Energy isolating device. A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switches and other control circuit type devices are not energy isolating devices.

Energy source. Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

Hot tap. A procedure used in the repair, maintenance and services activities which involves welding on a piece of equipment (pipelines, vessels or tanks) under pressure, in order to install connections or appurtenances. It is commonly used to replace or add sections of pipeline without the interruption of service for air, gas, water, steam, and petrochemical distribution systems.

Lockout. The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout device. A device that utilizes a positive means such as a lock, either key or combination type, to hold an energy isolating device in a safe position and prevent the energizing of a machine or equipment. Included are blank flanges and bolted slip blinds.

Normal production operations. The utilization of a machine or equipment

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to perform its intended production function.

Servicing and/or maintenance. Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, and maintaining and/or servicing machines or equipment. These activities include lubrication, cleaning or unjamming of machines or equipment and making adjustments or tool changes, where the employee may be exposed to the *unexpected* energization or startup of the equipment or release of hazardous energy.

Setting up. Any work performed to prepare a machine or equipment to perform its normal production operation.

Tagout. The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout device. A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy isolating device in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

(c) *General*—(1) *Energy control program.* The employer shall establish a program consisting of energy control procedures, employee training and periodic inspections to ensure that before any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, start up or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source, and rendered inoperative.

(2) *Lockout/tagout.* (i) If an energy isolating device is not capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize a tagout system.

(ii) If an energy isolating device is capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize lockout, unless the employer can demonstrate that the utilization of a tagout system will provide full employee protection as set forth in paragraph (c)(3) of this section.

(iii) After January 2, 1990, whenever replacement or major repair, renovation or modification of a machine or equipment is performed, and whenever new machines or equipment are installed, energy isolating devices for such machine or equipment shall be designed to accept a lockout device.

(3) *Full employee protection.* (i) When a tagout device is used on an energy isolating device which is capable of being locked out, the tagout device shall be attached at the same location that the lockout device would have been attached, and the employer shall demonstrate that the tagout program will provide a level of safety equivalent to that obtained by using a lockout program.

(ii) In demonstrating that a level of safety is achieved in the tagout program which is equivalent to the level of safety obtained by using a lockout program, the employer shall demonstrate full compliance with all tagout-related provisions of this standard together with such additional elements as are necessary to provide the equivalent safety available from the use of a lockout device. Additional means to be considered as part of the demonstration of full employee protection shall include the implementation of additional safety measures such as the removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnecting device, or the removal of a valve handle to reduce the likelihood of inadvertent energization.

(4) *Energy control procedure.* (i) Procedures shall be developed, documented and utilized for the control of potentially hazardous energy when employees are engaged in the activities covered by this section.

NOTE: *Exception:* The employer need not document the required procedure for a particular machine or equipment, when all of the following elements exist: (1) The machine or equipment has no potential for stored or residual energy or reaccumulation of stored energy after shut down which could endanger employees; (2) the machine or equipment has a single energy source which can be readily identified and isolated; (3) the isolation and locking out of that energy source will completely deenergize and deactivate the machine or equipment; (4) the machine or equipment is isolated from that energy source and locked out during servicing or maintenance; (5) a single lockout device will achieve a locked-out condition; (6) the lockout device is under the exclusive control of the authorized employee performing the servicing or maintenance; (7) the servicing or maintenance does not create hazards for other employees; and (8) the employer, in utilizing this exception, has had no accidents involving the unexpected activation or reenergization of the machine or equipment during servicing or maintenance.

(ii) The procedures shall clearly and specifically outline the scope, purpose, authorization, rules, and techniques to be utilized for the control of hazardous energy, and the means to enforce compliance including, but not limited to, the following:

(A) A specific statement of the intended use of the procedure;

(B) Specific procedural steps for shutting down, isolating, blocking and securing machines or equipment to control hazardous energy;

(C) Specific procedural steps for the placement, removal and transfer of lockout devices or tagout devices and the responsibility for them; and

(D) Specific requirements for testing a machine or equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other energy control measures.

(5) *Protective materials and hardware.* (i) Locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware shall be provided by the employer for isolating, securing or blocking of machines or equipment from energy sources.

(ii) Lockout devices and tagout devices shall be singularly identified; shall be the only devices(s) used for controlling energy; shall not be used for other purposes; and shall meet the following requirements:

(A) *Durable.* (*1*) Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.

(*2*) Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.

(*3*) Tags shall not deteriorate when used in corrosive environments such as areas where acid and alkali chemicals are handled and stored.

(B) *Standardized.* Lockout and tagout devices shall be standardized within the facility in at least one of the following criteria: Color; shape; or size; and additionally, in the case of tagout devices, print and format shall be standardized.

(C) *Substantial*—(*1*) *Lockout devices.* Lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters or other metal cutting tools.

(*2*) *Tagout devices.* Tagout devices, including and their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be of a non-reusable type, attachable by hand, self-locking, and non-releasable with a minimum unlocking strength of no less than 50 pounds and having the general design and basic characteristics of being at least equivalent to a one-piece, all-environment-tolerant nylon cable tie.

(D) *Identifiable.* Lockout devices and tagout devices shall indicate the identity of the employee applying the device(s).

(iii) Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: *Do Not Start, Do Not Open, Do Not Close, Do Not Energize, Do Not Operate.*

(6) *Periodic inspection.* (i) The employer shall conduct a periodic inspection of the energy control procedure at least annually to ensure that the procedure and the requirements of this standard are being followed.

(A) The periodic inspection shall be perfomed by an authorized employee other than the ones(s) utilizing the energy control procedure being inspected.

(B) The periodic inspection shall be conducted to correct any deviations or inadequacies identified.

(C) Where lockout is used for energy control, the periodic inspection shall include a review, between the inspector and each authorized employee, of that employee's responsibilities under the energy control procedure being inspected.

(D) Where tagout is used for energy control, the periodic inspection shall include a review, between the inspector and each authorized and affected employee, of that employee's responsibilities under the energy control procedure being inspected, and the elements set forth in paragraph (c)(7)(ii) of this section.

(ii) The employer shall certify that the periodic inspections have been performed. The certification shall identify the machine or equipment on which the energy control procedure was being utilized, the date of the inspection, the employees included in the inspection, and the person performing the inspection.

(7) *Training and communication.* (i) The employer shall provide training to ensure that the purpose and function of the energy control program are understood by employees and that the knowledge and skills required for the safe application, usage, and removal of the energy controls are acquired by employees. The training shall include the following:

(A) Each authorized employee shall receive training in the recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation and control.

(B) Each affected employee shall be instructed in the purpose and use of the energy control procedure.

(C) All other employees whose work operations are or may be in an area where energy control procedures may be utilized, shall be instructed about the procedure, and about the prohibition relating to attempts to restart or reenergize machines or equipment which are locked out or tagged out.

(ii) When tagout systems are used, employees shall also be trained in the following limitations of tags:

(A) Tags are essentially warning devices affixed to energy isolating devices, and do not provide the physical restraint on those devices that is provided by a lock.

(B) When a tag is attached to an energy isolating means, it is not to be removed without authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.

(C) Tags must be legible and understandable by all authorized employees, affected employees, and all other employees whose work operations are or may be in the area, in order to be effective.

(D) Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.

(E) Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.

(F) Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

(iii) Employee retraining.

(A) Retraining shall be provided for all authorized and affected employees whenever there is a change in their job assignments, a change in machines, equipment or processes that present a new hazard, or when there is a change in the energy control procedures.

(B) Additional retraining shall also be conducted whenever a periodic inspection under paragraph (c)(6) of this section reveals, or whenever the employer has reason to believe, that there are deviations from or inadequacies in the employee's knowledge or use of the energy control procedures.

(C) The retraining shall reestablish employee proficiency and introduce new or revised control methods and procedures, as necessary.

(iv) The employer shall certify that employee training has been accomplished and is being kept up to date. The certification shall contain each employee's name and dates of training.

(8) *Energy isolation.* Lockout or tagout shall be performed only bythe authorized employees who are performing the servicing or maintenance.

(9) *Notification of employees.* Affected employees shall be notified by the employer or authorized employee of the application and removal of lockout devices or tagout devices. Notification shall be given before the controls are applied, and after they are removed from the machine or equipment.

(d) *Application of control.* The established procedures for the application of energy control (the lockout or tagout procedures) shall cover the following elements and actions and shall be done in the following sequence:

(1) *Preparation for shutdown.* Before an authorized or affected employee turns off a machine or equipment, the authorized employee shall have knowledge of the type and magnitude of the energy, the hazards of the energy to be controlled, and the method or means to control the energy.

(2) *Machine or equipment shutdown.* The machine or equipment shall be turned off or shut down using the procedures established for the machine or equipment. An orderly shutdown must be utilized to avoid any additional or increased hazard(s) to employees as a result of the equipment stoppage.

(3) *Machine or equipment isolation.* All energy isolating devices that are needed to control the energy to the machine or equipment shall be physically located and operated in such a manner as to isolate the machine or equipment from the energy source(s).

(4) *Lockout or tagout device application.* (i) Lockout or tagout devices shall be affixed to each energy isolating device by authorized employees.

(ii) Lockout devices, where used, shall be affixed in a manner to that will hold the energy isolating devices in a "safe" or "off" position.

(iii) Tagout devices, where used, shall be affixed in such a manner as will clearly indicate that the operation or movement of energy isolating devices from the "safe" or "off" position is prohibited.

(A) Where tagout devices are used with energy isolating devices designed with the capability of being locked, the tag attachment shall be fastened at the same point at which the lock would have been attached.

(B) Where a tag cannot be affixed directly to the energy isolating device, the tag shall be located as close as safely possible to the device, in a position that will be immediately obvious to anyone attempting to operate the device.

(5) *Stored energy.* (i) Following the application of lockout or tagout devices to energy isolating devices, all potentially hazardous stored or residual energy shall be relieved, disconnected, restrained, and otherwise rendered safe.

(ii) If there is a possibility of reaccumulation of stored energy to a hazardous level, verification of isolation shall be continued until the servicing or maintenance is completed, or until the possibility of such accumulation no longer exists.

(6) *Verification of isolation.* Prior to starting work on machines or equipment that have been locked out or tagged out, the authorized employee shall verify that isolation and deenergization of the machine or equipment have been accomplished.

(e) *Release from lockout or tagout.* Before lockout or tagout devices are removed and energy is restored to the machine or equipment, procedures shall be followed and actions taken by the authorized employee(s) to ensure the following:

(1) *The machine or equipment.* The work area shall be inspected to ensure that nonessential items have been removed and to ensure that machine or equipment components are operationally intact.

(2) *Employees.* (i) The work area shall be checked to ensure that all employees have been safely positioned or removed.

(ii) After lockout or tagout devices have been removed and before a machine or equipment is started, affected employees shall be notified that the lockout or tagout device(s) have been removed.

(3) *Lockout or tagout devices removal.* Each lockout or tagout device shall be removed from each energy isolating device by the employee who applied the device. *Exception to paragraph (e)(3):* When the authorized employee who applied the lockout or tagout device is not available to remove it, that device may be removed under the direction of the employer, provided that specific procedures and training

for such removal have been developed, documented and incorporated into the employer's energy control program. The employer shall demonstrate that the specific procedure provides equivalent safety to the removal of the device by the authorized employee who applied it. The specific procedure shall include at least the following elements:

(i) Verification by the employer that the authorized employee who applied the device is not at the facility;

(ii) Making all reasonable efforts to contact the authorized employee to inform him/her that his/her lockout or tagout device has been removed; and

(iii) Ensuring that the authorized employee has this knowledge before he/she resumes work at that facility.

(f) *Additional requirements.* (1) *Testing or positioning of machines, equipment or components thereof.* In situations in which lockout or tagout devices must be temporarily removed from the energy isolating device and the machine or equipment energized to test or position the machine, equipment or component thereof, the following sequence of actions shall be followed:

(i) Clear the machine or equipment of tools and materials in accordance with paragraph (e)(1) of this section;

(ii) Remove employees from the machine or equipment area in accordance with paragraph (e)(2) of this section;

(iii) Remove the lockout or tagout devices as specified in paragraph (e)(3) of this section;

(iv) Energize and proceed with testing or positioning;

(v) Deenergize all systems and reapply energy control measures in accordance with paragraph (d) of this section to continue the servicing and/or maintenance.

(2) *Outside personnel (contractors, etc.).* (i) Whenever outside servicing personnel are to be engaged in activities covered by the scope and application of this standard, the on-site employer and the outside employer shall inform each other of their respective lockout or tagout procedures.

(ii) The on-site employer shall ensure that his/her employees understand and comply with the restrictions and prohibitions of the outside employer's energy control program.

(3) *Group lockout or tagout.* (i) 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.

(ii) Group lockout or tagout devices shall be used in accordance with the procedures required by paragraph (c)(4) of this section including, but not necessarily limited to, the following specific requirements:

(A) Primary responsibility is vested in an authorized employee for a set number of employees working under the protection of a group lockout or tagout device (such as an operations lock);

(B) Provision for the authorized employee to ascertain the exposure status of individual group members with regard to the lockout or tagout of the machine or equipment and

(C) When more than one crew, craft, department, etc. is involved, assignment of overall job-associated lockout or tagout control responsibility to an authorized employee designated to coordinate affected work forces and ensure continuity of protection; and

(D) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, 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.

(4) *Shift or personnel changes.* Specific procedures shall be utilized during shift or personnel changes to ensure the continuity of lockout or tagout protection, including provision for the orderly transfer of lockout or tagout device protection between off-going and oncoming employees, to minimize exposure to hazards from the unexpected energization or start-up of the machine or equipment, or the release of stored energy.

(The information collection requirements contained in this section are approved by the Office of Management and Budget (OMB) and listed under OMB control number 1218-0150)

NOTE: The following Appendix to § 1910.147 services as a non-mandatory guideline to assist employers and employees in complying with the requirements of this section, as well as to provide other helpful information. Nothing in the Appendix adds to or detracts from any of the requirements of this section.

APPENDIX A TO § 1910.147—Typical Minimal Lockout Procedure

General

The following simple lockout procedure is provided to assist employers in developing their procedures so they meet the requirements of this standard. When the energy isolating devices are not lockable, tagout may be used, provided the employer complies with the provisions of the standard which require additional training and more rigorous periodic inspections. When tagout is used and the energy isolating devices are lockable, the employer must provide full employee protection (*see* paragraph (c)(3)) and additional training and more rigorous periodic inspections are required. For more complex systems, more comprehensive procedures may need to be developed, documented and utilized.

Lockout Procedure

Lockout procedure for

(Name of Company for single procedure or identification of equipment if multiple procedures are used)

Purpose

This procedure establishes the minimum requirements for the lockout of energy isolating devices whenever maintenance or servicing is done on machines or equipment. It shall be used to ensure that the machine or equipment is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the machine or equipment or release of stored energy could cause injury.

Compliance With This Program

All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout. The authorized employees are required to perform the lockout in accordance with this procedure. All employees, upon observing a machine or piece of equipment which is locked out to perform servicing or maintenance shall not attempt to start, energize or use that machine or equipment.

Type of compliance enforcement to be taken for violation of the above.

Sequence of Lockout

(1) Notify all affected employees that servicing or maintenance is required on a machine or equipment and that the machine or equipment must be shut down and locked out to perform the servicing or maintenance.

Name(s)/Job Title(s) of affected employees and how to notify.

(2) The authorized employee shall refer to the company procedure to identify the type and magnitude of the energy that the machine or equipment utilizes, shall understand the hazards of the energy, and shall know the methods to control the energy.

Type(s) and magnitude(s) of energy, its hazards and the methods to control the energy.

(3) If the machine or equipment is operating, shut it down by the normal stopping procedure (depress stop button, open switch, close valve, etc.).

Type(s) and location(s) of machine or equipment operating controls.

(4) De-activate the energy isolating device(s) so that the machine or equipment is isolated from the energy source(s).

Type(s) and location(s) of energy isolating devices.

(5) Lock out the energy isolating device(s) with assigned individual lock(s).

(6) Stored or residual energy (such as that in capacitors, springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam, or water pressure, *etc.*) must be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding down, etc.

Type(s) of stored energy—methods to dissipate or restrain.

(7) Ensure that the equipment is disconnected from the energy source(s) by first checking that no personnel are exposed, then verify the isolation of the equipment by operating the push button or other normal operating control(s) or by testing to make certain the equipment will not operate.

CAUTION: Return operating control(s) to neutral or "off" position after verifying the isolation of the equipment.

Method of verifying the isolation of the equipment.

(8) The machine or equipment is now locked out.

Restoring Equipment to Service. When the servicing or maintenance is completed and the machine or equipment is ready to return to normal operating condition, the following steps shall be taken.

(1) Check the machine or equipment and the immediate area around the machine or equipment to ensure that nonessential items have been removed and that the machine or equipment components are operationally intact.

(2) Check the work area to ensure that all employees have been safely positioned or removed from the area.

(3) Verify that the controls are in neutral.

(4) Remove the lockout devices and reenergize the machine or equipment.

Note: The removal of some forms of blocking may require reenergization of the machine before safe removal.

(5) Notify affected employees that the servicing or maintenance is completed and the machine or equipment is ready for use.

[54 FR 36687, Sept. 1, 1989, as amended at 54 FR 42498, Oct. 17, 1989; 55 FR 38685, 38686, Sept. 20, 1990]

§ 1910.148 Standards organizations.

Standard and specifications of the following organizations have been referenced in this subpart J:

American National Standards Institute, 1430 Broadway, New York, NY 10018.
National Association of Plumbing and Mechanical Officials, 5032 Alhambra Avenue, Los Angeles, CA 90032.
American Society of Agricultural Engineers, 2950 Niles Road, Post Office Box 229, St. Joseph, MI 49085.

§ 1910.149 Effective dates.

(a) The provisions of this subpart J shall become effective on August 27, 1971, except as provided in the remaining paragraphs of this section.

(b) The following provisions shall become effective on February 15, 1972:

§ 1910.142(b) (2), (b) (5), (b) (7), (d) (6), (f), (g), (i) (1) and (2).

(c) Notwithstanding anything in paragraph (a), (b), or (d) of this section, any provision in any other section of this subpart which contains in itself a specific effective date or time limitation shall become effective on such date or shall apply in accordance with such limitation.

(d) Notwithstanding anything in paragraph (a) of this section, if any standard in 41 CFR part 50-204, other than a national consensus standard incorporated by reference in 50-204.2(a)(1), is or becomes applicable at any time to any employment and place of employment, by virtue of the Walsh-Healey Public Contracts Act, or the Service Contract Act of 1965, or the National Foundation on Arts and Humanities Act of 1965, any corresponding established Federal standard in this subpart J which is derived from 41 CFR part 50-204 shall also become effective, and shall be applicable to such employment and place of employment, on the same date.

§ 1910.150 Sources of standards.

The standards in this subpart J are derived from the following sources:

Sec.	Source
1910.141	ANSI Z4.1-1968, Minimum Requirements for Sanitation in Place of Employment.
1910.142	ANSI Z4.4-1968, Minimum Requirements for Sanitation in Temporary Labor Camps.
1910.143	ANSI Z4.3-1970, Minimum Requirements for Nonwater Carriage. Disposal Systems.
1910.144	ANSI Z53.1-1967, Safety Color Code for Marking Physical Hazards.
1910.145 (a)-(e)	ANSI Z35.1-1968, Specifications for Accident Prevention Signs, and ANSI B114.1-1971, Slow-Moving Vehicle Identification Emblem.
1910.145(f)	ANSI Z35.2-1968, Specifications for Accident Prevention Tags.

[39 FR 23502, June 27, 1974. Redesignated at 54 FR 36687, Sept. 1, 1989]

Subpart K—Medical and First Aid

AUTHORITY: Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059) or 9-83 (48 FR 35736), as applicable.

§ 1910.151 Medical services and first aid.

(a) The employer shall ensure the ready availability of medical personnel for advice and consultation on matters of plant health.

(b) In the absence of an infirmary, clinic, or hospital in near proximity to the workplace which is used for the treatment of all injured employees, a person or persons shall be adequately trained to render first aid. First aid supplies approved by the consulting physician shall be readily available.

(c) Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use.

§ 1910.152 [Reserved]

§ 1910.153 Sources of standards.

The standard in § 1910.151 is derived from 41 CFR 50-204.6.

Subpart L—Fire Protection

AUTHORITY: Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059) or No. 9-83 (48 FR 35736), as applicable.

Sections 1910.155, 1910.158, 1910.159, 1910.160 and 1910.161 also issued under 29 CFR part 1911.

§ 1910.155 Scope, application and definitions applicable to this subpart.

(a) *Scope.* This subpart contains requirements for fire brigades, and all portable and fixed fire suppression equipment, fire detection systems, and fire or employee alarm systems installed to meet the fire protection requirements of 29 CFR part 1910.

(b) *Application.* This subpart applies to all employments except for maritime, construction, and agriculture.

(c) *Definitions applicable to this subpart.* (1) *After-flame* means the time a test specimen continues to flame after the flame source has been removed.

(2) *Aqueous film forming foam (AFFF)* means a fluorinated surfactant with a foam stabilizer which is diluted with water to act as a temporary barrier to exclude air from mixing with the fuel vapor by developing an aqueous film on the fuel surface of some hydrocarbons which is capable of suppressing the generation of fuel vapors.

(3) *Approved* means acceptable to the Assistant Secretary under the following criteria:

(i) If it is accepted, or certified, or listed, or labeled or otherwise determined to be safe by a nationally recognized testing laboratory; or

(ii) With respect to an installation or equipment of a kind which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency and found in compliance with the provisions of the applicable National Fire Protection Association Fire Code; or

(iii) With respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary.

(iv) For the purposes of paragraph (c)(3) of this section:

(A) Equipment is listed if it is of a kind mentioned in a list which is published by a nationally recognized testing laboratory which makes periodic inspections of the production of such equipment and which states that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner;

(B) Equipment is labeled if there is attached to it a label, symbol, or other identifying mark of a nationally recognized testing laboratory which makes periodic inspections of the production of such equipment, and whose labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner;

(C) Equipment is accepted if it has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes; and

(D) Equipment is certified if it has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner or is of a kind whose production is periodically inspected by a nationally recognized testing laboratory, and if it bears a label, tag, or other record of certification.

Subject	National consensus standards
Dust removal and exhaust systems	ANSI/NFPA 91

APPENDIX C TO § 1910.272 GRAIN HANDLING FACILITIES

References for Further Information

The following references provide information which can be helpful in understanding the requirements contained in various provisions of the standard, as well as provide other helpful information.

1. *Accident Prevention Manual for Industrial Operations;* National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.
2. *Practical Guide to Elevator Design;* National Grain and Feed Association, P.O. Box 28328, Washington, DC 20005.
3. *Dust Control for Grain Elevators;* National Grain and Feed Association, P.O. Box 28328, Washington, DC 20005.
4. *Prevention of Grain Elevator and Mill Explosions;* National Academy of Sciences, Washington, DC. (Available from National Technical Information Service, Springfield, Virginia 22151.)
5. *Standard for the Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities,* NFPA 61B; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
6. *Standard for the Prevention of Fire and Dust Explosions in Feed Mills,* NFPA 61C; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
7. *Standard for the Prevention of Fire and Dust Explosions in the Milling of Agricultural Commodities for Human Consumption,* NFPA 61D; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
8. *Standard for Pneumatic Conveying Systems for Handling Feed, Flour, Grain and Other Agricultural Dusts,* NFPA 66; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
9. *Guide for Explosion Venting,* NFPA 68; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
10. *Standard on Explosion Prevention Systems,* NFPA 69; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
11. *Safety-Operations Plans;* U.S. Department of Agriculture, Washington, DC 20250.
12. *Inplant Fire Prevention Control Programs;* Mill Mutual Fire Prevention Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
13. *Guidelines for Terminal Elevators;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
14. *Standards for Preventing the Horizontal and Vertical Spread of Fires in Grain Handling Properties;* Mill Mutual Fire Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
15. *Belt Conveyors for Bulk Materials,* Part I and Part II, Data Sheet 570, Revision A; National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.
16. *Suggestions for Precautions and Safety Practices in Welding and Cutting;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
17. *Food Bins and Tanks,* Data Sheet 524; National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.
18. *Pneumatic Dust Control in Grain Elevators;* National Academy of Sciences, Washington, DC. (Available from National Technical Information Service, Springfield, Virginia 22151.)
19. *Dust Control Analysis and Layout Procedures for Grain Storage and Processing Plants;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
20. *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal,* NFPA 91; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
21. *Standards for the Installation of Direct Heat Grain Driers in Grain and Milling Properties;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
22. *Guidelines for Lubrication and Bearing Maintenance;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
23. *Organized Maintenance in Grain and Milling Properties;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
24. *Safe and Efficient Elevator Legs for Grain and Milling Properties;* Mill Mutual Fire Prevention Bureau, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
25. *Explosion Venting and Supression of Bucket Elevators;* National Grain and Feed Association, P.O. Box 28328, Washington, DC 20005.
26. *Lightning Protection Code,* NFPA 78; National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.
27. *Occupational Safety in Grain Elevators,* DHHS (NIOSH) Publication No. 83-126); National Institute for Occupational Safety and Health, Morgantown, West Virginia 26505.
28. *Retrofitting and Constructing Grain Elevators;* National Grain and Feed Association, P.O. Box 28328, Washington, DC 20005.
29. *Grain Industry Safety and Health Center—Training Series* (Preventing grain dust explosions, operations maintenance safety, transportation safety, occupational safety and health); Grain Elevator and Processing Society, P.O. Box 15026, Commerce Station, Minneapolis, Minnesota 55415-0026.
30. *Suggestions for Organized Maintenance;* The Mill Mutuals Loss Control Department, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
31. *Safety—The First Step to Success;* The Mill Mutual Loss Control Department, 1 Pierce Place, Suite 1260 West, Itasca, Illinois 60143-1269.
32. *Emergency Plan Notebook;* Schoeff, Robert W. and James L. Balding, Kansas State University, Cooperative Extension Service, Extension Grain Science and Industry, Shellenberger Hall, Manhattan, Kansas 66506.

[52 FR 49625, Dec. 31, 1987, as amended at 53 FR 17696, May 18, 1988; 54 FR 24334, June 7, 1989; 55 FR 25094, June 20, 1990]

§ 1910.274 Sources of standards.

Sec.	Source
1910.261	ANSI P1.1—1969, Safety Standard for Pulp, Paper, and Paperboard Mills.
1910.264	ANSI L1.1—1956, Textile Safety Code.
1910.263	ANSI Z50.1—1947, Safety Code for Bakery Equipment.
1910.262	ANSI Z8.1—1961, Safety Code for Laundry Machinery and Operations.
1910.265	ANSI O2.1—1969, Safety Requirements for Sawmills.
1910.266	ANSI O3.1—1971, Pulpwood Logging Safety Standards.

[39 FR 23502, June 27, 1974. Redesignated at 40 FR 13449, Mar. 26, 1975]

§ 1910.275 Standards organizations.

Specific standards of the following organizations have been referenced in this subpart. Copies of the referenced standards may be obtained from the issuing organizations. The names and addresses of the issuing organizations are as follows:

American National Standards Institute (ANSI)
1430 Broadway
New York, New York 10018

National Fire Protection Association (NFPA)
470 Atlantic Avenue
Boston, Massachusetts 02210

American Society of Mechanical Engineers, Inc., United Engineering Center
345 East 47th Street
New York, New York 10017

Institute of Markers of Explosives
420 Lexington Avenue
New York, New York 10017

Underwriters' Laboratories, Inc.
207 East Ohio Street
Chicago, Illinois 60611

American Society for Testing & Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103

[40 FR 13449, Mar. 26, 1975]

Subpart S—Electrical

AUTHORITY: Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657; Secretary of Labor's Order No. 8-76 (41 FR 25059) or 1-90 (55 FR 9033), as applicable; 29 CFR part 1911.

SOURCE: 46 FR 4056, Jan. 16, 1981, unless otherwise noted.

GENERAL

§ 1910.301 Introduction.

This subpart addresses electrical safety requirements that are necessary for the practical safeguarding of employees in their workplaces and is divided into four major divisions as follows:

(a) *Design safety standards for electrical systems.* These regulations are contained in §§ 1910.302 through 1910.330. Sections 1910.302 through 1910.308 contain design safety standards for electric utilization systems. Included in this category are all electric equipment and installations used to provide electric power and light for employee workplaces. Sections 1910.309 through 1910.330 are reserved for possible future design safety standards for other electrical systems.

(b) *Safety-related work practices.* These regulations will be contained in §§ 1910.331 through 1910.360.

(c) *Safety-related maintenance requirements.* These regulations will be contained in §§ 1910.361 through 1910.380.

(d) *Safety requirements for special equipment.* These regulations will be contained in §§ 1910.381 through 1910.398.

(e) *Definitions.* Definitions applicable to each division are contained in § 1910.399.

[46 FR 4056, Jan. 16, 1982; 46 FR 40185, Aug. 7, 1981]

DESIGN SAFETY STANDARDS FOR ELECTRICAL SYSTEMS

§ 1910.302 Electric utilization systems.

Sections 1910.302 through 1910.308 contain design safety standards for electric utilization systems.

(a) *Scope*—(1) *Covered.* The provisions of §§ 1910.302 through 1910.308 of this subpart cover electrical installations and utilization equipment installed or used within or on buildings, structures, and other premises including:

(i) Yards,

(ii) Carnivals,

(iii) Parking and other lots,

(iv) Mobile homes,

(v) Recreational vehicles,

(vi) Industrial substations,

(vii) Conductors that connect the installations to a supply of electricity, and

(viii) Other outside conductors on the premises.

(2) *Not covered.* The provisions of §§ 1910.302 through 1910.308 of this subpart do not cover:

(i) Installations in ships, watercraft, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles.

(ii) Installations underground in mines.

(iii) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communication purposes.

(iv) Installations of communication equipment under the exclusive control of communication utilities, located outdoors or in building spaces used exclusively for such installations.

(v) Installations under the exclusive control of electric utilities for the purpose of communication or metering; or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or located outdoors on property owned or leased by the utility or on public highways, streets, roads, etc., or outdoors by established rights on private property.

(b) *Extent of application.* (1) The requirements contained in the sections listed below shall apply to all electrical installations and utilization equipment, regardless of when they were designed or installed.

Sections:

1910.303(b)	Examination, installation, and use of equipment.
1910.303(c)	Splices.
1910.303(d)	Arcing parts.
1910.303(e)	Marking.
1910.303(f)	Identification of disconnecting means.
1910.303(g)(2)	Guarding of live parts.
1910.304(e)(1)(i)	Protection of conductors and equipment.
1910.304(e)(1)(iv)	Location in or on premises.
1910.304(e)(1)(v)	Arcing or suddenly moving parts.
1910.304(f)(1)(ii)	2-Wire DC systems to be grounded:
1910.304(f)(1)(iii) and 1910.304(f)(1)(iv).	AC Systems to be grounded.
1910.304(f)(1)(v)	AC Systems 50 to 1000 volts not required to be grounded.
1910.304(f)(3)	Grounding connections.
1910.304(f)(4)	Grounding path.
1910.304(f)(5)(iv)(*a*) through 1910.304(f)(5)(iv)(*d*).	Fixed equipment required to be grounded.
1910.304(f)(5)(v)	Grounding of equipment connected by cord and plug.
1910.304(f)(5)(vi)	Grounding of nonelectrical equipment.
1910.304(f)(6)(i)	Methods of grounding fixed equipment.
1910.305(g)(1)(i) and 1910.305(g)(1)(ii).	Flexible cords and cables, uses.
1910.305(g)(1)(iii)	Flexible cords and cables prohibited.
1910.305(g)(2)(ii)	Flexible cords and cables, splices.
1910.305(g)(2)(iii)	Pull at joints and terminals of flexible cords and cables.
1910.307	Hazardous (classified) locations.

(2) Every electric utilization system and all utilization equipment installed after March 15, 1972, and every major replacement, modification, repair, or rehabilitation, after March 15, 1972, of any part of any electric utilization system or utilization equipment installed before March 15, 1972, shall comply with the provisions of §§ 1910.302 through 1910.308.

NOTE: "Major replacements, modifications, repairs, or rehabilitations" include work similar to that involved when a new building or facility is built, a new wing is added, or an entire floor is renovated.

(3) The following provisions apply to electric utilization systems and utilization equipment installed after April 16, 1981:

§ 1910.303(h)(4) (i) and (ii).	Entrance and access to workspace (over 600 volts).
§ 1910.304(e)(1)(vi)(*b*)	Circuit breakers operated vertically.
§ 1910.304(e)(1)(vi)(*c*)	Circuit breakers used as switches.
§ 1910.304(f)(7)(ii)	Grounding of systems of 1000 volts or more supplying portable or mobile equipment.
§ 1910.305(j)(6)(ii)(*b*)	Switching series capacitors over 600 volts.
§ 1910.306(c)(2)	Warning signs for elevators and escalators.
§ 1910.306(i)	Electrically controlled irrigation machines.
§ 1910.306(j)(5)	Ground-fault circuit interrupters for fountains.
§ 1910.308(a)(1)(ii)	Physical protection of conductors over 600 volts.
§ 1910.308(c)(2)	Marking of Class 2 and Class 3 power supplies.
§ 1910.308(d)	Fire protective signaling circuits.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.303 General requirements.

(a) *Approval.* The conductors and equipment required or permitted by this subpart shall be acceptable only if approved.

(b) *Examination, installation, and use of equipment*—(1) *Examination.* Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined using the following considerations:

(i) Suitability for installation and use in conformity with the provisions of this subpart. Suitability of equipment for an identified purpose may be evidenced by listing or labeling for that identified purpose.

(ii) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(iii) Electrical insulation.

(iv) Heating effects under conditions of use.

(v) Arcing effects.

(vi) Classification by type, size, voltage, current capacity, specific use.

(vii) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

(2) *Installation and use.* Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.

(c) *Splices.* Conductors shall be spliced or joined with splicing devices suitable for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device suitable for the purpose.

(d) *Arcing parts.* Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

(e) *Marking.* Electrical equipment may not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as necessary. The marking shall be of sufficient durability to withstand the environment involved.

(f) *Identification of disconnecting means and circuits.* Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involved.

(g) *600 Volts, nominal, or less*—(1) *Working space about electric equipment.* Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(i) *Working clearances.* Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive may not be less than indicated in Table S-1. In addition to the dimensions shown in Table S-1, workspace may not be less than 30 inches wide in front of the electric equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Concrete, brick, or tile walls are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

TABLE S-1—WORKING CLEARANCES

Nominal voltage to ground	Minimum clear distance for condition[2] (ft)		
	(a)	*(b)*	*(c)*
0–150	[1] 3	[1] 3	3
151–600	[1] 3	3½	4

[1] Minimum clear distances may be 2 feet 6 inches for installations built prior to April 16, 1981.

[2] Conditions *(a)*, *(b)*, and *(c)*, are as follows: *(a)* Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. *(b)* Exposed live parts on one side and grounded parts on the other side. *(c)* Exposed live parts on both sides of the workspace [not guarded as provided in Condition *(a)*] with the operator between.

(ii) *Clear spaces.* Working space required by this subpart may not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded.

(iii) *Access and entrance to working space.* At least one entrance of sufficient area shall be provided to give access to the working space about electric equipment.

(iv) *Front working space.* Where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment may not be less than 3 feet.

(v) *Illumination.* Illumination shall be provided for all working spaces about service equipment, switchboards, panelboards, and motor control centers installed indoors.

(vi) *Headroom.* The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 6 feet 3 inches.

NOTE: As used in this section a motor control center is an assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

(2) *Guarding of live parts.* (i) Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures, or by any of the following means:

(A) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(B) By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(C) By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(D) By elevation of 8 feet or more above the floor or other working surface.

(ii) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(h) *Over 600 volts, nominal*—(1) *General.* Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable provisions of paragraphs (a) through (g) of this section and with the following provisions which supplement or modify those requirements. The provisions of paragraphs (h)(2), (h)(3), and (h)(4) of this section do not apply to equipment on the supply side of the service conductors.

(2) *Enclosure for electrical installations.* Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other approved means, are considered to be accessible to qualified persons only. A wall, screen, or fence less than 8 feet in height is not considered to prevent access unless it has other features that provide a degree of isolation equivalent to an 8 foot fence. The entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

(i) *Installations accessible to qualified persons only.* Electrical installations having exposed live parts shall be accessible to qualified persons only and shall comply with the applicable provisions of paragraph (h)(3) of this section.

(ii) *Installations accessible to unqualified persons.* Electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area, access to which is controlled by a lock. If metal-enclosed equipment is installed so that the bottom of the enclosure is less than 8 feet above the floor, the door or cover shall be kept locked. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. If equipment is exposed to physical damage from vehicular traffic, suitable guards shall be provided to prevent such damage. Ventilating or similar openings in metal-enclosed equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(3) *Workspace about equipment.* Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace may not be less than 6 feet 6 inches high (measured vertically from the floor or platform), or less than 3 feet wide (measured parallel to the equipment). The depth shall be as required in Table S-2. The workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

(i) *Working space.* The minimum clear working space in front of electric equipment such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment may not be less than specified in Table S-2 unless otherwise specified in this subpart. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. However, working space is not required in back of equipment such as deadfront switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches horizontally shall be provided.

TABLE S-2—MINIMUM DEPTH OF CLEAR WORKING SPACE IN FRONT OF ELECTRIC EQUIPMENT

Nominal voltage to ground	Conditions[2] (ft)		
	(a)	*(b)*	*(c)*
601 to 2,500	3	4	5
2,501 to 9,000	4	5	6
9,001 to 25,000	5	6	9
25,001 to 75kV[1]	6	8	10

TABLE S-2—MINIMUM DEPTH OF CLEAR WORKING SPACE IN FRONT OF ELECTRIC EQUIPMENT—Continued

Nominal voltage to ground	Conditions[2] (ft) (a)	(b)	(c)
Above 75kV[1]	8	10	12

[1] Minimum depth of clear working space in front of electric equipment with a nominal voltage to ground above 25,000 volts may be the same as for 25,000 volts under Conditions (a), (b), and (c) for installations built prior to April 16, 1981.

[2] Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered as grounded surfaces. (c) Exposed live parts on both sides of the workspace not guarded as provided in Condition (a) with the operator between.

(ii) *Illumination.* Adequate illumination shall be provided for all working spaces about electric equipment. The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(iii) *Elevation of unguarded live parts.* Unguarded live parts above working space shall be maintained at elevations not less than specified in Table S-3.

TABLE S-3—ELEVATION OF UNGUARDED ENERGIZED PARTS ABOVE WORKING SPACE

Nominal voltage between phases	Minimum elevation
601 to 7,500	[1]8 feet 6 inches.
7,501 to 35,000	9 feet.
Over 35kV	9 feet + 0.37 inches per kV above 35kV.

[1] Note.—Minimum elevation may be 8 feet 0 inches for installations built prior to April 16, 1981 if the nominal voltage between phases is in the range of 601–6600 volts.

(4) *Entrance and access to workspace.* (See § 1910.302(b)(3).)

(i) At least one entrance not less than 24 inches wide and 6 feet 6 inches high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches in width, there shall be one entrance at each end of such board where practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be suitably guarded.

(ii) Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.304 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors.* (1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor may be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug may not be used for purposes other than grounding.

(b) *Branch circuits*—(1) [Reserved]

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served.

(c) *Outside conductors, 600 volts, nominal, or less.* Paragraphs (c)(1), (c)(2), (c)(3), and (c)(4) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors. Paragraph (c)(5) applies to lamps installed under such conductors.

(1) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(i) Power conductors below communication conductors—30 inches.

(ii) Power conductors alone or above communication conductors: 300 volts or less—24 inches; more than 300 volts—30 inches.

(iii) Communication conductors below power conductors with power conductors 300 volts or less—24 inches; more than 300 volts—30 inches.

(2) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

(i) 10 feet—above finished grade, sidewalks, or from any platform or projection from which they might be reached.

(ii) 12 feet—over areas subject to vehicular traffic other than truck traffic.

(iii) 15 feet—over areas other than those specified in paragraph (c)(2)(iv) of this section that are subject to truck traffic.

(iv) 18 feet—over public streets, alleys, roads, and driveways.

(3) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet from windows, doors, porches, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet away.

(4) *Clearance over roofs.* Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass, except that:

(i) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches in 12, the clearance from roofs shall be at least 3 feet, or

(ii) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet of the overhang portion of the roof and they are terminated at a through-the-roof raceway or approved support, the clearance from roofs shall be at least 18 inches.

(5) *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services*—(1) *Disconnecting means*—(i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

(i) *Guarding.* Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

(ii) *Warning signs.* Signs warning of high voltage shall be posted where other than qualified employees might come in contact with live parts.

(e) *Overcurrent protection.* (1) *600 volts, nominal, or less.* The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current.

(ii) *Grounded conductors.* Except for motor running overload protection, overcurrent devices may not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

(iii) *Disconnection of fuses and thermal cutouts.* Except for service fuses, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

(iv) *Location in or on premises.* Overcurrent devices shall be readily accessible to each employee or authorized building management personnel. These overcurrent devices may not be located where they will be exposed to physical damage nor in the vicinity of easily ignitible material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

(vi) *Circuit breakers.* (A) Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

(B) Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position. (See § 1910.302(b)(3).)

(C) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be approved for the purpose and marked "SWD." (See § 1910.302(b)(3).)

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(7) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) All 3-wire DC systems shall have their neutral conductor grounded.

(ii) Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless:

(A) They supply only industrial equipment in limited areas and are equipped with a ground detector; or

(B) They are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(iv), and (f)(1)(v) of this section; or

(C) They are fire-protective signaling circuits having a maximum current of 0.030 amperes.

(iii) AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(A) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(B) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(C) If the system is nominally rated 240/120 volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or

(D) If a service conductor is uninsulated.

(v) AC systems of 50 volts to 1000 volts are not required to be grounded under any of the following conditions:

(A) If the system is used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like.

(B) If the system is separately derived and is used exclusively for rectifiers supplying only adjustable speed industrial drives.

(C) If the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(*1*) The system is used exclusively for control circuits,

(*2*) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(*3*) Continuity of control power is required, and

(*4*) Ground detectors are installed on the control system.

(D) If the system is an isolated power system that supplies circuits in health care facilities.

(2) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(3) *Grounding connections.* (i) For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(iii) On extensions of existing branch circuits which do not have an equipment grounding conductor, grounding-type receptacles may be grounded to a grounded cold water pipe near the equipment.

(4) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(5) *Supports, enclosures, and equipment to be grounded*—(i) *Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

(A) Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; or

(B) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met: (*1*) Runs are less than 25 feet; (*2*) enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and (*3*) enclosures are guarded against employee contact.

(ii) *Service equipment enclosures.* Metal enclosures for service equipment shall be grounded.

(iii) *Frames of ranges and clothes dryers.* Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and metal outlet or junction boxes which are part of the circuit for these appliances shall be grounded.

(iv) *Fixed equipment.* Exposed non-current-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

(A) If within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects and subject to employee contact.

(B) If located in a wet or damp location and not isolated.

(C) If in electrical contact with metal.

(D) If in a hazardous (classified) location.

(E) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

(F) If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

(*1*) Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

(*2*) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

(*3*) The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet above ground or grade level.

(v) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(5)(v)(A) through (f)(5)(v)(C) of this section, exposed non-current-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded.

(A) If in hazardous (classified) locations (see § 1910.307).

(B) If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

(C) If the equipment is of the following types:

(*1*) Refrigerators, freezers, and air conditioners;

(*2*) Clothes-washing, clothes-drying and dishwashing machines, sump pumps, and electrical aquarium equipment;

(*3*) Hand-held motor-operated tools;

(*4*) Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers;

(*5*) Cord- and plug-connected appliances used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;

(*6*) Portable and mobile X-ray and associated equipment;

(*7*) Tools likely to be used in wet and conductive locations; and

(*8*) Portable hand lamps.

Tools likely to be used in wet and conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes an approved system of double insulation.

(vi) *Nonelectrical equipment.* The metal parts of the following nonelectrical equipment shall be grounded: frames and tracks of electrically operated cranes; frames of nonelectrically driven elevator cars to which electric conductors are attached; hand operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over 750 volts between conductors.

(6) *Methods of grounding fixed equipment.* (i) Non-current-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the non-current-carrying metal parts of fixed equipment in paragraph (f)(6)(i) of this section. For installations made before April 16, 1981, only, electric equipment is also considered to be effectively grounded if it is secured to, and in metallic contact with, the grounded structural metal frame of a building. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(7) *Grounding of systems and circuits of 1000 volts and over (high voltage.)*—(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(6) of this section as supplemented and modified by this paragraph (f)(7).

(ii) *Grounding of systems supplying portable or mobile equipment.* (See § 1910.302(b)(3).) Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(A) Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.

(B) Exposed non-current-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(D) The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence, etc.

(iii) *Grounding of equipment.* All non-current-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet above ground or grade level need not be grounded.

[46 FR 4056, Jan. 16, 1981; 46 FR 40186, Aug. 7, 1981, as amended at 55 FR 32015, Aug. 6, 1990]

§ 1910.305 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this section do not apply to the conductors that are an integral part of factory-assembled equipment.

(1) *General requirements*—(i) *Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

(ii) *Wiring in ducts.* No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type may be installed in any duct used for vapor removal or for ventilation of commercial-type cooking equipment, or in any shaft containing only such ducts.

(2) *Temporary wiring.* Temporary electrical power and lighting wiring methods may be of a class less than would be required for a permanent installation. Except as specifically modified in this paragraph, all other requirements of this subpart for permanent wiring shall apply to temporary wiring installations.

(i) *Uses permitted, 600 volts, nominal, or less.* Temporary electrical power and lighting installations 600 volts, nominal, or less may be used only:

(A) During and for remodeling, maintenance, repair, or demolition of buildings, structures, or equipment, and similar activities;

(B) For experimental or development work, and

(C) For a period not to exceed 90 days for Christmas decorative lighting, carnivals, and similar purposes.

(ii) *Uses permitted, over 600 volts, nominal.* Temporary wiring over 600 volts, nominal, may be used only during periods of tests, experiments, or emergencies.

(iii) *General requirements for temporary wiring.* (A) Feeders shall originate in an approved distribution center. The conductors shall be run as multiconductor cord or cable assemblies, or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet apart.

(B) Branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be multiconductor cord or cable assemblies or open conductors. If run as open conductors they shall be fastened at ceiling height every 10 feet. No branch-circuit conductor may be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if run as open conductors.

(C) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor and all receptacles shall be electrically connected to the grounding conductor.

(D) No bare conductors nor earth returns may be used for the wiring of any temporary circuit.

(E) Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(F) Lamps for general illumination shall be protected from accidental contact or breakage. Protection shall be provided by elevation of at least 7 feet from normal working surface or by a suitable fixture or lampholder with a guard.

(G) Flexible cords and cables shall be protected from accidental damage. Sharp corners and projections shall be avoided. Where passing through doorways or other pinch points, flexible cords and cables shall be provided with protection to avoid damage.

(3) *Cable trays.* (i) *Uses permitted.* (*a*) Only the following may be installed in cable tray systems:

(*1*) Mineral-insulated metal-sheathed cable (Type MI);

(*2*) Armored cable (Type AC);

(*3*) Metal-clad cable (Type MC);

(*4*) Power-limited tray cable (Type PLTC);

(*5*) Nonmetallic-sheathed cable (Type NM or NMC);

(*6*) Shielded nonmetallic-sheathed cable (Type SNM);

(*7*) Multiconductor service-entrance cable (Type SE or USE);

(*8*) Multiconductor underground feeder and branch-circuit cable (Type UF);

(*9*) Power and control tray cable (Type TC);

(*10*) Other factory-assembled, multi-conductor control, signal, or power cables which are specifically approved for installation in cable trays; or

(*11*) Any approved conduit or raceway with its contained conductors.

(*b*) In industrial establishments only, where conditions of maintenance and supervision assure that only qualified persons will service the installed cable tray system, the following cables may also be installed in ladder, ventilated trough, or 4 inch ventilated channel-type cable trays:

(*1*) Single conductor cables which are 250 MCM or larger and are Types RHH, RHW, MV, USE, or THW, and other 250 MCM or larger single conductor cables if specifically approved for installation in cable trays. Where exposed to direct rays of the sun, cables shall be sunlight-resistant.

(*2*) Type MV cables, where exposed to direct rays of the sun, shall be sunlight-resistant.

(*c*) Cable trays in hazardous (classified) locations shall contain only the cable types permitted in such locations.

(ii) *Uses not permitted.* Cable tray systems may not be used in hoistways or where subjected to severe physical damage.

(4) *Open wiring on insulators*—(i) *Uses permitted.* Open wiring on insulators is only permitted on systems of 600 volts, nominal, or less for industrial or agricultural establishments and for services.

(ii) *Conductor supports.* Conductors shall be rigidly supported on noncombustible, nonabsorbent insulating materials and may not contact any other objects.

(iii) *Flexible nonmetallic tubing.* In dry locations where not exposed to severe physical damage, conductors may be separately enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths not exceeding 15 feet and secured to the surface by straps at intervals not exceeding 4 feet 6 inches.

(iv) *Through walls, floors, wood cross members, etc.* Open conductors shall be separated from contact with walls, floors, wood cross members, or partitions through which they pass by tubes or bushings of noncombustible, nonabsorbent insulating material. If the bushing is shorter than the hole, a waterproof sleeve of nonconductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at each end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor shall be carried through a separate tube or sleeve.

(v) *Protection from physical damage.* Conductors within 7 feet from the floor are considered exposed to physical damage. Where open conductors cross ceiling joints and wall studs and are exposed to physical damage, they shall be protected.

(b) *Cabinets, boxes, and fittings*—(1) *Conductors entering boxes, cabinets, or fittings.* Conductors entering boxes, cabinets, or fittings shall also be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall be effectively closed.

(2) *Covers and canopies.* All pull boxes, junction boxes, and fittings shall be provided with covers approved for the purpose. If metal covers are used they shall be grounded. In completed installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible

cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

(3) *Pull and junction boxes for systems over 600 volts, nominal.* In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:

(i) Boxes shall provide a complete enclosure for the contained conductors or cables.

(ii) Boxes shall be closed by suitable covers securely fastened in place. Underground box covers that weigh over 100 pounds meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

(c) *Switches*—(1) *Knife switches.* Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical a locking device shall be provided to ensure that the blades remain in the open position when so set.

(2) *Faceplates for flush-mounted snap switches.* Flush snap switches that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces shall be provided with faceplates of nonconducting, noncombustible material.

(d) *Switchboards and panelboards.* Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures approved for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

(e) *Enclosures for damp or wet locations.* (1) Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

(2) Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

(f) *Conductors for general wiring.* All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is approved for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other suitable means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

(g) *Flexible cords and cables*—(1) *Use of flexible cords and cables.* (i) Flexible cords and cables shall be approved and suitable for conditions of use and location. Flexible cords and cables shall be used only for:

(A) Pendants;

(B) Wiring of fixtures;

(C) Connection of portable lamps or appliances;

(D) Elevator cables;

(E) Wiring of cranes and hoists;

(F) Connection of stationary equipment to facilitate their frequent interchange;

(G) Prevention of the transmission of noise or vibration;

(H) Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair; or

(*I*) Data processing cables approved as a part of the data processing system.

(ii) If used as permitted in paragraphs (g)(1)(i)(*c*), (g)(1)(i)(*f*), or (g)(1)(i)(*h*) of this section, the flexible cord shall be equipped with an attachment plug and shall be energized from an approved receptacle outlet.

(iii) Unless specifically permitted in paragraph (g)(1)(i) of this section, flexible cords and cables may not be used:

(A) As a substitute for the fixed wiring of a structure;

(B) Where run through holes in walls, ceilings, or floors;

(C) Where run through doorways, windows, or similar openings;

(D) Where attached to building surfaces; or

(E) Where concealed behind building walls, ceilings, or floors.

(iv) Flexible cords used in show windows and showcases shall be Type S, SO, SJ, SJO, ST, STO, SJT, SJTO, or AFS except for the wiring of chain-supported lighting fixtures and supply cords for portable lamps and other merchandise being displayed or exhibited.

(2) *Identification, splices, and terminations.* (i) A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors. Types SJ, SJO, SJT, SJTO, S, SO, ST, and STO shall be durably marked on the surface with the type designation, size, and number of conductors.

(ii) Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

(iii) Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

(h) *Portable cables over 600 volts, nominal.* Multiconductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2,000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables may not be operated with splices unless the splices are of the permanent molded, vulcanized, or other approved type. Termination enclosures shall be suitably marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

(i) *Fixture wires*—(1) *General.* Fixture wires shall be approved for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.

(2) *Uses permitted.* Fixture wires may be used:

(i) For installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or

(ii) For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

(3) *Uses not permitted.* Fixture wires may not be used as branch-circuit conductors except as permitted for Class 1 power limited circuits.

(j) *Equipment for general use*—(1) *Lighting fixtures, lampholders, lamps, and receptacles.* (i) Fixtures, lampholders, lamps, rosettes, and receptacles may have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet above the floor may have exposed parts.

(ii) Handlamps of the portable type supplied through flexible cords shall be equipped with a handle of molded composition or other material approved for the purpose, and a substantial guard shall be attached to the lampholder or the handle.

(iii) Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(iv) Fixtures installed in wet or damp locations shall be approved for the purpose and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

(2) *Receptacles, cord connectors, and attachment plugs (caps).* (i) Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a different voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating.

(ii) A receptacle installed in a wet or damp location shall be suitable for the location.

(3) *Appliances.* (i) Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, may have no live parts normally exposed to employee contact.

(ii) A means shall be provided to disconnect each appliance.

(iii) Each appliance shall be marked with its rating in volts and amperes or volts and watts.

(4) *Motors.* This paragraph applies to motors, motor circuits, and controllers.

(i) *In sight from.* If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet from the other.

(ii) *Disconnecting means.* (A) A disconnecting means shall be located in sight from the controller location. However, a single disconnecting means may be located adjacent to a group of coordinated controllers mounted adjacent to each other on a multi-motor continuous process machine. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

(B) The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

(C) If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(*1*) The controller disconnecting means shall be capable of being locked in the open position.

(*2*) A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

(D) The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

(E) The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.

(F) An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions:

(*1*) If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;

(*2*) If a group of motors is under the protection of one set of branch-circuit protective devices; or

(*3*) If a group of motors is in a single room in sight from the location of the disconnecting means.

(iii) *Motor overload, short-circuit, and ground-fault protection.* Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions shall not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

(iv) *Protection of live parts—all voltages.* (A) Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

(*1*) By installation in a room or enclosure that is accessible only to qualified persons;

(*2*) By installation on a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

(*3*) By elevation 8 feet or more above the floor.

(B) Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

(5) *Transformers.* (i) The following paragraphs cover the installation of all transformers except the following:

(A) Current transformers;

(B) Dry-type transformers installed as a component part of other apparatus;

(C) Transformers which are an integral part of an X-ray, high frequency, or electrostatic-coating apparatus;

(D) Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signalling circuits; and

(E) Liquid-filled or dry-type transformers used for research, development, or testing, where effective safeguard arrangements are provided.

(ii) The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.

(iii) Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35kV shall be in a vault.

(iv) If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

(v) Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

(vi) Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.

(vii) Any pipe or duct system foreign to the vault installation may not enter or pass through a transformer vault.

(viii) Materials may not be stored in transformer vaults.

(6) *Capacitors.* (i) All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge after the capacitor is disconnected from its source of supply.

(ii) Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:

(A) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

(B) For series capacitors (see § 1910.302(b)(3)), the proper switching shall be assured by use of at least one of the following:

(*1*) Mechanically sequenced isolating and bypass switches,

(*2*) Interlocks, or

(*3*) Switching procedure prominently displayed at the switching location.

(7) *Storage batteries.* Provisions shall be made for sufficient diffusion and ventilation of gases from storage batteries to prevent the accumulation of explosive mixtures.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.306 Specific purpose equipment and installations.

(a) *Electric signs and outline lighting*—(1) *Disconnecting means.* Signs operated by electronic or electromechanical controllers located outside the sign shall have a disconnecting means located inside the controller enclosure or within sight of the controller location, and it shall be capable of being locked in the open position. Such disconnecting means shall have no pole that can be operated independently, and it shall open all ungrounded conductors that supply the controller and sign. All other signs, except the portable type, and all outline lighting installations shall have an externally operable disconnecting means which can open all ungrounded conductors and is within the sight of the sign or outline lighting it controls.

(2) Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to other than qualified persons shall either be provided with interlock switches to disconnect the primary circuit or shall be so fastened that the use of other than ordinary tools will be necessary to open them.

(b) *Cranes and hoists.* This paragraph applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

(1) *Disconnecting means.* A readily accessible disconnecting means (i) shall be provided between the runway contact conductors and the power supply.

(ii) Another disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply on any crane or monorail hoist.

(A) If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

(B) The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:

(*1*) The unit is floor controlled;

(*2*) The unit is within view of the power supply disconnecting means; and

(*3*) No fixed work platform has been provided for servicing the unit.

(2) *Control.* A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

(3) *Clearance.* The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches. Where controls are enclosed in cabinets, the door(s) shall either open at least 90 degrees or be removable.

(c) *Elevators, dumbwaiters, escalators, and moving walks*—(1) *Disconnecting means.* Elevators, dumbwaiters, escalators, and moving walks shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.

(2) *Warning signs.* If interconnections between control panels are necessary for operation of the system on a multicar installation that remains energized from a source other than the disconnecting means, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall read "Warning—Parts of the control panel are not de-energized by this switch." (See § 1910.302(b)(3).)

(3) *Control panels.* If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

(d) *Electric welders—disconnecting means.* (1) A disconnecting means shall be provided in the supply circuit for each motor-generator arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an intergral part of the welder.

(2) A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means may not be less than the supply conductor ampacity.

(e) *Data processing systems—disconnecting means.* A disconnecting means shall be provided to disconnect the power to all electronic equipment in data processing or computer rooms. This disconnecting means shall be controlled from locations readily accessible to the operator at the principal exit doors. There shall also be a similar disconnecting means to disconnect the air conditioning system serving this area.

(f) *X-Ray equipment.* This paragraph applies to X-ray equipment for other than medical or dental use.

(1) *Disconnecting means.* (i) A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.

(ii) If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by employees with its live parts.

(2) *Control*—(i) *Radiographic and fluoroscopic types.* Radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that de-energize the equipment automatically to prevent ready access to live current-carrying parts.

(ii) *Diffraction and irradiation types.* Diffraction- and irradiation-type equipment shall be provided with a means to indicate when it is energized unless the equipment or installation is effectively enclosed or is provided with interlocks to prevent access to live current-carrying parts during operation.

(g) *Induction and dielectric heating equipment*—(1) *Scope.* Paragraphs (g)(2) and (g)(3) of this section cover induction and dielectric heating equipment and accessories for industrial and scientific applications, but not for medical or dental applications or for appliances.

(2) *Guarding and grounding.* (i) *Enclosures.* The converting apparatus (including the DC line) and high-frequency electric circuits (excluding the output circuits and remote-control circuits) shall be completely contained within enclosures of noncombustible material.

(ii) *Panel controls.* All panel controls shall be of dead-front construction.

(iii) *Access to internal equipment.* Where doors are used for access to voltages from 500 to 1000 volts AC or DC, either door locks or interlocks shall be provided. Where doors are used for access to voltages of over 1000 volts AC or DC, either mechanical lockouts with a disconnecting means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks, shall be provided.

(iv) *Warning labels.* "Danger" labels shall be attached on the equipment and shall be plainly visible even when doors are open or panels are removed from compartments containing voltages of over 250 volts AC or DC.

(v) *Work applicator shielding.* Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils shall be protected by insulation and/or refractory materials. Interlock switches shall be used on all hinged access doors, sliding panels, or other such means of access to the applicator. Interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels are not required if the applicator is an induction heating coil at DC ground potential or operating at less than 150 volts AC.

(vi) *Disconnecting means.* A readily accessible disconnecting means shall be provided by which each unit of heating equipment can be isolated from its supply circuit.

(3) *Remote control.* If remote controls are used for applying power, a selector switch shall be provided and interlocked to provide power from only one control point at a time. Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing of the switch.

(h) *Electrolytic cells.* (1) *Scope.* These provisions for electrolytic cells apply to the installation of the electrical components and accessory equipment of electrolytic cells, electrolytic cell lines, and process power supply for the production of aluminum, cadmium, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, sodium chlorate, and zinc. Cells used as a source of electric energy and for electroplating processes and cells used for production of hydrogen are not covered by these provisions.

(2) *Definitions applicable to this paragraph.*

Cell line: An assembly of electrically interconnected electrolytic cells supplied by a source of direct-current power.

Cell line attachments and auxiliary equipment: Cell line attachments and auxiliary equipment include, but are not limited to: auxiliary tanks; process piping; duct work; structural supports; exposed cell line conductors; conduits and other raceways; pumps; positioning equipment and cell cutout or by-pass electrical devices. Auxiliary equipment also includes tools, welding machines, crucibles, and other portable equipment used for operation and maintenance within the electrolytic cell line working zone. In the cell line working zone, auxiliary equipment includes the exposed conductive surfaces of ungrounded cranes and crane-mounted cell-servicing equipment.

Cell line working zone: The cell line working zone is the space envelope wherein operation or maintenance is normally performed on or in the vicinity of exposed energized surfaces of cell lines or their attachments.

Electrolytic Cells: A receptacle or vessel in which electrochemical reactions are caused by applying energy for the purpose of refining or producing usable materials.

(3) *Application.* Installations covered by paragraph (h) of this section shall comply with all applicable provisions of this subpart, except as follows:

(i) Overcurrent protection of electrolytic cell DC process power circuits need not comply with the requirements of § 1910.304(e).

(ii) Equipment located or used within the cell line working zone or associated with the cell line DC power circuits need not comply with the provisions of § 1910.304(f).

(iii) Electrolytic cells, cell line conductors, cell line attachments; and the wiring of auxiliary equipment and devices within the cell line working zone need not comply with the provisions of §§ 1910.303, and 1910.304 (b) and (c).

(4) *Disconnecting means.* (i) If more than one DC cell line process power supply serves the same cell line, a disconnecting means shall be provided on the cell line circuit side of each power supply to disconnect it from the cell line circuit.

(ii) Removable links or removable conductors may be used as the disconnecting means.

(5) *Portable electric equipment.* (i) The frames and enclosures of portable electric equipment used within the cell line working zone may not be grounded. However, these frames and enclosures may be grounded if the cell line circuit voltage does not exceed 200 volts DC or if the frames are guarded.

(ii) Ungrounded portable electric equipment shall be distinctively marked and may not be interchangeable with grounded portable electric equipment.

(6) *Power supply circuits and receptacles for portable electric equipment.* (i) Circuits supplying power to ungrounded receptacles for hand-held, cord- and plug-connected equipment shall be electrically isolated from any distribution system supplying areas other than the cell line working zone and shall be ungrounded. Power for these circuits shall be supplied through isolating transformers.

(ii) Receptacles and their mating plugs for ungrounded equipment may not have provision for a grounding conductor and shall be of a configuration which prevents their use for equipment required to be grounded.

(iii) Receptacles on circuits supplied by an isolating transformer with an ungrounded secondary shall have a distinctive configuration, shall be distinctively marked, and may not be used in any other location in the plant.

(7) *Fixed and portable electric equipment.* (i) AC systems supplying fixed and portable electric equipment within the cell line working zone need not be grounded.

(ii) Exposed conductive surfaces, such as electric equipment housings, cabinets, boxes, motors, raceways and the like that are within the cell line working zone need not be grounded.

(iii) Auxiliary electrical devices, such as motors, transducers, sensors, control devices, and alarms, mounted on an electrolytic cell or other energized surface, shall be connected by any of the following means:

(A) Multiconductor hard usage or extra hard usage flexible cord;

(B) Wire or cable in suitable raceways; or

(C) Exposed metal conduit, cable tray, armored cable, or similar metallic systems installed with insulating breaks such that they will not cause a potentially hazardous electrical condition.

(iv) Fixed electric equipment may be bonded to the energized conductive surfaces of the cell line, its attachments, or auxiliaries. If fixed electric equipment is mounted on an energized conductive surface, it shall be bonded to that surface.

(8) *Auxiliary nonelectric connections.* Auxiliary nonelectric connections, such as air hoses, water hoses, and the like, to an electrolytic cell, its attachments, or auxiliary equipment may not have continuous conductive reinforcing wire, armor, braids, and the like. Hoses shall be of a nonconductive material.

(9) *Cranes and hoists.* (i) The conductive surfaces of cranes and hoists that enter the cell line working zone need not be grounded. The portion of an overhead crane or hoist which contacts an energized electrolytic cell or energized attachments shall be insulated from ground.

(ii) Remote crane or hoist controls which may introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems:

(A) Insulated and ungrounded control circuit;

(B) Nonconductive rope operator;

(C) Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces;

(D) Radio.

(i) *Electrically driven or controlled irrigation machines.* (See § 1910.303(b)(3).)

(1) *Lightning protection.* If an electrically driven or controlled irrigation machine has a stationary point, a driven ground rod shall be connected to the machine at the stationary point for lightning protection.

(2) *Disconnecting means.* The main disconnecting means for a center pivot irrigation machine shall be located at the point of connection of electrical power to the machine and shall be readily accessible and capable of being locked in the open position. A disconnecting means shall be provided for each motor and controller.

(j) *Swimming pools, fountains, and similar installations*—(1) *Scope.* Paragraphs (j)(2) through (j)(5) of this section apply to electric wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative pools and fountains, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment. Therapeutic pools in health care facilities are exempt from these provisions.

(2) *Lighting and receptacles*—(i) *Receptacles.* A single receptacle of the locking and grounding type that provides power for a permanently installed swimming pool recirculating pump motor may be located not less than 5 feet from the inside walls of a pool. All other receptacles on the property shall be located at least 10 feet from the inside walls of a pool. Receptacles which are located within 15 feet of the inside walls of the pool shall be protected by ground-fault circuit interrupters.

NOTE: In determining these dimensions, the distance to be measured is the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, or ceiling of a building or other effective permanent barrier.

(ii) *Lighting fixtures and lighting outlets.* (A) Unless they are 12 feet above the maximum water level, lighting fixtures and lighting outlets may not be installed over a pool or over the area extending 5 feet horizontally from the inside walls of a pool. However, a lighting fixture or lighting outlet which has been installed before April 16, 1981, may be located less than 5 feet measured horizontally from the inside walls of a pool if it is at least 5 feet above the surface of the maximum water level and shall be rigidly attached to the existing structure. It shall also be protected by a ground-fault circuit interrupter installed in the branch circuit supplying the fixture.

(B) Unless installed 5 feet above the maximum water level and rigidly attached to the structure adjacent to or enclosing the pool, lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool shall be protected by a ground-fault circuit interrupter.

(3) *Cord- and plug-connected equipment.* Flexible cords used with the following equipment may not exceed 3 feet in length and shall have a copper equipment grounding conductor with a grounding-type attachment plug.

(i) Cord- and plug-connected lighting fixtures installed within 16 feet of the water surface of permanently installed pools.

(ii) Other cord- and plug-connected, fixed or stationary equipment used with permanently installed pools.

(4) *Underwater equipment.* (i) A ground-fault circuit interrupter shall be installed in the branch circuit supplying underwater fixtures operating at more than 15 volts. Equipment installed underwater shall be approved for the purpose.

(ii) No underwater lighting fixtures may be installed for operation at over 150 volts between conductors.

(5) *Fountains.* All electric equipment operating at more than 15 volts, including power supply cords, used with fountains shall be protected by ground-fault circuit interrupters. (See § 1910.302(b)(3).)

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.307 Hazardous (classified) locations.

(a) *Scope.* This section covers the requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following: aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1
Class I, Division 2
Class II, Division 1
Class II, Division 2
Class III, Division 1
Class III, Division 2

For definitions of these locations see § 1910.399(a). All applicable requirements in this subpart shall apply to hazardous (classified) locations, unless modified by provisions of this section.

(b) *Electrical installations.* Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be intrinsically safe, approved for the hazardous (classified) location, or safe or for the hazardous (classified) location. Requirements for each of these options are as follows:

(1) *Intrinsically safe.* Equipment and associated wiring approved as intrinsically safe shall be permitted in any hazardous (classified) location for which it is approved.

(2) *Approved for the hazardous (classified) location.* (i) Equipment shall be approved not only for the class of location but also for the ignitible or combustible properties of the specific gas, vapor, dust, or fiber that will be present.

NOTE: NFPA 70, the National Electrical Code, lists or defines hazardous gases, vapors, and dusts by "Groups" characterized by their ignitible or combustible properties.

(ii) Equipment shall be marked to show the class, group, and operating temperature or temperature range, based on operation in a 40 degrees C ambient, for which it is approved. The temperature marking may not exceed the ignition temperature of the specific gas or vapor to be encountered. However, the following provisions modify this marking requirement for specific equipment:

(A) Equipment of the non-heat-producing type, such as junction boxes, conduit, and fittings, and equipment of the heat-producing type having a maximum temperature not more than 100 degrees C (212 degrees F) need not have a marked operating temperature or temperature range.

(B) Fixed lighting fixtures marked for use in Class I, Division 2 locations only, need not be marked to indicate the group.

(C) Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.

(D) Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

(3) *Safe for the hazardous (classified) location.* Equipment which is safe for the location shall be of a type and design which the employer demonstrates will provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

NOTE: The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installations which will meet this requirement. The guidelines of this document address electric wiring, equipment, and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections; conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote control systems, local loud speaker and communication systems, ventilation piping, live parts, lightning surge protection, and grounding. Compliance with these guidelines will constitute one means, but not the only means, of compliance with this paragraph.

(c) *Conduits.* All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

(d) *Equipment in Division 2 locations.* Equipment that has been approved for a Division 1 location may be installed in a Division 2 location of the same class and group. General-purpose equipment or equipment in general-purpose enclosures may be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.308 Special systems.

(a) *Systems over 600 volts, nominal.* Paragraphs (a) (1) through (4) of this section cover the general requirements for all circuits and equipment operated at over 600 volts.

(1) *Wiring methods for fixed installations.* (i) Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable suitable for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.

(ii) Conductors emerging from the ground shall be enclosed in approved raceways. (See § 1910.302(b)(3).)

(2) *Interrupting and isolating devices.* (i) Circuit breaker installations located indoors shall consist of metal-enclosed units or fire-resistant cell-mounted units. In locations accessible only to qualified personnel, open

mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

(ii) Fused cutouts installed in buildings or tranformer vaults shall be of a type approved for the purpose. They shall be readily accessible for fuse replacement.

(iii) A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load curent of the circuit shall be either interlocked with an approved circuit interrupter or provided with a sign warning against opening them under load.

(3) *Mobile and portable equipment.* (i) *Power cable connections to mobile machines.* A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to effectively ground the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and shall be marked with a sign warning of the presence of energized parts.

(ii) *Guarding live parts.* All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

(4) *Tunnel installation*—(i) *Application.* The provisions of this paragraph apply to installation and use of high-voltage power distribution and utilization equipment which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

(ii) *Conductors.* Conductors in tunnels shall be installed in one or more of the following:

(A) Metal conduit or other metal raceway,

(B) Type MC cable, or

(C) Other approved multiconductor cable.

Conductors shall also be so located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

(iii) *Guarding live parts.* Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.

(iv) *Disconnecting means.* A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.

(v) *Grounding and bonding.* All non-energized metal parts of electric equipment and metal raceways and cable sheaths shall be effectively grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet throughout the tunnel.

(b) *Emergency power systems*—(1) *Scope.* The provisions for emergency systems apply to circuits, systems, and equipment intended to supply power for illumination and special loads, in the event of failure of the normal supply.

(2) *Wiring methods.* Emergency circuit wiring shall be kept entirely independent of all other wiring and equipment and may not enter the same raceway, cable, box, or cabinet or other wiring except either where common circuit elements suitable for the purpose are required, or for trans-

ferring power from the normal to the emergency source.

(3) *Emergency illumination.* Where emergency lighting is necessary, the system shall be so arranged that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave any space in total darkness.

(c) *Class 1, Class 2, and Class 3 remote control, signaling, and power-limited circuits*—(1) *Classification.* Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations as summarized in paragraphs (c)(1)(i) through (c)(1)(iii) of this section.

(i) *Class 1 circuits.* (A) A Class 1 power-limited circuit is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.

(B) A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.

(ii) *Class 2 and Class 3 circuits.* (A) Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

(B) The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.

(C) The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a Class 3 power source limited by overcurrent protection.

(iii) The maximum circuit voltages in paragraphs (c)(1)(i) and (c)(1)(ii) of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurence is not likely.

(2) *Marking.* A Class 2 or Class 3 power supply unit shall be durably marked where plainly visible to indicate the class of supply and its electrical rating. (See § 1910.302(b)(3).)

(d) *Fire protective signaling systems.* (See § 1910.302(b)(3).)

(1) *Classifications.* Fire protective signaling circuits shall be classified either as non-power limited or power limited.

(2) *Power sources.* The power sources for use with fire protective signaling circuits shall be either power limited or nonlimited as follows:

(i) The power supply of non-power-limited fire protective signaling circuits shall have an output voltage not in excess of 600 volts.

(ii) The power for power-limited fire protective signaling circuits shall be either inherently limited, in which no overcurrent protection is required, or limited by a combination of a power source and overcurrent protection.

(3) *Non-power-limited conductor location.* Non-power-limited fire protective signaling circuits and Class 1 circuits may occupy the same enclosure, cable, or raceway provided all conductors are insulated for maximum voltage of any conductor within the enclosure, cable, or raceway. Power supply and fire protective signaling circuit conductors are permitted in the same enclosure, cable, or raceway only if connected to the same equipment.

(4) *Power-limited conductor location.* Where open conductors are installed, power-limited fire protective signaling circuits shall be separated at least 2 inches from conductors of any light, power, Class 1, and non-power-limited fire protective signaling circuits unless a special and equally protective method of conductor separation is employed. Cables and conductors of two or more power-limited fire protective signaling circuits or Class 3 circuits are permitted in the same cable, enclosure, or raceway. Conductors of one or more Class 2 circuits are permitted within the same cable, enclosure, or raceway with conductors of power-limited fire protective signaling circuits provided that the insulation of Class 2 circuit conductors in the cable, enclosure, or raceway is at least that needed for the power-limited fire protective signaling circuits.

(5) *Identification.* Fire protective signaling circuits shall be identified at

terminal and junction locations in a manner which will prevent unintentional interference with the signaling circuit during testing and servicing. Power-limited fire protective signaling circuits shall be durably marked as such where plainly visible at terminations.

(e) *Communications systems*—(1) *Scope.* These provisions for communication systems apply to such systems as central-station-connected and non-central-station-connected telephone circuits, radio and television receiving and transmitting equipment, including community antenna television and radio distribution systems, telegraph, district messenger, and outside wiring for fire and burglar alarm, and similar central station systems. These installations need not comply with the provisions of §§ 1910.303 through 1910.308(d), except § 1910.304(c)(1) and § 1910.307(b).

(2) *Protective devices.* (i) Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with a protector approved for the purpose.

(ii) Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other suitable means that will drain static charges from the antenna system.

(3) *Conductor location*—(i) *Outside of buildings.* (*a*) Receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light or power conductors.

(*b*) The clearance between lead-in conductors and any lightning protection conductors may not be less than 6 feet.

(ii) *On poles.* Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors may not be attached to a crossarm that carries light or power conductors.

(iii) *Inside of buildings.* Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation, approved for the purpose, is employed.

(4) *Equipment location.* Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

(5) *Grounding*—(i) *Lead-in conductors.* If exposed to contact with electric light and power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded in an approved manner.

(ii) *Antenna structures.* Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.

(iii) *Equipment enclosures.* Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§§ 1910.309—1910.330 [Reserved]

SAFETY-RELATED WORK PRACTICES

§ 1910.331 Scope.

(a) *Covered work by both qualified and unqualified persons.* The provisions of §§ 1910.331 through 1910.335 cover electrical safety-related work practices for both qualified persons (those who have training in avoiding the electrical hazards of working on or near exposed energized parts) and unqualified persons (those with little or no such training) working on, near, or with the following installations:

(1) *Premises wiring.* Installations of electric conductors and equipment within or on buildings or other structures, and on other premises such as yards, carnival, parking, and other lots, and industrial substations;

(2) *Wiring for connection to supply.* Installations of conductors that connect to the supply of electricity; and

(3) *Other wiring.* Installations of other outside conductors on the premises.

(4) *Optical fiber cable.* Installations of optical fiber cable where such installations are made along with electric conductors.

NOTE: See § 1910.399 for the definition of "qualified person." See § 1910.332 for training requirements that apply to qualified and unqualified persons.

(b) *Other covered work by unqualified persons.* The provisions of §§ 1910.331 through 1910.335 also cover work performed by unqualified persons on, near, or with the installations listed in paragraphs (c)(1) through (c)(4) of this section.

(c) *Excluded work by qualified persons.* The provisions of §§ 1910.331 through 1910.335 do not apply to work performed by qualified persons on or directly associated with the following installations:

(1) *Generation, transmission, and distribution installations.* Installations for the generation, control, transformation, transmission, and distribution of electric energy (including communication and metering) located in buildings used for such purposes or located outdoors.

NOTE 1: Work on or directly associated with installations of utilization equipment used for purposes other than generating, transmitting, or distributing electric energy (such as installations which are in office buildings, warehouses, garages, machine shops, or recreational buildings, or other utilization installations which are not an integral part of a generating installation, substation, or control center) is covered under paragraph (a)(1) of this section.

NOTE 2: Work on or directly associated with generation, transmission, or distribution installations includes:

(1) Work performed directly on such installations, such as repairing overhead or underground distribution lines or repairing a feed-water pump for the boiler in a generating plant.

(2) Work directly associated with such installations, such as line-clearance tree trimming and replacing utility poles.

(3) Work on electric utilization circuits in a generating plant provided that:

(A) Such circuits are commingled with installations of power generation equipment or circuits, and

(B) The generation equipment or circuits present greater electrical hazards than those posed by the utilization equipment or circuits (such as exposure to higher voltages or lack of overcurrent protection).

(2) *Communications installations.* Installations of communication equipment to the extent that the work is covered under § 1910.268.

(3) *Installations in vehicles.* Installations in ships, watercraft, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles.

(4) *Railway installations.* Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations of railways used exclusively for signaling and communication purposes.

[55 FR 32016, Aug. 6, 1990]

§ 1910.332 Training.

(a) *Scope.* The training requirements contained in this section apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of §§ 1910.303 through 1910.308.

NOTE: Employees in occupations listed in Table S-4 face such a risk and are required to be trained. Other employees who also may reasonably be expected to face a comparable risk of injury due to electric shock or other electrical hazards must also be trained.

(b) *Content of training.* (1) *Practices addressed in this standard.* Employees shall be trained in and familiar with the safety-related work practices required by §§ 1910.331 through 1910.335 that pertain to their respective job assignments.

(2) *Additional requirements for unqualified persons.* Employees who are covered by paragraph (a) of this section but who are not qualified persons shall also be trained in and familiar with any electrically related safety practices not specifically addressed by §§ 1910.331 through 1910.335 but which are necessary for their safety.

(3) *Additional requirements for qualified persons.* Qualified persons (i.e., those permitted to work on or near exposed energized parts) shall, at a minimum, be trained in and familiar with the following:

(i) The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment,

(ii) The skills and techniques necessary to determine the nominal voltage of exposed live parts, and

(iii) The clearance distances specified in § 1910.333(c) and the corresponding voltages to which the qualified person will be exposed.

NOTE 1: For the purposes of §§ 1910.331 through 1910.335, a person must have the training required by paragraph (b)(3) of this section in order to be considered a qualified person.

NOTE 2: Qualified persons whose work on energized equipment involves either direct contact or contact by means of tools or materials must also have the training needed to meet § 1910.333(c)(2).

(c) *Type of training.* The training required by this section shall be of the classroom or on-the-job type. The degree of training provided shall be determined by the risk to the employee.

TABLE S-4.—TYPICAL OCCUPATIONAL CATEGORIES OF EMPLOYEES FACING A HIGHER THAN NORMAL RISK OF ELECTRICAL ACCIDENT

Occupation
Blue collar supervisors.[1]
Electrical and electronic engineers.[1]
Electrical and electronic equipment assemblers.[1]
Electrical and electronic technicians.[1]
Electricians.
Industrial machine operators.[1]
Material handling equipment operators.[1]
Mechanics and repairers.[1]
Painters.[1]
Riggers and roustabouts.[1]
Stationary engineers.[1]
Welders.

[1] Workers in these groups do not need to be trained if their work or the work of those they supervise does not bring them or the employees they supervise close enough to exposed parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

[55 FR 32016, Aug. 6, 1990]

§ 1910.333 Selection and use of work practices.

(a) *General.* Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards.

(1) *Deenergized parts.* Live parts to which an employee may be exposed shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

NOTE 1: Examples of increased or additional hazards include interruption of life support equipment, deactivation of emergency alarm systems, shutdown of hazardous location ventilation equipment, or removal of illumination for an area.

NOTE 2: Examples of work that may be performed on or near energized circuit parts because of infeasibility due to equipment design or operational limitations include testing of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous industrial process in a chemical plant that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

NOTE 3: Work on or near deenergized parts is covered by paragraph (b) of this section.

(2) *Energized parts.* If the exposed live parts are not deenergized (i.e., for reasons of increased or additional hazards or infeasibility), other safety-related work practices shall be used to protect employees who may be exposed to the electrical hazards involved. Such work practices shall protect employees against contact with energized circuit parts directly with any part of their body or indirectly through some other conductive object. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the exposed electric conductors or circuit parts. Specific work practice requirements are detailed in paragraph (c) of this section.

(b) *Working on or near exposed deenergized parts.* (1) *Application.* This paragraph applies to work on exposed deenergized parts or near enough to them to expose the employee to any electrical hazard they present. Conductors and parts of electric equipment that have been deenergized but have not been locked out or tagged in accordance with paragraph (b) of this section shall be treated as energized parts, and paragraph (c) of this section applies to work on or near them.

(2) *Lockout and tagging.* While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged or both in accordance with the requirements of this paragraph. The requirements shall be followed in the order in which they are presented (i.e., paragraph (b)(2)(i) first, then paragraph (b)(2)(ii), etc.).

NOTE 1: As used in this section, fixed equipment refers to equipment fastened in place or connected by permanent wiring methods.

NOTE 2: Lockout and tagging procedures that comply with paragraphs (c) through (f) of § 1910.147 will also be deemed to comply with paragraph (b)(2) of this section provided that:

(1) The procedures address the electrical safety hazards covered by this Subpart; and

(2) The procedures also incorporate the requirements of paragraphs (b)(2)(iii)(D) and (b)(2)(iv)(B) of this section.

(i) *Procedures.* The employer shall maintain a written copy of the procedures outlined in paragraph (b)(2) and shall make it available for inspection by employees and by the Assistant Secretary of Labor and his or her authorized representatives.

NOTE: The written procedures may be in the form of a copy of paragraph (b) of this section.

(ii) *Deenergizing equipment.* (A) Safe procedures for deenergizing circuits and equipment shall be determined before circuits or equipment are deenergized.

(B) The circuits and equipment to be worked on shall be disconnected from all electric energy sources. Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for deenergizing circuits or equipment. Interlocks for electric equipment may not be used as a substitute for lockout and tagging procedures.

(C) Stored electric energy which might endanger personnel shall be released. Capacitors shall be discharged and high capacitance elements shall be short-circuited and grounded, if the stored electric energy might endanger personnel.

NOTE: If the capacitors or associated equipment are handled in meeting this requirement, they shall be treated as energized.

(D) Stored non-electrical energy in devices that could reenergize electric circuit parts shall be blocked or relieved to the extent that the circuit parts could not be accidentally energized by the device.

(iii) *Application of locks and tags.* (A) A lock and a tag shall be placed on each disconnecting means used to deenergize circuits and equipment on which work is to be performed, except as provided in paragraphs (b)(2)(iii)(C) and (b)(2)(iii)(E) of this section. The lock shall be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools.

(B) Each tag shall contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

(C) If a lock cannot be applied, or if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by the use of a lock, a tag may be used without a lock.

(D) A tag used without a lock, as permitted by paragraph (b)(2)(iii)(C) of this section, shall be supplemented by at least one additional safety measure that provides a level of safety equivalent to that obtained by the use of a lock. Examples of additional safety measures include the removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

(E) A lock may be placed without a tag only under the following conditions:

(*1*) Only one circuit or piece of equipment is deenergized, and

(*2*) The lockout period does not extend beyond the work shift, and

(*3*) Employees exposed to the hazards associated with reenergizing the circuit or equipment are familiar with this procedure.

(iv) Verification of deenergized condition. The requirements of this paragraph shall be met before any circuits or equipment can be considered and worked as deenergized.

(A) A qualified person shall operate the equipment operating controls or otherwise verify that the equipment cannot be restarted.

(B) A qualified person shall use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and shall verify that the circuit elements and equipment parts are deenergized. The test shall also determine if any energized condition exists as a result of inadvertently induced voltage or unrelated voltage backfeed even though specific parts of the circuit have been deenergized and presumed to be safe. If the circuit to be tested is over 600 volts, nominal, the test equipment shall be checked for proper operation immediately before and immediately after this test.

(v) *Reenergizing equipment.* These requirements shall be met, in the order given, before circuits or equipment are reenergized, even temporarily.

(A) A qualified person shall conduct tests and visual inspections, as necessary, to verify that all tools, electrical jumpers, shorts, grounds, and other such devices have been removed, so that the circuits and equipment can be safely energized.

(B) Employees exposed to the hazards associated with reenergizing the circuit or equipment shall be warned to stay clear of circuits and equipment.

(C) Each lock and tag shall be removed by the employee who applied it or under his or her direct supervision. However, if this employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated to perform this task provided that:

(*1*) The employer ensures that the employee who applied the lock or tag is not available at the workplace, and

(*2*) The employer ensures that the employee is aware that the lock or tag has been removed before he or she resumes work at that workplace.

(D) There shall be a visual determination that all employees are clear of the circuits and equipment.

(c) *Working on or near exposed energized parts.* (*1*) *Application.* This paragraph applies to work performed on exposed live parts (involving either direct contact or contact by means of tools or materials) or near enough to them for employees to be exposed to any hazard they present.

(2) *Work on energized equipment.* Only qualified persons may work on electric circuit parts or equipment that have not been deenergized under the procedures of paragraph (b) of this section. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

(3) *Overhead lines.* If work is to be performed near overhead lines, the

lines shall be deenergized and grounded, or other protective measures shall be provided before work is started. If the lines are to be deenergized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to deenergize and ground them. If protective measures, such as guarding, isolating, or insulating are provided, these precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

NOTE: The work practices used by qualified persons installing insulating devices on overhead power transmission or distribution lines are not covered by §§ 1910.332 through 1910.335. Under paragraph (c)(2) of this section, unqualified persons are prohibited from performing this type of work.

(i) *Unqualified persons.* (A) When an unqualified person is working in an elevated position near overhead lines, the location shall be such that the person and the longest conductive object he or she may contact cannot come closer to any unguarded, energized overhead line than the following distances:

(*1*) For voltages to ground 50kV or below—10 ft. (305 cm);

(*2*) For voltages to ground over 50kV—10 ft. (305 cm) plus 4 in. (10 cm) for every 10kV over 50kV.

(B) When an unqualified person is working on the ground in the vicinity of overhead lines, the person may not bring any conductive object closer to unguarded, energized overhead lines than the distances given in paragraph (c)(3)(i)(A) of this section.

NOTE: For voltages normally encountered with overhead power lines, objects which do not have an insulating rating for the voltage involved are considered to be conductive.

(ii) *Qualified persons.* When a qualified person is working in the vicinity of overhead lines, whether in an elevated position or on the ground, the person may not approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table S-5 unless:

(A) The person is insulated from the energized part (gloves, with sleeves if necessary, rated for the voltage involved are considered to be insulation of the person from the energized part on which work is performed), or

(B) The energized part is insulated both from all other conductive objects at a different potential and from the person, or

(C) The person is insulated from all conductive objects at a potential different from that of the energized part.

TABLE S-5.—APPROACH DISTANCES FOR QUALIFIED EMPLOYEES—ALTERNATING CURRENT

Voltage range (phase to phase)	Minimum approach distance
300V and less	Avoid contact.
Over 300V, not over 750V	1 ft. 0 in. (30.5 cm).
Over 750V, not over 2kV	1 ft. 6 in. (46 cm).
Over 2kV, not over 15kV	2 ft. 0 in. (61 cm).
Over 15kV, not over 37kV	3 ft. 0 in. (91 cm).
Over 37kV, not over 87.5kV	3 ft. 6 in. (107 cm).
Over 87.5kV, not over 121kV	4 ft. 0 in. (122 cm).
Over 121kV, not over 140kV	4 ft. 6 in. (137 cm).

(iii) *Vehicular and mechanical equipment.* (A) Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 ft. (305 cm) is maintained. If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10kV over that voltage. However, under any of the following conditions, the clearance may be reduced:

(*1*) If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft. (122 cm). If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10kV over that voltage.

(*2*) If insulating barriers are installed to prevent contact with the lines, and if the barriers are rated for the voltage of the line being guarded and are not a part of or an attachment to the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier.

(*3*) If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) may be reduced to the distance given in Table S-5.

(B) Employees standing on the ground may not contact the vehicle or mechanical equipment or any of its attachments, unless:

(*1*) The employee is using protective equipment rated for the voltage; or

(*2*) The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in paragraph (c)(3)(iii) of this section.

(C) If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding may not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials, depending on earth resistivity and fault currents, which can develop within the first few feet or more outward from the grounding point.

(4) *Illumination.* (i) Employees may not enter spaces containing exposed energized parts, unless illumination is provided that enables the employees to perform the work safely.

(ii) Where lack of illumination or an obstruction precludes observation of the work to be performed, employees may not perform tasks near exposed energized parts. Employees may not reach blindly into areas which may contain energized parts.

(5) *Confined or enclosed work spaces.* When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized parts, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized parts.

(6) *Conductive materials and equipment.* Conductive materials and equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent them from contacting exposed energized conductors or circuit parts. If an employee must handle long dimensional conductive objects (such as ducts and pipes) in areas with exposed live parts, the employer shall institute work practices (such as the use of insulation, guarding, and material handling techniques) which will minimize the hazard.

(7) *Portable ladders.* Portable ladders shall have nonconductive siderails if they are used where the employee or the ladder could contact exposed energized parts.

(8) *Conductive apparel.* Conductive articles of jewelry and clothing (such as watch bands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, or metal headgear) may not be worn if they might contact exposed energized parts. However, such articles may be worn if they are rendered nonconductive by covering, wrapping, or other insulating means.

(9) *Housekeeping duties.* Where live parts present an electrical contact hazard, employees may not perform housekeeping duties at such close distances to the parts that there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions) may not be used in proximity to energized parts unless procedures are followed which will prevent electrical contact.

(10) *Interlocks.* Only a qualified person following the requirements of paragraph (c) of this section may defeat an electrical safety interlock, and then only temporarily while he or she is working on the equipment. The interlock system shall be returned to its operable condition when this work is completed.

[55 FR 32016, Aug. 6, 1990; 55 FR 42053, Nov. 1, 1990]

§ 1910.334 Use of equipment.

(a) *Portable electric equipment.* This paragraph applies to the use of cord- and plug-connected equipment, including flexible cord sets (extension cords).

(1) *Handling.* Portable equipment shall be handled in a manner which will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment. Flexible cords may not be fastened with staples or otherwise hung in such a fashion as could damage the outer jacket or insulation.

(2) *Visual inspection.* (i) Portable cord- and plug-connected equipment and flexible cord sets (extension cords) shall be visually inspected before use on any shift for external defects (such as loose parts, deformed and missing pins, or damage to outer jacket or insulation) and for evidence of possible internal damage (such as pinched or crushed outer jacket). Cord- and plug-connected equipment and flexible cord sets (extension cords) which remain connected once they are put in place and are not exposed to damage need not be visually inspected until they are relocated.

(ii) If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made.

(iii) When an attachment plug is to be connected to a receptacle (including any on a cord set), the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of proper mating configurations.

(3) *Grounding-type equipment.* (i) A flexible cord used with grounding-type equipment shall contain an equipment grounding conductor.

(ii) Attachment plugs and receptacles may not be connected or altered in a manner which would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices may not be altered to allow the grounding pole of a plug to be inserted into slots intended for connection to the current-carrying conductors.

(iii) Adapters which interrupt the continuity of the equipment grounding connection may not be used.

(4) *Conductive work locations.* Portable electric equipment and flexible cords used in highly conductive work locations (such as those inundated with water or other conductive liquids), or in job locations where employees are likely to contact water or conductive liquids, shall be approved for those locations.

(5) *Connecting attachment plugs.* (i) Employees' hands may not be wet when plugging and unplugging flexible cords and cord- and plug-connected equipment, if energized equipment is involved.

(ii) Energized plug and receptacle connections may be handled only with insulating protective equipment if the condition of the connection could provide a conducting path to the employee's hand (if, for example, a cord connector is wet from being immersed in water).

(iii) Locking-type connectors shall be properly secured after connection.

(b) *Electric power and lighting circuits.* (1) *Routine opening and closing of circuits.* Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections may not be used for such purposes, except in an emergency.

(2) *Reclosing circuits after protective device operation.* After a circuit is deenergized by a circuit protective device, the circuit may not be manually reenergized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited.

NOTE: When it can be determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is reenergized.

(3) *Overcurrent protection modification.* Overcurrent protection of circuits and conductors may not be modified, even on a temporary basis, beyond that allowed by § 1910.304(e), the installation safety requirements for overcurrent protection.

(c) *Test instruments and equipment.* (1) *Use.* Only qualified persons may perform testing work on electric circuits or equipment.

(2) *Visual inspection.* Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made.

(3) *Rating of equipment.* Test instruments and equipment and their accessories shall be rated for the circuits and equipment to which they will be connected and shall be designed for the environment in which they will be used.

(d) *Occasional use of flammable or ignitible materials.* Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to: flammable gases, vapors, or liquids; combustible dust; and ignitible fibers or flyings.

NOTE: Electrical installation requirements for locations where flammable materials are present on a regular basis are contained in § 1910.307.

[55 FR 32019, Aug. 6, 1990]

§ 1910.335 Safeguards for personnel protection.

(a) *Use of protective equipment.* (1) *Personal protective equipment.*- (i) Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed.

NOTE: Personal protective equipment requirements are contained in subpart I of this part.

(ii) Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by § 1910.137.

(iii) If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.)

(iv) Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.

(v) Employees shall wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

(2) *General protective equipment and tools.* (i) When working near exposed energized conductors or circuit parts, each employee shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.

(A) Fuse handling equipment, insulated for the circuit voltage, shall be used to remove or install fuses when the fuse terminals are energized.

(B) Ropes and handlines used near exposed energized parts shall be nonconductive.

(ii) Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.

(b) *Alerting techniques.* The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:

(1) *Safety signs and tags.* Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by § 1910.145.

(2) *Barricades.* Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

(3) *Attendants.* If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

[55 FR 32020, Aug. 6, 1990]

§§ 1910.336—1910.360 [Reserved]

SAFETY-RELATED MAINTENANCE REQUIREMENTS

§§ 1910.361—1910.380 [Reserved]

SAFETY REQUIREMENTS FOR SPECIAL EQUIPMENT

§§ 1910.381—1910.398 [Reserved]

DEFINITIONS

§ 1910.399 Definitions applicable to this subpart.

Acceptable. An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart S:

(i) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory; or

(ii) With respect to an installation or equipment of a kind which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code and found in compliance with the provisions of the National Electrical Code as applied in this Subpart; or

(iii) With respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives. Refer to § 1910.7 for definition of nationally recognized testing laboratory.

Accepted. An installation is "accepted" if it has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes.

Accessible. (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "*concealed*" and "*exposed.*")

Accessible. (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See "*Readily accessible.*")

Ampacity. Current-carrying capacity of electric conductors expressed in amperes.

Appliances. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

Approved. Acceptable to the authority enforcing this subpart. The authority enforcing this subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this Subpart.

Approved for the purpose. Approved for a specific purpose, environment, or application described in a particular standard requirement.

Suitability of equipment or materials for a specific purpose, environment or application may be determined by a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation as part of its listing and labeling program. (See "*Labeled*" or "*Listed.*")

Armored cable. Type AC armored cable is a fabricated assembly of insulated conductors in a flexible metallic enclosure.

Askarel. A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap) (Cap). A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature, or mechanical configuration.

Bare conductor. See "*Conductor.*"

Bonding. The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper. A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Branch circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Building. A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet. An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

Cable tray system. A cable tray system is a unit or assembly of units or sections, and associated fittings, made of metal or other noncombustible materials forming a rigid structural system used to support cables. Cable tray systems include ladders, troughs, channels, solid bottom trays, and other similar structures.

Cablebus. Cablebus is an approved assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated, protective metal housing.

Center pivot irrigation machine. A center pivot irrigation machine is a multi-motored irrigation machine which revolves around a central pivot and employs alignment switches or similar devices to control individual motors.

Certified. Equipment is "certified" if it (a) has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner, or (b) is of a kind whose production is periodically inspected by a nationally recognized testing laboratory, and (c) it bears a label, tag, or other record of certification.

Circuit breaker. (i) (600 volts nominal, or less). A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(ii) (Over 600 volts, nominal). A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations include the following:

(i) *Class I, Division 1.* A Class I, Division 1 location is a location: (*a*) in which hazardous concentrations of flammable gases or vapors may exist under normal operating conditions; or (*b*) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (c) in which breakdown or faulty operation of equipment or processes might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

NOTE: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where flammable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(ii) *Class I, Division 2.* A Class I, Division 2 location is a location: (a) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (b) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or (c) that is adjacent to a Class I, Division 1 location, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

NOTE: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or a liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

Class II locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(i) *Class II, Division 1.* A Class II, Division 1 location is a location: (a) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures; or (b) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or (c) in which combustible dusts of an electrically conductive nature may be present.

NOTE: This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations which contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures. Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(ii) *Class II, Division 2.* A Class II, Division 2 location is a location in which: (a) combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or (b) dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitible by abnormal operation or failure of electrical equipment or other apparatus.

NOTE: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitible concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations. Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class III locations include the following:

(i) *Class III, Division 1.* A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

NOTE: Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions.

Easily ignitible fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(ii) *Class III, Division 2.* A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled, except in process of manufacture.

Collector ring. A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

Concealed. Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [*See "Accessible. (As applied to wiring methods.)"*]

Conductor. (i) *Bare.* A conductor having no covering or electrical insulation whatsoever.

(ii) *Covered.* A conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(iii) *Insulated.* A conductor encased within material of composition and thickness that is recognized as electrical insulation.

Conduit body. A separate portion of a conduit or tubing system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Boxes such as FS and FD or larger cast or sheet metal boxes are not classified as conduit bodies.

Controller. A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Cooking unit, counter-mounted. A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls. (*See "Oven, wall-mounted."*)

Covered conductor. See "Conductor."

Cutout. (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (*See "Cabinet."*)

Damp location. See "*Location.*"

Dead front. Without live parts exposed to a person on the operating side of the equipment.

Device. A unit of an electrical system which is intended to carry but not utilize electric energy.

Dielectric heating. Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

Disconnecting means. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch. (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dry location. See "*Location.*"

Electric sign. A fixed, stationary, or portable self-contained, electrically illuminated utilization equipment with words or symbols designed to convey information or attract attention.

Enclosed. Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Equipment. A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

Equipment grounding conductor. See "*Grounding conductor, equipment.*"

Explosion-proof apparatus. Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed. (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "*Accessible,*" and "*Concealed.*")

Exposed. (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "*Accessible.* (As applied to wiring methods.)"]

Exposed. (For the purposes of § 1910.308(e), *Communications systems.*) Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable. Capable of being operated without exposing the operator to contact with live parts.

Feeder. All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Fitting. An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Fuse. (Over 600 volts, nominal.) An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded. Connected to earth or to some conducting body that serves in place of the earth.

Grounded, effectively. (Over 600 volts, nominal.) Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Grounded conductor. A system or circuit conductor that is intentionally grounded.

Grounding conductor. A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment. The conductor used to connect the non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Grounding electrode conductor. The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

Ground-fault circuit-interrupter. A device whose function is to interrupt the electric circuit to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Health care facilities. Buildings or portions of buildings and mobile homes that contain, but are not limited to, hospitals, nursing homes, extended care facilities, clinics, and medical and dental offices, whether fixed or mobile.

Heating equipment. For the purposes of § 1910.306(g), the term *heating equipment* includes any equipment used for heating purposes if heat is generated by induction or dielectric methods.

Hoistway. Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified. Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be readily recognized as grounded.

Induction heating. Induction heating is the heating of a nominally conductive material due to its own I^2R losses when the material is placed in a varying electromagnetic field.

Insulated conductor. See *Conductor.*

Interrupter switch. (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

Irrigation machine. An irrigation machine is an electrically driven or controlled machine, with one or more motors, not hand portable, and used primarily to transport and distribute water for agricultural purposes.

Isolated. Not readily accessible to persons unless special means for access are used.

Isolated power system. A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled. Equipment is *labeled* if there is attached to it a label, symbol, or other identifying mark of a nationally recognized testing laboratory which, (a) makes periodic inspections of the production of such equipment, and (b) whose labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner.

Lighting outlet. An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Line-clearance tree trimming. The pruning, trimming, repairing, maintaining, removing, or clearing of trees or cutting of brush that is within 10 feet (305 cm) of electric supply lines and equipment.

Listed. Equipment is *listed* if it is of a kind mentioned in a list which, (a) is published by a nationally recognized laboratory which makes periodic inspection of the production of such equipment, and (b) states such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

Location—(i) *Damp location.* Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.

(ii) *Dry location.* A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(iii) *Wet location.* Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations exposed to weather and unprotected.

May. If a discretionary right, privilege, or power is conferred, the word "may" is used. If a right, privilege, or power is abridged or if an obligation to abstain from acting is imposed, the word "may" is used with a restrictive "no," "not," or "only." (E.g., no employer may . . . ; an employer may not . . . ; only qualified persons may. . . .)

Medium voltage cable. Type MV medium voltage cable is a single or multiconductor solid dielectric insulated cable rated 2000 volts or higher.

Metal-clad cable. Type MC cable is a factory assembly of one or more conductors, each individually insulated and enclosed in a metallic sheath of interlocking tape, or a smooth or corrugated tube.

Mineral-insulated metal-sheathed cable. Type MI mineral-insulated metal-sheathed cable is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight continuous copper sheath.

Mobile X-ray. X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Nonmetallic-sheathed cable. Nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors having an outer sheath of moisture resistant, flame-retardant, nonmetallic material. Nonmetallic sheathed cable is manufactured in the following types:

(i) *Type NM.* The overall covering has a flame-retardant and moisture-resistant finish.

(ii) *Type NMC.* The overall covering is flame-retardant, moisture-resistant, fungus-resistant, and corrosion-resistant.

Oil (filled) cutout. (Over 600 volts, nominal.) A cutout in which all or part of the fuse support and its fuse link or disconnecting blade are mounted in oil with complete immersion of the contacts and the fusible portion of the conducting element (fuse link), so that arc interruption by severing of the fuse link or by opening of the contacts will occur under oil.

Open wiring on insulators. Open wiring on insulators is an exposed wiring method using cleats, knobs, tubes, and flexible tubing for the protection and support of single insulated conductors run in or on buildings, and not concealed by the building structure.

Outlet. A point on the wiring system at which current is taken to supply utilization equipment.

Outline lighting. An arrangement of incandescent lamps or electric discharge tubing to outline or call attention to certain features such as the shape of a building or the decoration of a window.

Oven, wall-mounted. An oven for cooking purposes designed for mounting in or on a wall or other surface and consisting of one of more heating elements, internal wiring, and built-in or separately mountable controls. (See *Cooking unit, counter-mounted.*)

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

Overload. Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See *Overcurrent.*)

Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See *Switchboard.*)

Permanently installed decorative fountains and reflection pools. Those that are constructed in the ground, on the ground, or in a building in such a manner that the pool cannot be readily disassembled for storage and are served by electrical circuits of any nature. These units are primarily constructed for their aesthetic value and not intended for swimming or wading.

Permanently installed swimming pools, wading and therapeutic pools. Those that are constructed in the ground, on the ground, or in a building in such a manner that the pool cannot be readily disassembled for storage whether or not served by electrical circuits of any nature.

Portable X-ray. X-ray equipment designed to be hand-carried.

Power and control tray cable. Type TC power and control tray cable is a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a nonmetallic sheath, approved for installation in cable trays, in raceways, or where supported by a messenger wire.

Power fuse. (Over 600 volts, nominal.) See *Fuse.*

Power-limited tray cable. Type PLTC nonmetallic-sheathed power limited tray cable is a factory assembly of two or more insulated conductors under a nonmetallic jacket.

Power outlet. An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to supply and control power to mobile homes, recreational vehicles or boats, or to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises wiring system. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person. One familiar with the construction and operation of the equipment and the hazards involved.

NOTE 1: Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace. It is possible and, in fact, likely for an individual to be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment. (See § 1910.332(b)(3) for training requirements that specifically apply to qualified persons.)

NOTE 2: An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

Raceway. A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Readily accessible. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (*See "Accessible.*)

Receptacle. A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

Receptacle outlet. An outlet where one or more receptacles are installed.

Remote-control circuit. Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment. Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system. A premises wiring system whose power is derived from generator, transformer, or converter winding and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service cable. Service conductors made up in the form of a cable.

Service conductors. The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Service drop. The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance cable. Service-entrance cable is a single conductor or multiconductor assembly provided with or without an overall covering, primarily used for services and of the following types:

(i) *Type SE*, having a flame-retardant, moisture-resistant covering, but not required to have inherent protection against mechanical abuse.

(ii) *Type USE*, recognized for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering or inherent protection against mechanical abuse. Single-conductor cables having an insulation specifically approved for the purpose do not require an outer covering.

Service-entrance conductors, overhead system. The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service entrance conductors, underground system. The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to consititute the main control and means of cutoff of the supply.

Service raceway. The raceway that encloses the service-entrance conductors.

Shielded nonmetallic-sheathed cable. Type SNM, shielded nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant nonmetallic material, covered with an overlapping spiral metal tape and wire shield and jacketed with an extruded moisture-, flame-, oil-, corrosion-, fungus-, and sunlight-resistant nonmetallic material.

Show window. Any window used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear and whether or not it has a platform raised higher than the street floor level.

Sign. See *Electric Sign*.

Signaling circuit. Any electric circuit that energizes signaling equipment.

Special permission. The written consent of the authority having jurisdiction.

Storable swimming or wading pool. A pool with a maximum dimension of 15 feet and a maximum wall height of 3 feet and is so constructed that it may be readily disassembled for storage and reassembled to its original integrity.

Switchboard. A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See *Panelboard*.)

Switches.

(i) *General-use switch*. A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

(ii) *General-use snap switch*. A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.

(iii) *Isolating switch*. A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

(iv) *Motor-circuit switch*. A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices. (Over 600 volts, nominal.) Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, interrupter switches, and oil (filled) cutouts.

Transportable X-ray. X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment. Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

Utilization system. A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

Ventilated. Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid. A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point.

Voltage (of a circuit). The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight. So constructed that moisture will not enter the enclosure.

Weatherproof. So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wet location. See *Location*.

Wireways. Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981, as amended at 53 FR 12123, Apr. 12, 1988; 55 FR 32020, Aug. 6, 1990; 55 FR 46054, Nov. 1, 1990]

APPENDIX A TO SUBPART S—REFERENCE DOCUMENTS

The following references provide information which can be helpful in understanding and complying with the requirements contained in Subpart S:

ANSI A17.1-71 Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks.
ANSI B9.1-71 Safety Code for Mechanical Refrigeration.
ANSI B30.2-76 Safety Code for Overhead and Gantry Cranes.
ANSI B30.3-75 Hammerhead Tower Cranes.
ANSI B30.4-73 Safety Code for Portal, Tower, and Pillar Cranes.
ANSI B30.5-68 Safety Code for Crawler, Locomotive, and Truck Cranes.
ANSI B30.6-77 Derricks.
ANSI B30.7-77 Base Mounted Drum Hoists.
ANSI B30.8-71 Safety Code for Floating Cranes and Floating Derricks.
ANSI B30.11-73 Monorail Systems and Underhung Cranes.
ANSI B30.12-75 Handling Loads Suspended from Rotorcraft.
ANSI B30.13-77 Controlled Mechanical Storage Cranes.
ANSI B30.15-73 Safety Code for Mobile Hydraulic Cranes.
ANSI B30.16-73 Overhead Hoists.
ANSI C2-81 National Electrical Safety Code.
ANSI C33.27-74 Safety Standard for Outlet Boxes and Fittings for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G.
ANSI K61.1-72 Safety Requirements for the Storage and Handling of Anhydrous Ammonia.
ASTM D2155-66 Test Method for Autoignition Temperature of Liquid Petroleum Products.
ASTM D3176-74 Method for Ultimate Analysis of Coal and Coke.
ASTM D3180-74 Method for Calculating Coal and Coke Analyses from As Determined to Different Bases.
IEEE 463-77 Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones.
NFPA 20-76 Standard for the Installation of Centrifugal Fire Pumps.
NFPA 30-78 Flammable and Combustible Liquids Code.
NFPA 32-74 Standard for Drycleaning Plants.
NFPA 33-73 Standard for Spray Application Using Flammable and Combustible Materials.
NFPA 34-74 Standard for Dip Tanks Containing Flammable or Combustible Liquids.
NFPA 35-76 Standard for the Manufacture of Organic Coatings.
NFPA 36-74 Standard for Solvent Extraction Plants.
NFPA 40-74 Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film.
NFPA 56A-73 Standard for the Use of Inhalation Anesthetics (Flammable and Nonflammable).
NFPA 56F-74 Standard for Nonflammable Medical Gas Systems.
NFPA 58-76 Standard for the Storage and Handling of Liquefied Petroleum Gases.
NFPA 59-76 Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants.
NFPA 70-78 National Electrical Code.
NFPA 70C-74 Hazardous Locations Classification.
NFPA 70E Standard for the Electrical Safety Requirements for Employee Workplaces.
NFPA 71-77 Standard for the Installation, Maintenance, and Use of Central Station Signaling Systems.
NFPA 72A-75 Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Watchman, Fire Alarm, and Supervisory Service.
NFPA 72B-75 Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service.
NFPA 72C-75 Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems.
NFPA 72D-75 Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems for Watchman, Fire Alarm, and Supervisory Service.
NFPA 72E-74 Standard for Automatic Fire Detectors.
NFPA 74-75 Standard for Installation, Maintenance, and Use of Household Fire Warning Equipment.
NFPA 76A-73 Standard for Essential Electrical Systems for Health Care Facilities.
NFPA 77-72 Recommended Practice on Static Electricity.

NFPA 80-77 Standard for Fire Doors and Windows.
NFPA 86A-73 Standard for Ovens and Furnaces; Design, Location and Equipment.
NFPA 88A-73 Standard for Parking Structures.
NFPA 88B-73 Standard for Repair Garages.
NFPA 91-73 Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal, or Conveying.
NFPA 101-78 Code for Safety to Life from Fire in Buildings and Structures. (Life Safety Code.)
NFPA 325M-69 Fire-Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.
NFPA 493-75 Standard for Intrinsically Safe Apparatus for Use in Class I Hazardous Locations and Its Associated Apparatus.
NFPA 496-74 Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations.
NFPA 497-75 Recommended Practice for Classification of Class I Hazardous Locations for Electrical Installations in Chemical Plants.
NFPA 505-75 Fire Safety Standard for Powered Industrial Trucks Including Type Designations and Areas of Use.
NMAB 353-1-79 Matrix of Combustion-Relevant Properties and Classification of Gases, Vapors, and Selected Solids.
NMAB 353-2-79 Test Equipment for Use in Determining Classifications of Combustible Dusts.
NMAB 353-3-80 Classification of Combustible Dusts in Accordance with the National Electrical Code.

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

APPENDIX B TO SUBPART S—EXPLANATORY DATA [RESERVED]

APPENDIX C TO SUBPART S—TABLES, NOTES, AND CHARTS [RESERVED]

Subpart T—Commercial Diving Operations

AUTHORITY: Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Sec. 41, Longshoremen's and Harbor Workers' Compensation Act (33 U.S.C. 941); Secretary of Labor's Order No. 8-76 (41 FR 25059) or 9-83 (48 FR 35736), as applicable; 29 CFR part 1911.

SOURCE: 42 FR 37668, July 22, 1977, unless otherwise noted.

GENERAL

§ 1910.401 Scope and application.

(a) *Scope.* (1) This subpart (standard) applies to every place of employment within the waters of the United States, or within any State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, Guam, the Trust Territory of the Pacific Islands, Wake Island, Johnston Island, the Canal Zone, or within the Outer Continental Shelf lands as defined in the Outer Continental Shelf Lands Act (67 Stat. 462, 43 U.S.C. 1331), where diving and related support operations are performed.

(2) This standard applies to diving and related support operations conducted in connection with all types of work and employments, including general industry, construction, ship repairing, shipbuilding, shipbreaking and longshoring. However, this standard does not apply to any diving operation:

(i) Performed solely for instructional purposes, using open-circuit, compressed-air SCUBA and conducted within the no-decompression limits;

(ii) Performed solely for search, rescue, or related public safety purposes by or under the control of a governmental agency; or

(iii) Governed by 45 CFR part 46 (Protection of Human Subjects, U.S. Department of Health, Education, and Welfare) or equivalent rules or regulations established by another federal agency, which regulate research, development, or related purposes involving human subjects.

(iv) Defined as scientific diving and which is under the direction and control of a diving program containing at least the following elements:

(A) Diving safety manual which includes at a minimum: Procedures covering all diving operations specific to the program; procedures for emergency care, including recompression and evacuation; and criteria for diver training and certification.

(B) Diving control (safety) board, with the majority of its members being active divers, which shall at a minimum have the authority to: Ap-

APPENDIX D

29 CFR 1926, SUBPARTS K AND V

flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.

(b) Precautions shall be taken to prevent ignition of highly flammable hardened preservative coatings. When coatings are determined to be highly flammable, they shall be stripped from the area to be heated to prevent ignition.

(c) Protection against toxic preservative coatings: (1) In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators, meeting the requirements of subpart E of this part.

(2) In the open air, employees shall be protected by a respirator, in accordance with requirements of subpart E of this part.

(d) The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Subpart K—Electrical

AUTHORITY: Secs. 6 and 8, Occupational Safety and Health Act (29 U.S.C. 655, 657); sec. 107, Contract Work Hours and Safety Standards Act (40 U.S.C. 333); Secretary of Labor's Order No. 9-83 (48 FR 35736); 29 CFR Part 1911.

SOURCE: 51 FR 25318, July 11, 1986, unless otherwise noted.

GENERAL

§ 1926.400 Introduction.

This subpart addresses electrical safety requirements that are necessary for the practical safeguarding of employees involved in construction work and is divided into four major divisions and applicable definitions as follows:

(a) *Installation safety requirements.* Installation safety requirements are contained in §§ 1926.402 through 1926.408. Included in this category are electric equipment and installations used to provide electric power and light on jobsites.

(b) *Safety-related work practices.* Safety-related work practices are contained in §§ 1926.416 and 1926.417. In addition to covering the hazards arising from the use of electricity at jobsites, these regulations also cover the hazards arising from the accidental contact, direct or indirect, by employees with all energized lines, above or below ground, passing through or near the jobsite.

(c) *Safety-related maintenance and environmental considerations.* Safety-related maintenance and environmental considerations are contained in §§ 1926.431 and 1926.432.

(d) *Safety requirements for special equipment.* Safety requirements for special equipment are contained in § 1926.441.

(e) *Definitions.* Definitions applicable to this subpart are contained in § 1926.449.

§ 1926.401 [Reserved]

INSTALLATION SAFETY REQUIREMENTS

§ 1926.402 Applicability.

(a) *Covered.* Sections 1926.402 through 1926.408 contain installation safety requirements for electrical equipment and installations used to provide electric power and light at the jobsite. These sections apply to installations, both temporary and permanent, used on the jobsite; but these sections do not apply to existing permanent installations that were in place before the construction activity commenced.

NOTE: If the electrical installation is made in accordance with the National Electrical Code ANSI/NFPA 70-1984, exclusive of Formal Interpretations and Tentative Interim Amendments, it will be deemed to be in compliance with §§ 1926.403 through 1926.408, except for §§ 1926.404(b)(1) and 1926.405(a)(2)(ii) (E), (F), (G), and (J).

(b) *Not covered.* Sections 1926.402 through 1926.408 do not cover installations used for the generation, transmission, and distribution of electric energy, including related communication, metering, control, and transformation installations. (However, these regulations do cover portable and vehicle-mounted generators used to provide power for equipment used at the jobsite.) See subpart V of this part for the construction of power distribution and transmission lines.

§ 1926.403 General requirements.

(a) *Approval.* All electrical conductors and equipment shall be approved.

(b) *Examination, installation, and use of equipment*—(1) *Examination.* The employer shall ensure that electrical equipment is free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined on the basis of the following considerations:

(i) Suitability for installation and use in conformity with the provisions of this subpart. Suitability of equipment for an identified purpose may be evidenced by listing, labeling, or certification for that identified purpose.

(ii) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(iii) Electrical insulation.

(iv) Heating effects under conditions of use.

(v) Arcing effects.

(vi) Classification by type, size, voltage, current capacity, specific use.

(vii) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

(2) *Installation and use.* Listed, labeled, or certified equipment shall be installed and used in accordance with instructions included in the listing, labeling, or certification.

(c) *Interrupting rating.* Equipment intended to break current shall have an interrupting rating at system voltage sufficient for the current that must be interrupted.

(d) *Mounting and cooling of equipment*—(1) *Mounting.* Electric equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used.

(2) *Cooling.* Electrical equipment which depends upon the natural circulation of air and convection principles for cooling of exposed surfaces shall be installed so that room air flow over such surfaces is not prevented by walls or by adjacent installed equipment. For equipment designed for floor mounting, clearance between top surfaces and adjacent surfaces shall be provided to dissipate rising warm air. Electrical equipment provided with ventilating openings shall be installed so that walls or other obstructions do not prevent the free circulation of air through the equipment.

(e) *Splices.* Conductors shall be spliced or joined with splicing devices designed for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device designed for the purpose.

(f) *Arcing parts.* Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

(g) *Marking.* Electrical equipment shall not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment and unless other markings are provided giving voltage, current, wattage, or other ratings as necessary. The marking shall be of sufficient durability to withstand the environment involved.

(h) *Identification of disconnecting means and circuits.* Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involved.

(i) *600 Volts, nominal, or less.* This paragraph applies to equipment operating at 600 volts, nominal, or less.

(1) *Working space about electric equipment.* Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(i) *Working clearances.* Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive shall not be less than indicated in Table K-1. In addition to the dimensions shown in Table K-1, workspace shall not be less than 30 inches (762 mm) wide in front of the electric equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Walls constructed of concrete, brick, or tile are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

TABLE K-1—WORKING CLEARANCES

Nominal voltage to ground	Minimum clear distance for conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
0–150	3	3	3
151–600	3	3½	4

[1] Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. (c) Exposed live parts on both sides of the workspace (not guarded as provided in Condition (a)) with the operator between.

[2] Note: For International System of Units (SI): one foot=0.3048m.

(ii) *Clear spaces.* Working space required by this subpart shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be guarded.

(iii) *Access and entrance to working space.* At least one entrance shall be provided to give access to the working space about electric equipment.

(iv) *Front working space.* Where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 3 feet (914 mm).

(v) *Headroom.* The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 6 feet 3 inches (1.91 m).

(2) *Guarding of live parts.* (i) Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by cabinets or other forms of enclosures, or by any of the following means:

(A) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(B) By partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(C) By location on a balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(D) By elevation of 8 feet (2.44 m) or more above the floor or other working surface and so installed as to exclude unqualified persons.

(ii) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(j) *Over 600 volts, nominal.* (1) *General.* Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable

provisions of paragraphs (a) through (g) of this section and with the following provisions which supplement or modify those requirements. The provisions of paragraphs (j)(2), (j)(3), and (j)(4) of this section do not apply to equipment on the supply side of the service conductors.

(2) *Enclosure for electrical installations.* Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other equivalent means, are considered to be accessible to qualified persons only. A wall, screen, or fence less than 8 feet (2.44 m) in height is not considered adequate to prevent access unless it has other features that provide a degree of isolation equivalent to an 8-foot (2.44-m) fence. The entrances to all buildings, rooms or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

(i) *Installations accessible to qualified persons only.* Electrical installations having exposed live parts shall be accessible to qualified persons only and shall comply with the applicable provisions of paragraph (j)(3) of this section.

(ii) *Installations accessible to unqualified persons.* Electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area, access to which is controlled by a lock. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. If equipment is exposed to physical damage from vehicular traffic, guards shall be provided to prevent such damage. Ventilating or similar openings in metal-enclosed equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(3) *Workspace about equipment.* Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace shall not be less than 6 feet 6 inches (1.98 m) high (measured vertically from the floor or platform), or less than 3 feet (914 mm) wide (measured parallel to the equipment). The depth shall be as required in Table K-2. The workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

(i) *Working space.* The minimum clear working space in front of electric equipment such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment shall not be less than specified in Table K-2 unless otherwise specified in this subpart. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. However, working space is not required in back of equipment such as deadfront switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches (762 mm) horizontally shall be provided.

TABLE K-2—MINIMUM DEPTH OF CLEAR WORKING SPACE IN FRONT OF ELECTRIC EQUIPMENT

Nominal voltage to ground	Conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
601 to 2,500	3	4	5
2,501 to 9,000	4	5	6
9,001 to 25,000	5	6	9
25,001 to 75 kV	6	8	10
Above 75kV	8	10	12

[1] Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. Walls constructed of concrete, brick, or tile are considered to be grounded surfaces. (c) Exposed live parts on both sides of the workspace (not guarded as provided in Condition (a)) with the operator between.

[2] NOTE: For SI units: one foot=0.3048 m.

(ii) *Lighting outlets and points of control.* The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(iii) *Elevation of unguarded live parts.* Unguarded live parts above working space shall be maintained at elevations not less than specified in Table K-3.

TABLE K-3—ELEVATION OF UNGUARDED ENERGIZED PARTS ABOVE WORKING SPACE

Nominal voltage between phases	Minimum elevation
601-7,500	8 feet 6 inches.[1]
7,501-35,000	9 feet.
Over 35kV	9 feet+0.37 inches per kV above 35kV.

[1] NOTE: For SI units: one inch=25.4 mm; one foot=0.3048 m.

(4) *Entrance and access to workspace.* At least one entrance not less than 24 inches (610 mm) wide and 6 feet 6 inches (1.98 m) high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches (1.22 m) in width, there shall be one entrance at each end of such board where practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be guarded.

(Information collection requirements contained in paragraphs (g) and (h) were approved by the Office of Management and Budget under control number 1218-0130)

§ 1926.404 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors*—(1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug shall not be used for purposes other than grounding.

(b) *Branch circuits*—(1) *Ground-fault protection*—(i) *General.* The employer shall use either ground fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.

(ii) *Ground-fault circuit interrupters.* All 120-volt, single-phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(iii) *Assured equipment grounding conductor program.* The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(A) A written description of the program, including the specific procedures adopted by the employer, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(B) The employer shall designate one or more competent persons (as defined in § 1926.32(f)) to implement the program.

(C) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded:

(*1*) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(*2*) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

(E) All required tests shall be performed:

(*1*) Before first use;

(*2*) Before equipment is returned to service following any repairs;

(*3*) Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and

(*4*) At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.

(F) The employer shall not make available or permit the use by employees of any equipment which has not met the requirements of this paragraph (b)(1)(iii) of this section.

(G) Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served and shall comply with the following:

(i) *Single receptacles.* A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

(ii) *Two or more receptacles.* Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table K-4.

(iii) *Receptacles used for the connection of motors.* The rating of an attachment plug or receptacle used for cord- and plug-connection of a motor to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts if individual overload protection is omitted.

TABLE K-4—RECEPTACLE RATINGS FOR VARIOUS SIZE CIRCUITS

Circuit rating amperes	Receptacle rating amperes
15	Not over 15.
20	15 or 20.
30	30.
40	40 or 50.
50	50.

(c) *Outside conductors and lamps*—(1) *600 volts, nominal, or less.* Paragraphs (c)(1)(i) through (c)(1)(iv) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors.

(i) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(A) Power conductors below communication conductors—30 inches (762 mm).

(B) Power conductors alone or above communication conductors: 300 volts or less—24 inches (610 mm); more than 300 volts—30 inches (762 mm).

(C) Communication conductors below power conductors: with power conductors 300 volts or less—24 inches (610 mm); more than 300 volts—30 inches (762 mm).

(ii) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

(A) 10 feet (3.05 m)—above finished grade, sidewalks, or from any platform or projection from which they might be reached.

(B) 12 feet (3.66 m)—over areas subject to vehicular traffic other than truck traffic.

(C) 15 feet (4.57 m)—over areas other than those specified in paragraph (c)(1)(ii)(D) of this section that are subject to truck traffic.

(D) 18 feet (5.49 m)—over public streets, alleys, roads, and driveways.

(iii) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet (914 mm) from windows, doors, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet (914 mm) away.

(iv) *Clearance over roofs.* Conductors above roof space accessible to employees on foot shall have a clearance from the highest point of the roof surface of not less than 8 feet (2.44 m) vertical clearance for insulated conductors, not less than 10 feet (3.05 m) vertical or diagonal clearance for covered conductors, and not less than 15 feet (4.57 m) for bare conductors, except that:

(A) Where the roof space is also accessible to vehicular traffic, the vertical clearance shall not be less than 18 feet (5.49 m), or

(B) Where the roof space is not normally accessible to employees on foot, fully insulated conductors shall have a vertical or diagonal clearance of not less than 3 feet (914 mm), or

(C) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches (102 mm) in 12 inches (305 mm), the clearance from roofs shall be at least 3 feet (914 mm), or

(D) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet (1.22 m) of the overhang portion of the roof and they are terminated at a through-the-roof raceway or support, the clearance from roofs shall be at least 18 inches (457 mm).

(2) *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services*—(1) *Disconnecting means*—(i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

(i) *Guarding.* Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

(ii) *Warning signs.* Signs warning of high voltage shall be posted where unauthorized employees might come in contact with live parts.

(e) *Overcurrent protection*—(1) *600 volts, nominal, or less.* The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current. Conductors shall have sufficient ampacity to carry the load.

(ii) *Grounded conductors.* Except for motor-running overload protection, overcurrent devices shall not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

(iii) *Disconnection of fuses and thermal cutouts.* Except for devices provided for current-limiting on the supply side of the service disconnecting means, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

(iv) *Location in or on premises.* Overcurrent devices shall be readily accessible. Overcurrent devices shall not be located where they could create an employee safety hazard by being exposed to physical damage or located in the vicinity of easily ignitible material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

(vi) *Circuit breakers*—(A) Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

(B) Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position.

(C) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be marked "SWD."

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(11) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) *Three-wire DC systems.* All 3-wire DC systems shall have their neutral conductor grounded.

(ii) *Two-wire DC systems.* Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless they are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(iv), and (f)(1)(v) of this section.

(iii) *AC circuits, less than 50 volts.* AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) *AC systems, 50 volts to 1000 volts.* AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(A) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(B) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(C) If the system is nominally rated 240/120 volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or

(D) If a service conductor is uninsulated.

(v) *Exceptions.* AC systems of 50 volts to 1000 volts are not required to be grounded if the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(A) The system is used exclusively for control circuits,

(B) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(C) Continuity of control power is required, and

(D) Ground detectors are installed on the control system.

(2) *Separately derived systems.* Where paragraph (f)(1) of this section requires grounding of wiring systems whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system, paragraph (f)(5) of this section shall also apply.

(3) *Portable and vehicle-mounted generators*—(i) *Portable generators.* Under the following conditions, the frame of a portable generator need not be grounded and may serve as the grounding electrode for a system supplied by the generator:

(A) The generator supplies only equipment mounted on the generator and/or cord- and plug-connected equipment through receptacles mounted on the generator, and

(B) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

(ii) *Vehicle-mounted generators.* Under the following conditions the frame of a vehicle may serve as the grounding electrode for a system supplied by a generator located on the vehicle:

(A) The frame of the generator is bonded to the vehicle frame, and

(B) The generator supplies only equipment located on the vehicle and/or cord- and plug-connected equipment through receptacles mounted on the vehicle or on the generator, and

(C) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame, and

(D) The system complies with all other provisions of this section.

(iii) *Neutral conductor bonding.* A neutral conductor shall be bonded to the generator frame if the generator is a component of a separately derived system. No other conductor need be bonded to the generator frame.

(4) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(5) *Grounding connections*—(i) *Grounded system.* For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) *Ungrounded systems.* For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(6) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(7) *Supports, enclosures, and equipment to be grounded*—(i) *Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

(A) Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; and

(B) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met:

(*1*) Runs are less than 25 feet (7.62 m);

(*2*) Enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and

(*3*) Enclosures are guarded against employee contact.

(ii) *Service equipment enclosures.* Metal enclosures for service equipment shall be grounded.

(iii) *Fixed equipment.* Exposed noncurrent-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

(A) If within 8 feet (2.44 m) vertically or 5 feet (1.52 m) horizontally of ground or grounded metal objects and subject to employee contact.

(B) If located in a wet or damp location and subject to employee contact.

(C) If in electrical contact with metal.

(D) If in a hazardous (classified) location.

(E) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

(F) If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

(*1*) Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

(*2*) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

(*3*) The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet (2.44 m) above ground or grade level.

(iv) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(7)(iv)(A) through (f)(7)(iv)(C) of this section, exposed noncurrent-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded:

(A) If in a hazardous (classified) location (see § 1926.407).

(B) If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

(C) If the equipment is one of the types listed in paragraphs (f)(7)(iv)(C)(*1*) through (f)(7)(iv)(C)(*5*) of this section. However, even though the equipment may be one of these types, it need not be grounded if it is exempted by paragraph (f)(7)(iv)(C)(*6*).

(*1*) Hand held motor-operated tools;

(*2*) Cord- and plug-connected equipment used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;

(*3*) Portable and mobile X-ray and associated equipment;

(*4*) Tools likely to be used in wet and/or conductive locations; and

(*5*) Portable hand lamps.

(*6*) Tools likely to be used in wet and/or conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by a system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes a system of double insulation.

(v) *Nonelectrical equipment.* The metal parts of the following nonelectrical equipment shall be grounded: Frames and tracks of electrically operated cranes; frames of nonelectrically driven elevator cars to which electric conductors are attached; hand-operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over IkV between conductors.

(8) *Methods of grounding equipment*—(i) *With circuit conductors.* Noncurrent-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) *Grounding conductor.* A conductor used for grounding fixed or movable equipment shall have capacity to conduct safely any fault current which may be imposed on it.

(iii) *Equipment considered effectively grounded.* Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the noncurrent-carrying metal parts of fixed equipment in paragraph (f)(8)(i) of this section. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(9) *Bonding.* If bonding conductors are used to assure electrical continuity, they shall have the capacity to con-

duct any fault current which may be imposed.

(10) *Made electrodes.* If made electrodes are used, they shall be free from nonconductive coatings, such as paint or enamel; and, if practicable, they shall be embedded below permanent moisture level. A single electrode consisting of a rod, pipe or plate which has a resistance to ground greater than 25 ohms shall be augmented by one additional electrode installed no closer than 6 feet (1.83 m) to the first electrode.

(11) *Grounding of systems and circuits of 1000 volts and over (high voltage)*—(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(10) of this section as supplemented and modified by this paragraph (f)(11).

(ii) *Grounding of systems supplying portable or mobile equipment.* Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(A) Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.

(B) Exposed noncurrent-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(D) The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet (6.1 m) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence or like objects.

(iii) *Grounding of equipment.* All noncurrent-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet (2.44 m) above ground or grade level need not be grounded.

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§ 1926.405 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this paragraph do not apply to conductors which form an integral part of equipment such as motors, controllers, motor control centers and like equipment.

(1) *General requirements*—(i) *Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

(ii) *Wiring in ducts.* No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type shall be installed in any duct used for vapor removal or in any shaft containing only such ducts.

(2) *Temporary wiring*—(i) *Scope.* The provisions of paragraph (a)(2) of this section apply to temporary electrical power and lighting wiring methods which may be of a class less than would be required for a permanent installation. Except as specifically modified in paragraph (a)(2) of this section, all other requirements of this subpart for permanent wiring shall apply to temporary wiring installations. Temporary wiring shall be removed immediately upon completion of construction or the purpose for which the wiring was installed.

(ii) *General requirements for temporary wiring*—(A) Feeders shall originate in a distribution center. The conductors shall be run as multiconductor cord or cable assemblies or within raceways; or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet (3.05 m) apart.

(B) Branch circuits shall originate in a power outlet or panelboard. Conductors shall be run as multiconductor cord or cable assemblies or open conductors, or shall be run in raceways. All conductors shall be protected by overcurrent devices at their ampacity. Runs of open conductors shall be located where the conductors will not be subject to physical damage, and the conductors shall be fastened at intervals not exceeding 10 feet (3.05 m). No branch-circuit conductors shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if the branch circuit is run as open conductors.

(C) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor. Receptacles for uses other than temporary lighting shall not be installed on branch circuits which supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits which supply temporary lighting.

(D) Disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(E) All lamps for general illumination shall be protected from accidental contact or breakage. Metal-case sockets shall be grounded.

(F) Temporary lights shall not be suspended by their electric cords unless cords and lights are designed for this means of suspension.

(G) Portable electric lighting used in wet and/or other conductive locations, as for example, drums, tanks, and vessels, shall be operated at 12 volts or less. However, 120-volt lights may be used if protected by a ground-fault circuit interrupter.

(H) A box shall be used wherever a change is made to a raceway system or a cable system which is metal clad or metal sheathed.

(I) Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided. Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage.

(J) Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra-hard usage. Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage.

NOTE: The National Electrical Code, ANSI/NFPA 70, in Article 400, Table 400-4, lists various types of flexible cords, some of which are noted as being designed for hard or extra-hard usage. Examples of these types of flexible cords include hard service cord (types S, ST, SO, STO) and junior hard service cord (types SJ, SJO, SJT, SJTO).

(iii) *Guarding.* For temporary wiring over 600 volts, nominal, fencing, barriers, or other effective means shall be provided to prevent access of other than authorized and qualified personnel.

(b) *Cabinets, boxes, and fittings.* (1) *Conductors entering boxes, cabinets, or fittings.* Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall also be effectively closed.

(2) *Covers and canopies.* All pull boxes, junction boxes, and fittings shall be provided with covers. If metal covers are used, they shall be grounded. In energized installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings de-

signed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

(3) *Pull and junction boxes for systems over 600 volts, nominal.* In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:

(i) *Complete enclosure.* Boxes shall provide a complete enclosure for the contained conductors or cables.

(ii) *Covers.* Boxes shall be closed by covers securely fastened in place. Underground box covers that weigh over 100 pounds (43.6 kg) meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

(c) *Knife switches.* Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

(d) *Switchboards and panelboards.* Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

(e) *Enclosures for damp or wet locations* (1) *Cabinets, fittings, and boxes.* Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

(2) *Switches and circuit breakers.* Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

(f) *Conductors for general wiring.* All conductors used for general wiring shall be insulated unless otherwise permitted in this subpart. The conductor insulation shall be of a type that is suitable for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

(g) *Flexible cords and cables*—(1) *Use of flexible cords and cables*—(i) *Permitted uses.* Flexible cords and cables shall be suitable for conditions of use and location. Flexible cords and cables shall be used only for:

(A) Pendants;

(B) Wiring of fixtures;

(C) Connection of portable lamps or appliances;

(D) Elevator cables;

(E) Wiring of cranes and hoists;

(F) Connection of stationary equipment to facilitate their frequent interchange;

(G) Prevention of the transmission of noise or vibration; or

(H) Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair.

(ii) *Attachment plugs for cords.* If used as permitted in paragraphs (g)(1)(i)(C), (g)(1)(i)(F), or (g)(1)(i)(H) of this section, the flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet.

(iii) *Prohibited uses.* Unless necessary for a use permitted in paragraph (g)(1)(i) of this section, flexible cords and cables shall not be used:

(A) As a substitute for the fixed wiring of a structure;

(B) Where run through holes in walls, ceilings, or floors;

(C) Where run through doorways, windows, or similar openings, except as permitted in paragraph (a)(2)(ii)(I) of this section;

(D) Where attached to building surfaces; or

(E) Where concealed behind building walls, ceilings, or floors.

(2) *Identification, splices, and terminations*—(i) *Identification.* A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors.

(ii) *Marking.* Type SJ, SJO, SJT, SJTO, S, SO, ST, and STO cords shall not be used unless durably marked on the surface with the type designation, size, and number of conductors.

(iii) *Splices.* Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

(iv) *Strain relief.* Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

(v) *Cords passing through holes.* Flexible cords and cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

(h) *Portable cables over 600 volts, nominal.* Multiconductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables shall not be operated with splices unless the splices are of the permanent molded, vulcanized, or other equivalent type. Termination enclosures shall be marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

(i) *Fixture wires*—(1) *General.* Fixture wires shall be suitable for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.

(2) *Uses permitted.* Fixture wires may be used:

(i) For installation in lighting, fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or

(ii) For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

(3) *Uses not permitted.* Fixture wires shall not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

(j) *Equipment for general use*—(1) *Lighting fixtures, lampholders, lamps, and receptacles*—(i) *Live parts.* Fixtures, lampholders, lamps, rosettes, and receptacles shall have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet (2.44 m) above the floor may have exposed parts.

(ii) *Support.* Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture that weighs more than 6 pounds (2.72 kg) or exceeds 16 inches (406 mm) in any dimension shall not be supported by the screw shell of a lampholder.

(iii) *Portable lamps.* Portable lamps shall be wired with flexible cord and an attachment plug of the polarized or grounding type. If the portable lamp uses an Edison-based lampholder, the grounded conductor shall be identified and attached to the screw shell and the identified blade of the attachment plug. In addition, portable handlamps shall comply with the following:

(A) Metal shell, paperlined lampholders shall not be used;

(B) Handlamps shall be equipped with a handle of molded composition or other insulating material;

(C) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle;

(D) Metallic guards shall be grounded by the means of an equipment grounding conductor run within the power supply cord.

(iv) *Lampholders.* Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(v) *Fixtures.* Fixtures installed in wet or damp locations shall be identified for the purpose and shall be installed so that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

(2) *Receptacles, cord connectors, and attachment plugs (caps)*—(i) *Configuration.* Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a different voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.

(ii) *Damp and wet locations.* A receptacle installed in a wet or damp location shall be designed for the location.

(3) *Appliances*—(i) *Live parts.* Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, shall have no live parts normally exposed to employee contact.

(ii) *Disconnecting means.* A means shall be provided to disconnect each appliance.

(iii) *Rating.* Each appliance shall be marked with its rating in volts and amperes or volts and watts.

(4) *Motors.* This paragraph applies to motors, motor circuits, and controllers.

(i) *In sight from.* If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet (15.2 m) from the other.

(ii) *Disconnecting means*—(A) A disconnecting means shall be located in sight from the controller location. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

(B) The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

(C) If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(*1*) The controller disconnecting means shall be capable of being locked in the open position.

(*2*) A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

(D) The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

(E) The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.

(F) An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions:

(*1*) If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;

(*2*) If a group of motors is under the protection of one set of branch-circuit protective devices; or

(*3*) If a group of motors is in a single room in sight from the location of the disconnecting means.

(iii) *Motor overload, short-circuit, and ground-fault protection.* Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions do not require overload protection that will stop a motor where a shutdown is likely to

introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

(iv) *Protection of live parts—all voltages*—(A) Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

(*1*) By installation in a room or enclosure that is accessible only to qualified persons;

(*2*) By installation on a balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

(*3*) By elevation 8 feet (2.44 m) or more above the floor.

(B) Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

(5) *Transformers*—(i) *Application.* The following paragraphs cover the installation of all transformers, except:

(A) Current transformers;

(B) Dry-type transformers installed as a component part of other apparatus;

(C) Transformers which are an integral part of an X-ray, high frequency, or electrostatic-coating apparatus;

(D) Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signaling circuits.

(ii) *Operating voltage.* The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.

(iii) *Transformers over 35 kV.* Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35 kV shall be in a vault.

(iv) *Oil-insulated transformers.* If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

(v) *Fire protection.* Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

(vi) *Transformer vaults.* Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.

(vii) *Pipes and ducts.* Any pipe or duct system foreign to the vault installation shall not enter or pass through a transformer vault.

(viii) *Material storage.* Materials shall not be stored in transformer vaults.

(6) *Capacitors*—(i) *Drainage of stored charge.* All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge and maintaining the discharged state after the capacitor is disconnected from its source of supply.

(ii) *Over 600 volts.* Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:

(A) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

(B) For series capacitors the proper switching shall be assured by use of at least one of the following:

(*1*) Mechanically sequenced isolating and bypass switches,

(*2*) Interlocks, or

(3) Switching procedure prominently displayed at the switching location.

(Information collection requirements contained in paragraphs (g)(2)(ii), (j)(3)(iii), (j)(4)(ii)(A), (j)(5)(ii), and (j)(6)(ii)(B)(3) were approved by the Office of Management and Budget under control number 1218-0130)

§ 1926.406 Specific purpose equipment and installations.

(a) *Cranes and hoists.* This paragraph applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

(1) *Disconnecting means*—(i) *Runway conductor disconnecting means.* A readily accessible disconnecting means shall be provided between the runway contact conductors and the power supply.

(ii) *Disconnecting means for cranes and monorail hoists.* A disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply on any crane or monorail hoist.

(A) If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

(B) The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:

(1) The unit is floor controlled;

(2) The unit is within view of the power supply disconnecting means; and

(3) No fixed work platform has been provided for servicing the unit.

(2) *Control.* A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

(3) *Clearance.* The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches (762 mm). Where controls are enclosed in cabinets, the door(s) shall open at least 90 degrees or be removable, or the installation shall provide equivalent access.

(4) *Grounding.* All exposed metal parts of cranes, monorail hoists, hoists and accessories including pendant controls shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded in accordance with § 1926.404(f). Moving parts, other than removable accessories or attachments, having metal-to-metal bearing surfaces shall be considered to be electrically connected to each other through the bearing surfaces for grounding purposes. The trolley frame and bridge frame shall be considered as electrically grounded through the bridge and trolley wheels and its respective tracks unless conditions such as paint or other insulating materials prevent reliable metal-to-metal contact. In this case a separate bonding conductor shall be provided.

(b) *Elevators, escalators, and moving walks*—(1) *Disconnecting means.* Elevators, escalators, and moving walks shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.

(2) *Control panels.* If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

(c) *Electric welders—disconnecting means*—(1) *Motor-generator, AC transformer, and DC rectifier arc welders.* A disconnecting means shall be provided in the supply circuit for each motor-generator arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder.

(2) *Resistance welders.* A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity.

(d) *X-Ray equipment*—(1) *Disconnecting means*—(i) *General.* A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.

(ii) *More than one piece of equipment.* If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by employees with its live parts.

(2) *Control—Radiographic and fluoroscopic types.* Radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that deenergize the equipment automatically to prevent ready access to live current-carrying parts.

§ 1926.407 Hazardous (classified) locations.

(a) *Scope.* This section sets forth requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1
Class I, Division 2
Class II, Division 1
Class II, Division 2
Class III, Division 1
Class III, Division 2

For definitions of these locations see § 1926.449. All applicable requirements in this subpart apply to all hazardous (classified) locations, unless modified by provisions of this section.

(b) *Electrical installations.* Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be approved as intrinsically safe or approved for the hazardous (classified) location or safe for the hazardous (classified) location. Requirements for each of these options are as follows:

(1) *Intrinsically safe.* Equipment and associated wiring approved as intrinsically safe is permitted in any hazardous (classified) location included in its listing or labeling.

(2) *Approved for the hazardous (classified) location*—(i) *General.* Equipment shall be approved not only for the class of location but also for the ignitible or combustible properties of the specific gas, vapor, dust, or fiber that will be present.

NOTE: NFPA 70, the National Electrical Code, lists or defines hazardous gases, vapors, and dusts by "Groups" characterized by their ignitible or combustible properties.

(ii) *Marking.* Equipment shall not be used unless it is marked to show the class, group, and operating temperature or temperature range, based on operation in a 40-degree C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas, vapor, or dust to be encountered. However, the following provisions modify this marking requirement for specific equipment:

(A) Equipment of the non-heat-producing type (such as junction boxes, conduit, and fitting) and equipment of the heat-producing type having a maximum temperature of not more than 100 degrees C (212 degrees F) need not have a marked operating temperature or temperature range.

(B) Fixed lighting fixtures marked for use only in Class I, Division 2 locations need not be marked to indicate the group.

(C) Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.

(D) Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

(3) *Safe for the hazardous (classified) location.* Equipment which is

safe for the location shall be of a type and design which the employer demonstrates will provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

NOTE: The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installations which will meet this requirement. The guidelines of this document address electric wiring, equipment, and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections, conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote control systems, local loud speaker and communication systems, ventilation piping, live parts, lightning surge protection, and grounding. Compliance with these guidelines will constitute one means, but not the only means, of compliance with this paragraph.

(c) *Conduits.* All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

(Information collection requirements contained in paragraph (b)(2)(ii) were approved by the Office of Management and Budget under control number 1218-0130)

§ 1926.408 Special systems.

(a) *Systems over 600 volts, nominal.* Paragraphs (a)(1) through (a)(4) of this section contain general requirements for all circuits and equipment operated at over 600 volts.

(1) *Wiring methods for fixed installations*—(i) *Above ground.* Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable designed for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations which are accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.

(ii) *Installations emerging from the ground.* Conductors emerging from the ground shall be enclosed in raceways. Raceways installed on poles shall be of rigid metal conduit, intermediate metal conduit, PVC schedule 80 or equivalent extending from the ground line up to a point 8 feet (2.44 m) above finished grade. Conductors entering a building shall be protected by an enclosure from the ground line to the point of entrance. Metallic enclosures shall be grounded.

(2) *Interrupting and isolating devices*—(i) *Circuit breakers.* Circuit breakers located indoors shall consist of metal-enclosed or fire-resistant, cell-mounted units. In locations accessible only to qualified personnel, open mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

(ii) *Fused cutouts.* Fused cutouts installed in buildings or transformer vaults shall be of a type identified for the purpose. They shall be readily accessible for fuse replacement.

(iii) *Equipment isolating means.* A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load current of the circuit shall be either interlocked with a circuit interrupter or provided with a sign warning against opening them under load.

(3) *Mobile and portable equipment*—(i) *Power cable connections to mobile machines.* A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to ground effectively the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and

shall be marked with a sign warning of the presence of energized parts.

(ii) *Guarding live parts.* All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

(4) *Tunnel installations*—(i) *Application.* The provisions of this paragraph apply to installation and use of high-voltage power distribution and utilization equipment which is associated with tunnels and which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

(ii) *Conductors.* Conductors in tunnels shall be installed in one or more of the following:

(A) Metal conduit or other metal raceway,

(B) Type MC cable, or

(C) Other suitable multiconductor cable.

Conductors shall also be so located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

(iii) *Guarding live parts.* Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.

(iv) *Disconnecting means.* A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.

(v) *Grounding and bonding.* All non-energized metal parts of electric equipment and metal raceways and cable sheaths shall be grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet (305 m) throughout the tunnel.

(b) *Class 1, Class 2, and Class 3 remote control, signaling, and power-limited circuits*— (1) *Classification.* Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations as summarized in paragraphs (b)(1)(i) through (b)(1)(iii) of this section.

(i) *Class 1 circuits*—(A) A Class 1 power-limited circuit is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.

(B) A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.

(ii) *Class 2 and Class 3 circuits*—(A) Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

(B) The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.

(C) The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a Class 3 power source limited by overcurrent protection.

(iii) *Application.* The maximum circuit voltages in paragraphs (b)(1)(i) and (b)(1)(ii) of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurrence is not likely.

(2) *Marking.* A Class 2 or Class 3 power supply unit shall not be used

unless it is durably marked where plainly visible to indicate the class of supply and its electrical rating.

(c) *Communications systems*—(1) *Scope.* These provisions for communication systems apply to such systems as central-station-connected and non-central-station-connected telephone circuits, radio receiving and transmitting equipment, and outside wiring for fire and burglar alarm, and similar central station systems. These installations need not comply with the provisions of §§ 1926.403 through 1926.408(b), except § 1926.404(c)(1)(ii) and § 1926.407.

(2) *Protective devices*—(i) *Circuits exposed to power conductors.* Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with an approved protector.

(ii) *Antenna lead-ins.* Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other means that will drain static charges from the antenna system.

(3) *Conductor location*—(i) *Outside of buildings*—(A) Receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light or power conductors.

(B) The clearance between lead-in conductors and any lightning protection conductors shall not be less than 6 feet (1.83 m).

(ii) *On poles.* Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors shall not be attached to a crossarm that carries light or power conductors.

(iii) *Inside of buildings.* Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches (50.8 mm) from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation is employed.

(4) *Equipment location.* Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

(5) *Grounding*—(i) *Lead-in conductors.* If exposed to contact with electric light or power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded.

(ii) *Antenna structures.* Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.

(iii) *Equipment enclosures.* Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

(Information collection requirements contained in paragraph (b)(2) were approved by the Office of Management and Budget under control number 1218-0130)

§§ 1926.409—1926.415 [Reserved]

SAFETY-RELATED WORK PRACTICES

§ 1926.416 General requirements.

(a) *Protection of employees*—(1) No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by

guarding it effectively by insulation or other means.

(2) In work areas where the exact location of underground electric powerlines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

(3) Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

(b) *Passageways and open spaces*—(1) Barriers or other means of guarding shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.

(2) Working spaces, walkways, and similar locations shall be kept clear of cords so as not to create a hazard to employees.

(c) *Load ratings.* In existing installations, no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring.

(d) *Fuses.* When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.

(e) *Cords and cables.* (1) Worn or frayed electric cords or cables shall not be used.

(2) Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

§ 1926.417 Lockout and tagging of circuits.

(a) *Controls.* Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

(b) *Equipment and circuits.* Equipment or circuits that are deenergized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.

(c) *Tags.* Tags shall be placed to identify plainly the equipment or circuits being worked on.

§§ 1926.418—1926.430 [Reserved]

SAFETY-RELATED MAINTENANCE AND ENVIRONMENTAL CONSIDERATIONS

§ 1926.431 Maintenance of equipment.

The employer shall ensure that all wiring components and utilization equipment in hazardous locations are maintained in a dust-tight, dust-ignition-proof, or explosion-proof condition, as appropriate. There shall be no loose or missing screws, gaskets, threaded connections, seals, or other impairments to a tight condition.

§ 1926.432 Environmental deterioration of equipment.

(a) *Deteriorating agents*—(1) Unless identified for use in the operating environment, no conductors or equipment shall be located:

(i) In damp or wet locations;

(ii) Where exposed to gases, fumes, vapors, liquids, or other agents having a deteriorating effect on the conductors or equipment; or

(iii) Where exposed to excessive temperatures.

(2) Control equipment, utilization equipment, and busways approved for use in dry locations only shall be protected against damage from the weather during building construction.

(b) *Protection against corrosion.* Metal raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware shall be of materials appropriate for the environment in which they are to be installed.

§§ 1926.433—1926.440 [Reserved]

SAFETY REQUIREMENTS FOR SPECIAL EQUIPMENT

§ 1926.441 Batteries and battery charging.

(a) *General requirements*—(1) Batteries of the unsealed type shall be located in enclosures with outside vents or in well ventilated rooms and shall be arranged so as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

(2) Ventilation shall be provided to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture.

(3) Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

(4) Floors shall be of acid resistant construction unless protected from acid accumulations.

(5) Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

(6) Facilities for quick drenching of the eyes and body shall be provided within 25 feet (7.62 m) of battery handling areas.

(7) Facilities shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

(b) *Charging*—(1) Battery charging installations shall be located in areas designated for that purpose.

(2) Charging apparatus shall be protected from damage by trucks.

(3) When batteries are being charged, the vent caps shall be kept in place to avoid electrolyte spray. Vent caps shall be maintained in functioning condition.

§§ 1926.442—1926.448 [Reserved]

DEFINITIONS

§ 1926.449 Definitions applicable to this subpart.

The definitions given in this section apply to the terms used in subpart K. The definitions given here for "approved" and "qualified person" apply, instead of the definitions given in § 1926.32, to the use of these terms in subpart K.

Acceptable. An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this subpart K:

(a) If it is accepted, or certified, or listed, or labeled or otherwise determined to be safe by a qualified testing laboratory capable of determining the suitability of materials and equipment for installation and use in accordance with this standard; or

(b) With respect to an installation or equipment of a kind which no qualified testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with those provisions; or

(c) With respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

Accepted. An installation is "accepted" if it has been inspected and found to be safe by a qualified testing laboratory.

Accessible. (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "*concealed*" and "*exposed.*")

Accessible. (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See "*Readily accessible.*")

Ampacity. The current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Appliances. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or conneceted as a unit to perform one or more functions.

Approved. Acceptable to the authority enforcing this subpart. The authority enforcing this subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this subpart.

Askarel. A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under

arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap)(Cap). A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

Bare conductor. See "*Conductor.*"

Bonding. The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper. A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Branch circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Building. A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet. An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

Certified. Equipment is "certified" if it:

(a) Has been tested and found by a qualified testing laboratory to meet applicable test standards or to be safe for use in a specified manner; and

(b) Is of a kind whose production is periodically inspected by a qualified testing laboratory. Certified equipment must bear a label, tag, or other record of certification.

Circuit breaker—(a) (600 volts nominal, or less.) A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(b) (Over 600 volts, nominal.) A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations include the following:

(a) *Class I, Division 1.* A Class I, Division 1 location is a location:

(1) In which ignitible concentrations of flammable gases or vapors may exist under normal operating conditions; or

(2) In which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

(3) In which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

NOTE: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(b) *Class I, Division 2.* A Class I, Division 2 location is a location:

(1) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of

such containers or systems, or in case of abnormal operation of equipment; or

(2) In which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or

(3) That is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

NOTE: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

Class II locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(a) *Class II, Division 1.* A Class II, Division 1 location is a location:

(1) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures; or

(2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or

(3) In which combustible dusts of an electrically conductive nature may be present.

NOTE: Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(b) *Class II, Division 2.* A Class II, Division 2 location is a location in which:

(1) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or

(2) Dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitible by abnormal operation or failure of electrical equipment or other apparatus.

NOTE: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitible concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations. Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures.

Class III locations include the following:

(a) *Class III, Division 1.* A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

NOTE: Easily ignitible fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, sawdust, woodchips, and other material of similar nature.

(b) *Class III, Division 2.* A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled, except in process of manufacture.

Collector ring. A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

Concealed. Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [See "*Accessible.* (As applied to wiring methods.)"]

Conductor—(a) *Bare.* A conductor having no covering or electrical insulation whatsoever.

(b) *Covered.* A conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(c) *Insulated.* A conductor encased within material of composition and thickness that is recognized as electrical insulation.

Controller. A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Covered conductor. See "*Conductor.*"

Cutout. (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "*Cabinet.*")

Damp location. See "*Location.*"

Dead front. Without live parts exposed to a person on the operating side of the equipment.

Device. A unit of an electrical system which is intended to carry but not utilize electric energy.

Disconnecting means. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch. (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dry location. See "*Location.*"

Enclosed. Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Equipment. A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

Equipment grounding conductor. See "*Grounding conductor, equipment.*"

Explosion-proof apparatus. Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed. (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "*Accessible*" and "*Concealed.*")

Exposed. (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "*Accessible.* (As applied to wiring methods.)"]

Exposed. (For the purposes of § 1926.408(d), Communications systems.) Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable. Capable of being operated without exposing the operator to contact with live parts.

Feeder. All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Festoon lighting. A string of outdoor lights suspended between two points more than 15 feet (4.57 m) apart.

Fitting. An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Fuse. (Over 600 volts, nominal.) An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded. Connected to earth or to some conducting body that serves in place of the earth.

Grounded, effectively (Over 600 volts, nominal.) Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Grounded conductor. A system or circuit conductor that is intentionally grounded.

Grounding conductor. A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment. The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Grounding electrode conductor. The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

Ground-fault circuit interrupter. A device for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Hoistway. Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified (conductors or terminals). Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be recognized as grounded.

Identified (for the use). Recognized as suitable for the specific purpose, function, use, environment, application, etc. where described as a requirement in this standard. Suitability of equipment for a specific purpose, environment, or application is determined by a qualified testing laboratory where such identification includes labeling or listing.

Insulated conductor. See "*Conductor.*"

Interrupter switch. (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

Intrinsically safe equipment and associated wiring. Equipment and associated wiring in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under certain prescribed test conditions, of causing ignition of a mixture of flammable or combustible material in air in its most easily ignitible concentration.

Isolated. Not readily accessible to persons unless special means for access are used.

Isolated power system. A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of a qualified testing laboratory which indicates compliance with appropriate standards or performance in a specified manner.

Lighting outlet. An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Listed. Equipment or materials included in a list published by a qualified testing laboratory whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Location—(a) *Damp location.* Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements.

(b) *Dry location.* A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(c) *Wet location.* Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected.

Mobile X-ray. X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Motor control center. An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Outlet. A point on the wiring system at which current is taken to supply utilization equipment.

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

Overload. Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See "*Overcurrent.*")

Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "*Switchboard.*")

Portable X-ray. X-ray equipment designed to be hand-carried.

Power fuse. (Over 600 volts, nominal.) See "*Fuse.*"

Power outlet. An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises wiring system. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person. One familiar with the construction and operation of the equipment and the hazards involved.

Qualified testing laboratory. A properly equipped and staffed testing laboratory which has capabilities for and which provides the following services:

(a) Experimental testing for safety of specified items of equipment and materials referred to in this standard to determine compliance with appropriate test standards or performance in a specified manner;

(b) Inspecting the run of such items of equipment and materials at factories for product evaluation to assure compliance with the test standards;

(c) Service-value determinations through field inspections to monitor the proper use of labels on products and with authority for recall of the label in the event a hazardous product is installed;

(d) Employing a controlled procedure for identifying the listed and/or labeled equipment or materials tested; and

(e) Rendering creditable reports or findings that are objective and without bias of the tests and test methods employed.

Raceway. A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Readily accessible. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "*Accessible.*")

Receptacle. A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

Receptacle outlet. An outlet where one or more receptacles are installed.

Remote-control circuit. Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment. Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system. A premises wiring system whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service conductors. The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Service drop. The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance conductors, overhead system. The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service-entrance conductors, underground system. The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service raceway. The raceway that encloses the service-entrance conductors.

Signaling circuit. Any electric circuit that energizes signaling equipment.

Switchboard. A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "*Panelboard.*")

Switches—(a) *General-use switch.* A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

(b) *General-use snap switch.* A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.

(c) *Isolating switch.* A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

(d) *Motor-circuit switch.* A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices. (Over 600 volts, nominal.) Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, and interrupter switches.

Transportable X-ray. X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment. Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

Utilization system. A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

Ventilated. Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid. A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 40 psia (276 kPa) at 38° C (100° F) whose temperature is above its flash point.

Voltage. (Of a circuit.) The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight. So constructed that moisture will not enter the enclosure.

Weatherproof. So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wet location. See "*Location.*"

(1) Bus wire. An expendable wire, used in parallel or series, in parallel circuits, to which are connected the leg wires of electric blasting caps.

(2) Connecting wire. An insulated expendable wire used between electric blasting caps and the leading wires or between the bus wire and the leading wires.

(3) Leading wire. An insulated wire used between the electric power source and the electric blasting cap circuit.

(4) Permanent blasting wire. A permanently mounted insulated wire used between the electric power source and the electric blasting cap circuit.

(m) *Electric delay blasting caps*—Caps designed to detonate at a predetermined period of time after energy is applied to the ignition system.

(n) *Explosives*—(1) Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion; that is, with substantially instantaneous release of gas and heat, unless such compound, mixture or device is otherwise specifically classified by the U.S. Department of Transportation.

(2) All material which is classified as Class A, Class B, and Class C Explosives by the U.S. Department of Transportation.

(3) Classification of explosives by the U.S. Department of Transportation is as follows:

Class A Explosives. Possessing detonating hazard, such as dynamite, nitroglycerin, picric acid, lead azide, fulminate of mercury, black powder, blasting caps, and detonating primers.

Class B Explosives. Possessing flammable hazard, such as propellant explosives, including some smokeless propellants.

Class C Explosives. Include certain types of manufactured articles which contain Class A or Class B explosives, or both, as components, but in restricted quantities.

(o) *Fuse lighters*—Special devices for the purpose of igniting safety fuse.

(p) *Magazine*—Any building or structure, other than an explosives manufacturing building, used for the storage of explosives.

(q) *Misfire*—An explosive charge which failed to detonate.

(r) *Mud-capping* (sometimes known as bulldozing, adobe blasting, or dobying). The blasting of boulders by placing a quantity of explosives against a rock, boulder, or other object without confining the explosives in a drill hole.

(s) *Nonelectric delay blasting cap*—A blasting cap with an integral delay element in conjunction with and capable of being detonated by a detonation impulse or signal from miniaturized detonating cord.

(t) *Primary blasting*—The blasting operation by which the original rock formation is dislodged from its natural location.

(u) *Primer*—A cartridge or container of explosives into which a detonator or detonating cord is inserted or attached.

(v) *Safety fuse*—A flexible cord containing an internal burning medium by which fire is conveyed at a continuous and uniform rate for the purpose of firing blasting caps.

(w) *Secondary blasting*—The reduction of oversize material by the use of explosives to the dimension required for handling, including mudcapping and blockholing.

(x) *Stemming*—A suitable inert incombustible material or device used to confine or separate explosives in a drill hole, or to cover explosives in mud-capping.

(y) *Springing*—The creation of a pocket in the bottom of a drill hole by the use of a moderate quantity of explosives in order that larger quantities or explosives may be inserted therein.

(z) *Water gels, or slurry explosives*—A wide variety of materials used for blasting. They all contain substantial proportions of water and high proportions of ammonium nitrate, some of which is in solution in the water. Two broad classes of water gels are: (1) Those which are sensitized by a material classed as an explosive, such as TNT or smokeless powder, and (2) those which contain no ingredient classified as an explosive; these are sensitized with metals such as aluminum or with other fuels. Water gels may be premixed at an explosives plant or mixed at the site immediately before delivery into the bore hole.

Subpart V—Power Transmission and Distribution

AUTHORITY: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable.

§ 1926.950 General requirements.

(a) *Application.* The occupational safety and health standards contained in this Subpart V shall apply to the construction of electric transmission and distribution lines and equipment.

(1) As used in this Subpart V the term "construction" includes the erection of new electric transmission and distribution lines and equipment, and the alteration, conversion, and improvement of existing electric transmission and distribution lines and equipment.

(2) Existing electric transmission and distribution lines and electrical equipment need not be modified to conform to the requirements of applicable standards in this Subpart V, until such work as described in paragraph (a)(1) of this section is to be performed on such lines or equipment.

(3) The standards set forth in this Subpart V provide minimum requirements for safety and health. Employers may require adherence to additional standards which are not in conflict with the standards contained in this Subpart V.

(b) *Initial inspections, tests, or determinations.* (1) Existing conditions shall be determined before starting work, by an inspection or a test. Such conditions shall include, but not be limited to, energized lines and equipment, conditions of poles, and the location of circuits and equipment, including power and communication lines, CATV and fire alarm circuits.

(2) Electric equipment and lines shall be considered energized until determined to be deenergized by tests or other appropriate methods or means.

(3) Operating voltage of equipment and lines shall be determined before working on or near energized parts.

(c) *Clearances.* The provisions of paragraph (c) (1) or (2) of this section shall be observed.

(1) No employee shall be permitted to approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table V-1, unless:

(i) The employee is insulated or guarded from the energized part (gloves or gloves with sleeves rated for the voltage involved shall be considered insulation of the employee from the energized part), or

(ii) The energized part is insulated or guarded from him and any other conductive object at a different potential, or

(iii) The employee is isolated, insulated, or guarded from any other conductive object(s), as during live-line bare-hand work.

(2) (i) The minimum working distance and minimum clear hot stick distances stated in Table V-1 shall not be violated. The minimum clear hot stick distance is that for the use of live-line tools held by linemen when performing live-line work.

(ii) Conductor support tools, such as link sticks, strain carriers, and insulator cradles, may be used: *Provided,* That the clear insulation is at least as long as the insulator string or the minimum distance specified in Table V-1 for the operating voltage.

TABLE V-1—ALTERNATING CURRENT—MINIMUM DISTANCES

Voltage range (phase to phase) kilovolt)	Minimum working and clear hot stick distance
2.1 to 15	2 ft. 0 in.
15.1 to 35	2 ft. 4 in.
35.1 to 46	2 ft. 6 in.
46.1 to 72.5	3 ft. 0 in.
72.6 to 121	3 ft. 4 in.
138 to 145	3 ft. 6 in.
161 to 169	3 ft. 8 in.
230 to 242	5 ft. 0 in.
345 to 362	[1] 7 ft. 0 in.
500 to 552	[1] 11 ft. 0 in.
700 to 765	[1] 15 ft. 0 in.

[1] NOTE: For 345-362 kv., 500-552 kv., and 700-765 kv., the minimum working distance and the minimum clear hot stick distance may be reduced provided that such distances are not less than the shortest distance between the energized part and a grounded surface.

(d) *Deenergizing lines and equipment.* (1) When deenergizing lines and equipment operated in excess of 600 volts, and the means of disconnecting from electric energy is not visibly open or visibly locked out, the provisions of paragraphs (d)(1) (i) through (vii) of this section shall be complied with:

(i) The particular section of line or equipment to be deenergized shall be clearly identified, and it shall be isolated from all sources of voltage.

(ii) Notification and assurance from the designated employee shall be obtained that:

(*a*) All switches and disconnectors through which electric energy may be supplied to the particular section of line or equipment to be worked have been deenergized;

(*b*) All switches and disconnectors are plainly tagged indicating that men are at work;

(*c*) And that where design of such switches and disconnectors permits, they have been rendered inoperable.

(iii) After all designated switches and disconnectors have been opened, rendered inoperable, and tagged, visual inspection or tests shall be conducted to insure that equipment or lines have been deenergized.

(iv) Protective grounds shall be applied on the disconnected lines or equipment to be worked on.

(v) Guards or barriers shall be erected as necessary to adjacent energized lines.

(vi) When more than one independent crew requires the same line or equipment to be deenergized, a prominent tag for each such independent crew shall be placed on the line or equipment by the designated employee in charge.

(vii) Upon completion of work on deenergized lines or equipment, each designated employee in charge shall determine that all employees in his crew are clear, that protective grounds installed by his crew have been removed, and he shall report to the designated authority that all tags protecting his crew may be removed.

(2) When a crew working on a line or equipment can clearly see that the means of disconnecting from electric energy are visibly open or visibly locked-out, the provisions of paragraphs (d)(1), and (ii) of this section shall apply:

(i) Guards or barriers shall be erected as necessary to adjacent energized lines.

(ii) Upon completion of work on deenergized lines or equipment, each designated employee in charge shall determine that all employees in his crew are clear, that protective grounds installed by his crew have been removed, and he shall report to the designated authority that all tags protecting his crew may be removed.

(e) *Emergency procedures and first aid.* (1) The employer shall provide training or require that his employees are knowledgeable and proficient in:

(i) Procedures involving emergency situations, and

(ii) First-aid fundamentals including resuscitation.

(2) In lieu of paragraph (e)(1) of this section the employer may comply with the provisions of § 1926.50(c) regarding first-aid requirements.

(f) *Night work.* When working at night, spotlights or portable lights for emergency lighting shall be provided as needed to perform the work safely.

(g) *Work near and over water.* When crews are engaged in work over or near water and when danger of drowning exists, suitable protection shall be provided as stated in § 1926.104, or § 1926.105, or § 1926.106.

(h) *Sanitation facilities.* The requirements of § 1926.51 of Subpart D of this part shall be complied with for sanitation facilities.

(i) *Hydraulic fluids.* All hydraulic fluids used for the insulated sections of derrick trucks, aerial lifts, and hydraulic tools which are used on or around energized lines and equipment shall be of the insulating type. The requirements for fire resistant fluids of § 1926.302(d)(1) do not apply to hydraulic tools covered by this paragraph.

§ 1926.951 Tools and protective equipment.

(a) *Protective equipment.* (1)(i) Rubber protective equipment shall be in accordance with the provisions of the American National Standards Institute (ANSI), ANSI J6 series, as follows:

Item	Standard
Rubber insulating gloves	J6.6-1971.
Rubber matting for use around electric apparatus.	J6.7-1935 (R1971).
Rubber insulating blankets	J6.4-1971.
Rubber insulating hoods	J6.2-1950 (R1971).
Rubber insulating line hose	J6.1-1950 (R1971).
Rubber insulating sleeves	J6.5-1971.

(ii) Rubber protective equipment shall be visually inspected prior to use.

(iii) In addition, an "air" test shall be performed for rubber gloves prior to use.

(iv) Protective equipment of material other than rubber shall provide equal or better electrical and mechanical protection.

(2) Protective hats shall be in accordance with the provisions of ANSI Z89.2-1971 Industrial Protective Helmets for Electrical Workers, Class B, and shall be worn at the jobsite by employees who are exposed to the hazards of falling objects, electric shock, or burns.

(b) *Personal climbing equipment.* (1) Body belts with straps or lanyards shall be worn to protect employees working at elevated locations on poles, towers, or other structures except where such use creates a greater hazard to the safety of the employees, in which case other safeguards shall be employed.

(2) Body belts and safety straps shall meet the requirements of § 1926.959. In addition to being used as an employee safeguarding item, body belts with approved tool loops may be used for the purpose of holding tools. Body belts shall be free from additional metal hooks and tool loops other than those permitted in § 1926.959.

(3) Body belts and straps shall be inspected before use each day to determine that they are in safe working condition.

(4)(i) Life lines and lanyards shall comply with the provisions of § 1926.104.

(ii) Safety lines are not intended to be subjected to shock loading and are used for emergency rescue such as lowering a man to the ground. Such safety lines shall be a minimum of one-half-inch diameter and three or four strand first-grade manila or its equivalent in strength (2,650 lb.) and durability.

(5) Defective ropes shall be replaced.

(c) *Ladders.* (1) Portable metal or conductive ladders shall not be used near energized lines or equipment except as may be necessary in specialized work such as in high voltage substations where nonconductive ladders might present a greater hazard than conductive ladders. Conductive or metal ladders shall be prominently marked as conductive and all necessary precautions shall be taken when used in specialized work.

(2) Hook or other type ladders used in structures shall be positively secured to prevent the ladder from being accidentally displaced.

(d) *Live-line tools.* (1) Only live-line tool poles having a manufacturer's certification to withstand the following minimum tests shall be used:

(i) 100,000 volts per foot of length for 5 minutes when the tool is made of fiberglass; or

(ii) 75,000 volts per foot of length for 3 minutes when the tool is made of wood; or

(iii) Other tests equivalent to paragraph (d) (i) or (ii) of this section as appropriate.

(2) All live-line tools shall be visually inspected before use each day. Tools to be used shall be wiped clean and if any hazardous defects are indicated such tools shall be removed from service.

(e) *Measuring tapes or measuring ropes.* Measuring tapes or measuring ropes which are metal or contain conductive strands shall not be used when working on or near energized parts.

(f) *Handtools.* (1) Switches for all powered hand tools shall comply with § 1926.300(d).

(2) All portable electric handtools shall:

(i) Be equipped with three-wire cord having the ground wire permanently connected to the tool frame and means for grounding the other end; or

(ii) Be of the double insulated type and permanently labeled as "Double Insulated"; or

(iii) Be connected to the power supply by means of an isolating transformer, or other isolated power supply.

(3) All hydraulic tools which are used on or around energized lines or equipment shall use nonconducting hoses having adequate strength for the normal operating pressures. It should be noted that the provisions of § 1926.302(d)(2) shall also apply.

(4) All pneumatic tools which are used on or around energized lines or equipment shall:

(i) Have nonconducting hoses having adequate strength for the normal operating pressures, and

(ii) Have an accumulator on the compressor to collect moisture.

§ 1926.952 Mechanical equipment.

(a) *General.* (1) Visual inspections shall be made of the equipment to determine that it is in good condition each day the equipment is to be used.

(2) Tests shall be made at the beginning of each shift during which the equipment is to be used to determine that the brakes and operating systems are in proper working condition.

(3) No employer shall use any motor vehicle equipment having an obstructed view to the rear unless:

(i) The vehicle has a reverse signal alarm audible above the surrounding noise level or:

(ii) The vehicle is backed up only when an observer signals that it is safe to do so.

(b) *Aerial lifts.* (1) The provisions of § 1926.556, Subpart N of this part, shall apply to the utilization of aerial lifts.

(2) When working near energized lines or equipment, aerial lift trucks shall be grounded or barricaded and considered as energized equipment, or the aerial lift truck shall be insulated for the work being performed.

(3) Equipment or material shall not be passed between a pole or structure and an aerial lift while an employee working from the basket is within reaching distance of energized conductors or equipment that are not covered with insulating protective equipment.

(c) *Derrick trucks, cranes and other lifting equipment.* (1) All derrick trucks, cranes and other lifting equipment shall comply with Subpart N and O of this part except:

(i) As stated in § 1926.550(a)(15) (i) and (ii) relating to clearance (for clearances in this subpart see Table V-1) and

(ii) Derrick truck (electric line trucks) shall not be required to comply with § 1926.550(a)(7)(vi), (a)(17), (b)(2), and (e).

(2) With the exception of equipment certified for work on the proper voltage, mechanical equipment shall not be operated closer to any energized line or equipment than the clearances set forth in § 1926.950(c) unless:

(i) An insulated barrier is installed between the energized part and the mechanical equipment, or

(ii) The mechanical equipment is grounded, or

(iii) The mechanical equipment is insulated, or

(iv) The mechanical equipment is considered as energized.

§ 1926.953 Material handling.

(a) *Unloading.* Prior to unloading steel, poles, cross arms and similar material, the load shall be thoroughly examined to ascertain if the load has shifted, binders or stakes have broken or the load is otherwise hazardous to employees.

(b) *Pole hauling.* (1) During pole hauling operations, all loads shall be secured to prevent displacement and a red flag shall be displayed at the trailing end of the longest pole.

(2) Precautions shall be exercised to prevent blocking of roadways or endangering other traffic.

(3) When hauling poles during the hours of darkness, illuminated warning devices shall be attached to the trailing end of the longest pole.

(c) *Storage.* (1) No materials or equipment shall be stored under energized bus, energized lines, or near energized equipment, if it is practical to store them elsewhere.

(2) When materials or equipment are stored under energized lines or near energized equipment, applicable clearances shall be maintained as stated in Table V-1; and extraordinary caution shall be exercised when moving materials near such energized equipment.

(d) *Tag line.* Where hazards to employees exist tag lines or other suitable devices shall be used to control

loads being handled by hoisting equipment.

(e) *Oil filled equipment.* During construction or repair of oil filled equipment the oil may be stored in temporary containers other than those required in § 1926.152, such as pillow tanks.

(f) *Framing.* During framing operations, employees shall not work under a pole or a structure suspended by a crane, A-frame or similar equipment unless the pole or structure is adequately supported.

(g) *Attaching the load.* The hoist rope shall not be wrapped around the load. This provision shall not apply to electric construction crews when setting or removing poles.

§ 1926.954 Grounding for protection of employees.

(a) *General.* All conductors and equipment shall be treated as energized until tested or otherwise determined to be deenergized or until grounded.

(b) *New construction.* New lines or equipment may be considered deenergized and worked as such where:

(1) The lines or equipment are grounded, or

(2) The hazard of induced voltages is not present, and adequate clearances or other means are implemented to prevent contact with energized lines or equipment and the new lines or equipment.

(c) *Communication conductors.* Bare wire communication conductors on power poles or structures shall be treated as energized lines unless protected by insulating materials.

(d) *Voltage testing.* Deenergized conductors and equipment which are to be grounded shall be tested for voltage. Results of this voltage test shall determine the subsequent procedures as required in § 1926.950(d).

(e) *Attaching grounds.* (1) When attaching grounds, the ground end shall be attached first, and the other end shall be attached and removed by means of insulated tools or other suitable devices.

(2) When removing grounds, the grounding device shall first be removed fromt the line or equipment using insulating tools or other suitable devices.

(f) Grounds shall be placed between work location and all sources of energy and as close as practicable to the work location, or grounds shall be placed at the work location. If work is to be performed at more than one location in a line section, the line section must be grounded and short circuited at one location in the line section and the conductor to be worked on shall be grounded at each work location. The minimum distance shown in Table V-1 shall be maintained from ungrounded conductors at the work location. Where the making of a ground is impracticable, or the conditions resulting therefrom would be more hazardous than working on the lines or equipment without grounding, the grounds may be omitted and the line or equipment worked as energized.

(g) *Testing without grounds.* Grounds may be temporarily removed only when necessary for test purposes and extreme caution shall be exercised during the test procedures.

(h) *Grounding electrode.* When grounding electrodes are utilized, such electrodes shall have a resistance to ground low enough to remove the danger of harm to personnel or permit prompt operation of protective devices.

(i) *Grounding to tower.* Grounding to tower shall be made with a tower clamp capable of conducting the anticipated fault current.

(j) *Ground lead.* A ground lead, to be attached to either a tower ground or driven ground, shall be capable of conducting the anticipated fault current and shall have a minimum conductance of No. 2 AWG copper.

§ 1926.955 Overhead lines.

(a) *Overhead lines.* (1) When working on or with overhead lines the provisions of paragraphs (a) (2) through (8) of this section shall be complied with in addition to other applicable provisions of this subpart.

(2) Prior to climbing poles, ladders, scaffolds, or other elevated structures, an inspection shall be made to determine that the structures are capable of sustaining the additional or unbal-

anced stresses to which they will be subjected.

(3) Where poles or structures may be unsafe for climbing, they shall not be climbed until made safe by guying, bracing, or other adequate means.

(4) Before installing or removing wire or cable, strains to which poles and structures will be subjected shall be considered and necessary action taken to prevent failure of supporting structures.

(5)(i) When setting, moving, or removing poles using cranes, derricks, gin poles, A-frames, or other mechanized equipment near energized lines or equipment, precautions shall be taken to avoid contact with energized lines or equipment, except in bare-hand live-line work, or where barriers or protective devices are used.

(ii) Equipment and machinery operating adjacent to energized lines or equipment shall comply with § 1926.952(c)(2).

(6)(i) Unless using suitable protective equipment for the voltage involved, employees standing on the ground shall avoid contacting equipment or machinery working adjacent to energized lines or equipment.

(ii) Lifting equipment shall be bonded to an effective ground or it shall be considered energized and barricaded when utilized near energized equipment or lines.

(7) Pole holes shall not be left unattended or unguarded in areas where employees are currently working.

(8) Tag lines shall be of a nonconductive type when used near energized lines.

(b) *Metal tower construction.* (1) When working in unstable material the excavation for pad- or pile-type footings in excess of 5 feet deep shall be either sloped to the angle of repose as required in § 1926.652 or shored if entry is required. Ladders shall be provided for access to pad- or pile-type footing excavations in excess of 4 feet.

(2) When working in unstable material provision shall be made for cleaning out auger-type footings without requiring an employee to enter the footing unless shoring is used to protect the employee.

(3)(i) A designated employee shall be used in directing mobile equipment adjacent to footing excavations.

(ii) No one shall be permitted to remain in the footing while equipment is being spotted for placement.

(iii) Where necessary to assure the stability of mobile equipment the location of use for such equipment shall be graded and leveled.

(4)(i) Tower assembly shall be carried out with a minimum exposure of employees to falling objects when working at two or more levels on a tower.

(ii) Guy lines shall be used as necessary to maintain sections or parts of sections in position and to reduce the possibility of tipping.

(iii) Members and sections being assembled shall be adequately supported.

(5) When assembling and erecting towers the provisions of paragraphs (b)(5) (i), (ii) and (iii) of this section shall be complied with:

(i) The construction of transmission towers and the erecting of poles, hoisting machinery, site preparation machinery, and other types of construction machinery shall conform to the applicable requirements of this part.

(ii) No one shall be permitted under a tower which is in the process of erection or assembly, except as may be required to guide and secure the section being set.

(iii) When erecting towers using hoisting equipment adjacent to energized transmission lines, the lines shall be deenergized when practical. If the lines are not deenergized, extraordinary caution shall be exercised to maintain the minimum clearance distances required by § 1926.950(c), including Table V-1.

(6)(i) Erection cranes shall be set on firm level foundations and when the cranes are so equipped outriggers shall be used.

(ii) Tag lines shall be utilized to maintain control of tower sections being raised and positioned, except where the use of such lines would create a greater hazard.

(iii) The loadline shall not be detached from a tower section until the section is adequately secured.

(iv) Except during emergency restoration procedures erection shall be discontinued in the event of high wind or other adverse weather conditions which would make the work hazardous.

(v) Equipment and rigging shall be regularly inspected and maintained in safe operating condition.

(7) Adequate traffic control shall be maintained when crossing highways and railways with equipment as required by the provisions of § 1926.200(g) (1) and (2).

(8) A designated employee shall be utilized to determine that required clearance is maintained in moving equipment under or near energized lines.

(c) *Stringing or removing deenergized conductors.* (1) When stringing or removing deenergized conductors, the provisions of paragraphs (c) (2) through (12) of this section shall be complied with.

(2) Prior to stringing operations a briefing shall be held setting forth the plan of operation and specifying the type of equipment to be used, grounding devices and procedures to be followed, crossover methods to be employed, and the clearance authorization required.

(3) Where there is a possibility of the conductor accidentally contacting an energized circuit or receiving a dangerous induced voltage buildup, to further protect the employee from the hazards of the conductor, the conductor being installed or removed shall be grounded or provisions made to insulate or isolate the employee.

(4)(i) If the existing line is deenergized, proper clearance authorization shall be secured and the line grounded on both sides of the crossover or, the line being strung or removed shall be considered and worked as energized.

(ii) When crossing over energized conductors in excess of 600 volts, rope nets or guard structures shall be installed unless provision is made to isolate or insulate the workman or the energized conductor. Where practical the automatic reclosing feature of the circuit interrupting device shall be made inoperative. In addition, the line being strung shall be grounded on either side of the crossover or considered and worked as energized.

(5) Conductors being strung in or removed shall be kept under positive control by the use of adequate tension reels, guard structures, tielines, or other means to prevent accidental contact with energized circuits.

(6) Guard structure members shall be sound and of adequate dimension and strength, and adequately supported.

(7)(i) Catch-off anchors, rigging, and hoists shall be of ample capacity to prevent loss of the lines.

(ii) The manufacturer's load rating shall not be exceeded for stringing lines, pulling lines, sock connections, and all load-bearing hardware and accessories.

(iii) Pulling lines and accessories shall be inspected regularly and replaced or repaired when damaged or when dependability is doubtful. The provisions of § 1926.251(c)(4)(ii) (concerning splices) shall not apply.

(8) Conductor grips shall not be used on wire rope unless designed for this application.

(9) While the conductor or pulling line is being pulled (in motion) employees shall not be permitted directly under overhead operations, nor shall any employee be permitted on the crossarm.

(10) A transmission clipping crew shall have a minimum of two structures clipped in between the crew and the conductor being sagged. When working on bare conductors, clipping and tying crews shall work between grounds at all times. The grounds shall remain intact until the conductors are clipped in, except on dead end structures.

(11)(i) Except during emergency restoration procedures, work from structures shall be discontinued when adverse weather (such as high wind or ice on structures) makes the work hazardous.

(ii) Stringing and clipping operations shall be discontinued during the progress of an electrical storm in the immediate vicinity.

(12)(i) Reel handling equipment, including pulling and braking machines, shall have ample capacity, operate smoothly, and be leveled and aligned in accordance with the manufacturer's operating instructions.

(ii) Reliable communications between the reel tender and pulling rig operator shall be provided.

(iii) Each pull shall be snubbed or dead ended at both ends before subsequent pulls.

(d) *Stringing adjacent to energized lines.* (1) Prior to stringing parallel to an existing energized transmission line a competent determination shall be made to ascertain whether dangerous induced voltage buildups will occur, particularly during switching and ground fault conditions. When there is a possibility that such dangerous induced voltage may exist the employer shall comply with the provisions of paragraphs (d) (2) through (9) of this section in addition to the provisions of paragraph (c) of this § 1926.955, unless the line is worked as energized.

(2) When stringing adjacent to energized lines the tension stringing method or other methods which preclude unintentional contact between the lines being pulled and any employee shall be used.

(3) All pulling and tensioning equipment shall be isolated, insulated, or effectively grounded.

(4) A ground shall be installed between the tensioning reel setup and the first structure in order to ground each bare conductor, subconductor, and overhead ground conductor during stringing operations.

(5) During stringing operations, each bare conductor, subconductor, and overhead ground conductor shall be grounded at the first tower adjacent to both the tensioning and pulling setup and in increments so that no point is more than 2 miles from a ground.

(i) The grounds shall be left in place until conductor installation is completed.

(ii) Such grounds shall be removed as the last phase of aerial cleanup.

(iii) Except for moving type grounds, the grounds shall be placed and removed with a hot stick.

(6) Conductors, subconductors, and overhead ground conductors shall be grounded at all dead-end or catch-off points.

(7) A ground shall be located at each side and within 10 feet of working areas where conductors, subconductors, or overhead ground conductors are being spliced at ground level. The two ends to be spliced shall be bonded to each other. It is recommended that splicing be carried out on either an insulated platform or on a conductive metallic grounding mat bonded to both grounds. When a grounding mat is used, it is recommended that the grounding mat be roped off and an insulated walkway provided for access to the mat.

(8)(i) All conductors, subconductors, and overhead ground conductors shall be bonded to the tower at any isolated tower where it may be necessary to complete work on the transmission line.

(ii) Work on dead-end towers shall require grounding on all deenergized lines.

(iii) Grounds may be removed as soon as the work is completed: *Provided*, That the line is not left open circuited at the isolated tower at which work is being completed.

(9) When performing work from the structures, clipping crews and all others working on conductors, subconductors, or overhead ground conductors shall be protected by individual grounds installed at every work location.

(e) *Live-line bare-hand work.* In addition to any other applicable standards contained elsewhere in this subpart all live-line bare-hand work shall be performed in accordance with the following requirements:

(1) Employees shall be instructed and trained in the live-line bare-hand technique and the safety requirements pertinent thereto before being permitted to use the technique on energized circuits.

(2) Before using the live-line bare-hand technique on energized high-voltage conductors or parts, a check shall be made of:

(i) The voltage rating of the circuit on which the work is to be performed;

(ii) The clearances to ground of lines and other energized parts on which work is to be performed; and

(iii) The voltage limitations of the aerial-lift equipment intended to be used.

(3) Only equipment designed, tested, and intended for live-line bare-hand work shall be used.

(4) All work shall be personally supervised by a person trained and qualified to perform live-line bare-hand work.

(5) The automatic reclosing feature of circuit interrupting devices shall be made inoperative where practical before working on any energized line or equipment.

(6) Work shall not be performed during the progress of an electrical storm in the immediate vicinity.

(7) A conductive bucket liner or other suitable conductive device shall be provided for bonding the insulated aerial device to the energized line or equipment.

(i) The employee shall be connected to the bucket liner by use of conductive shoes, leg clips, or other suitable means.

(ii) Where necessary, adequate electrostatic shielding for the voltage being worked or conductive clothing shall be provided.

(8) Only tools and equipment intended for live-line bare-hand work shall be used, and such tools and equipment shall be kept clean and dry.

(9) Before the boom is elevated, the outriggers on the aerial truck shall be extended and adjusted to stabilize the truck and the body of the truck shall be bonded to an effective ground, or barricaded and considered as energized equipment.

(10) Before moving the aerial lift into the work position, all controls (ground level and bucket) shall be checked and tested to determine that they are in proper working condition.

(11) Arm current tests shall be made before starting work each day, each time during the day when higher voltage is going to be worked and when changed conditions indicate a need for additional tests. Aerial buckets used for bare-hand live-line work shall be subjected to an arm current test. This test shall consist of placing the bucket in contact with an energized source equal to the voltage to be worked upon for a minimum time of three (3) minutes. the leakage current shall not exceed 1 microampere per kilo-volt of nominal line-to-line voltage. Work operations shall be suspended immediately upon any indication of a malfunction in the equipment.

(12) All aerial lifts to be used for live-line bare-hand work shall have dual controls (lower and upper) as required by paragraph (e)(12) (i) and (ii) of this section.

(i) The upper controls shall be within easy reach of the employee in the basket. If a two basket type lift is used access to the controls shall be within easy reach from either basket.

(ii) The lower set of controls shall be located near base of the boom that will permit over-ride operation of equipment at any time.

(13) Ground level lift control shall not be operated unless permission has been obtained from the employee in lift, except in case of emergency.

(14) Before the employee contacts the energized part to be worked on, the conductive bucket liner shall be bonded to the energized conductor by means of a positive connection which shall remain attached to the energized conductor until the work on the energized circuit is completed.

(15) The minimum clearance distances for live-line bare-hand work shall be as specified in Table V-2. These minimum clearance distances shall be maintained from all grounded objects and from lines and equipment at a different potential than that to which the insulated aerial device is bonded unless such grounded objects or other lines and equipment are covered by insulated guards. These distances shall be maintained when approaching, leaving, and when bonded to the energized circuit.

TABLE V-2—MINIMUM CLEARANCE DISTANCES FOR LIVE-LINE BARE-HAND WORK (ALTERNATING CURRENT)

Voltage range (phase-to-phase) kilovolts	Distance in feet and inches for maximum voltage	
	Phase to ground	Phase to phase
2.1 to 15	2'0"	2'0"
15.1 to 35	2'4"	2'4"
35.1 to 46	2'6"	2'6"

TABLE V-2—MINIMUM CLEARANCE DISTANCES FOR LIVE-LINE BARE-HAND WORK (ALTERNATING CURRENT)—Continued

Voltage range (phase-to-phase) kilovolts	Distance in feet and inches for maximum voltage	
	Phase to ground	Phase to phase
46.1 to 72.5	3'0"	3'0"
72.6 to 121	3'4"	4'6"
138 to 145	3'6"	5'0"
161 to 169	3'8"	5'6"
230 to 242	5'0"	8'4"
345 to 362	[1] 7'0"	[1] 13'4"
500 to 552	[1] 11'0"	[1] 20'0"
700 to 765	[1] 15'0"	[1] 31'0"

[1] For 345-362kv., 500-552kv., and 700-765kv., the minimum clearance distance may be reduced provided the distances are not made less than the shortest distance between the energized part and a grounded surface.

(16) When approaching, leaving, or bonding to an energized circuit the minimum distances in Table V-2 shall be maintained between all parts of the insulated boom assembly and any grounded parts (including the lower arm or portions of the truck).

(17) When positioning the bucket alongside an energized bushing or insulator string, the minimum line-to-ground clearances of Table V-2 must be maintained between all parts of the bucket and the grounded end of the bushing or insulator string.

(18)(i) The use of handlines between buckets, booms, and the ground is prohibited.

(ii) No conductive materials over 36 inches long shall be placed in the bucket, except for appropriate length jumpers, armor rods, and tools.

(iii) Nonconductive-type handlines may be used from line to ground when not supported from the bucket.

(19) The bucket and upper insulated boom shall not be overstressed by attempting to lift or support weights in excess of the manufacturer's rating.

(20)(i) A minimum clearance table (as shown in table V-2) shall be printed on a plate of durable nonconductive material, and mounted in the buckets or its vicinity so as to be visible to the operator of the boom.

(ii) It is recommended that insulated measuring sticks be used to verify clearance distances.

§ 1926.956 Underground lines.

(a) *Guarding and ventilating street opening used for access to underground lines or equipment.* (1) Appropriate warning signs shall be promptly placed when covers of manholes, handholes, or vaults are removed. What is an appropriate warning sign is dependent upon the nature and location of the hazards involved.

(2) Before an employee enters a street opening, such as a manhole or an unvented vault, it shall be promptly protected with a barrier, temporary cover, or other suitable guard.

(3) When work is to be performed in a manhole or unvented vault:

(i) No entry shall be permitted unless forced ventilation is provided or the atmosphere is found to be safe by testing for oxygen deficiency and the presence of explosive gases or fumes;

(ii) Where unsafe conditions are detected, by testing or other means, the work area shall be ventilated and otherwise made safe before entry;

(iii) Provisions shall be made for an adequate continuous supply of air.

(b) *Work in manholes.* (1) While work is being performed in manholes, an employee shall be available in the immediate vicinity to render emergency assistance as may be required. This shall not preclude the employee in the immediate vicinity from occasionally entering a manhole to provide assistance, other than emergency. This requirement does not preclude a qualified employee, working alone, from entering for brief periods of time, a manhole where energized cables or equipment are in service, for the purpose of inspection, housekeeping, taking readings, or similar work if such work can be performed safely.

(2) When open flames must be used or smoking is permitted in manholes, extra precautions shall be taken to provide adequate ventilation.

(3) Before using open flames in a manhole or excavation in an area where combustible gases or liquids may be present, such as near a gasoline service station, the atmosphere of the manhole or excavation shall be tested and found safe or cleared of the combustible gases or liquids.

(c) *Trenching and excavating.* (1) During excavation or trenching, in order to prevent the exposure of employees to the hazards created by damage to dangerous underground facilities, efforts shall be made to determine the location of such facilities and work conducted in a manner designed to avoid damage.

(2) Trenching and excavation operations shall comply with §§ 1926.651 and 1926.652.

(3) When underground facilities are exposed (electric, gas, water, telephone, etc.) they shall be protected as necessary to avoid damage.

(4) Where multiple cables exist in an excavation, cables other than the one being worked on shall be protected as necessary.

(5) When multiple cables exist in an excavation, the cable to be worked on shall be identified by electrical means unless its identity is obvious by reason of distinctive appearance.

(6) Before cutting into a cable or opening a splice, the cable shall be identified and verified to be the proper cable.

(7) When working on buried cable or on cable in manholes, metallic sheath continuity shall be maintained by bonding across the opening or by equivalent means.

§ 1926.957 Construction in energized substations.

(a) *Work near energized equipment facilities.* (1) When construction work is performed in an energized substation, authorization shall be obtained from the designated, authorized person before work is started.

(2) When work is to be done in an energized substation, the following shall be determined:

(i) What facilities are energized, and

(ii) What protective equipment and precautions are necessary for the safety of personnel.

(3) Extraordinary caution shall be exercised in the handling of busbars, tower steel, materials, and equipment in the vicinity of energized facilities. The requirements set forth in § 1926.950(c), shall be complied with.

(b) *Deenergized equipment or lines.* When it is necessary to deenergize equipment or lines for protection of employees, the requirements of § 1926.950(d) shall be complied with.

(c) *Barricades and barriers.* (1) Barricades or barriers shall be installed to prevent accidental contact with energized lines or equipment.

(2) Where appropriate, signs indicating the hazard shall be posted near the barricade or barrier. These signs shall comply with § 1926.200.

(d) *Control panels.* (1) Work on or adjacent to energized control panels shall be performed by designated employees.

(2) Precaution shall be taken to prevent accidental operation of relays or other protective devices due to jarring, vibration, or improper wiring.

(e) *Mechanized equipment.* (1) Use of vehicles, gin poles, cranes, and other equipment in restricted or hazardous areas shall at all times be controlled by designated employees.

(2) All mobile cranes and derricks shall be effectively grounded when being moved or operated in close proximity to energized lines or equipment, or the equipment shall be considered energized.

(3) Fenders shall not be required for lowboys used for transporting large electrical equipment, transformers, or breakers.

(f) *Storage.* The storage requirements of § 1926.953(c) shall be complied with.

(g) *Substation fences.* (1) When a substation fence must be expanded or removed for construction purposes, a temporary fence affording similar protection when the site is unattended, shall be provided. Adequate interconnection with ground shall be maintained between temporary fence and permanent fence.

(2) All gates to all unattended substations shall be locked, except when work is in progress.

(h) *Footing excavation.* (1) Excavation for auger, pad and piling type footings for structures and towers shall require the same precautions as for metal tower construction (see § 1926.955(b)(1)).

(2) No employee shall be permitted to enter an unsupported auger-type excavation in unstable material for any purpose. Necessary clean-out in

such cases shall be accomplished without entry.

§ 1926.958 External load helicopters.

In all operations performed using a rotorcraft for moving or placing external loads, the provisions of § 1926.551 of Subpart N of this part shall be complied with.

§ 1926.959 Lineman's body belts, safety straps, and lanyards.

(a) *General requirements.* The requirements of paragraphs (a) and (b) of this section shall be complied with for all lineman's body belts, safety straps and lanyards acquired for use after the effective date of this subpart.

(1) Hardware for lineman's body belts, safety straps, and lanyards shall be drop forged or pressed steel and have a corrosive resistive finish tested to American Society for Testing and Materials B117-64 (50-hour test). Surfaces shall be smooth and free of sharp edges.

(2) All buckles shall withstand a 2,000-pound tensile test with a maximum permanent deformation no greater than one sixty-fourth inch.

(3) D rings shall withstand a 5,000-pound tensile test without failure. Failure of a D ring shall be considered cracking or breaking.

(4) Snaphooks shall withstand a 5,000-pound tensile test without failure. Failure of a snaphook shall be distortion sufficient to release the keeper.

(b) *Specific requirements.* (1)(i) All fabric used for safety straps shall withstand an A.C. dielectric test of not less than 25,000 volts per foot "dry" for 3 minutes, without visible deterioration.

(ii) All fabric and leather used shall be tested for leakage current and shall not exceed 1 milliampere when a potention of 3,000 volts is applied to the electrodes positioned 12 inches apart.

(iii) Direct current tests may be permitted in lieu of alternating current tests.

(2) The cushion part of the body belt shall:

(i) Contain no exposed rivets on the inside;

(ii) Be at least three (3) inches in width;

(iii) Be at least five thirty-seconds (5/32) inch thick, if made of leather; and

(iv) Have pocket tabs that extended at least 1½ inches down and three (3) inches back of the inside of circle of each D ring for riveting on plier or tool pockets. On shifting D belts, this measurement for pocket tabs shall be taken when the D ring section is centered.

(3) A maximum of four (4) tool loops shall be so situated on the body belt that four (4) inches of the body belt in the center of the back, measuring from D ring to D ring, shall be free of tool loops, and any other attachments.

(4) Suitable copper, steel, or equivalent liners shall be used around bar of D rings to prevent wear between these members and the leather or fabric enclosing them.

(5) All stitching shall be of a minimum 42-pound weight nylon or equivalent thread and shall be lock stitched. Stitching parallel to an edge shall not be less than three-sixteenths (3/16) inch from edge of narrowest member caught by the thread. The use of cross stitching on leather is prohibited.

(6) The keeper of snaphooks shall have a spring tension that will not allow the keeper to begin to open with a weight of 2½ pounds or less, but the keeper of snaphooks shall begin to open with a weight of four (4) pounds, when the weight is supported on the keeper against the end of the nose.

(7) Testing of lineman's safety straps, body belts and lanyards shall be in accordance with the following procedure:

(i) Attach one end of the safety strap or lanyard to a rigid support, the other end shall be attached to a 250-pound canvas bag of sand:

(ii) Allow the 250-pound canvas bag of sand to free fall 4 feet for (safety strap test) and 6 feet for (lanyard test); in each case stopping the fall of the 250-pound bag:

(iii) Failure of the strap or lanyard shall be indicated by any breakage, or slippage sufficient to permit the bag to fall free of the strap or lanyard. The entire "body belt assembly" shall be tested using one D ring. A safety

strap or lanyard shall be used that is capable of passing the "impact loading test" and attached as required in paragraph (b)(7)(i) of this section. The body belt shall be secured to the 250-pound bag of sand at a point to simulate the waist of a man and allowed to drop as stated in paragraph (b)(7)(ii) of this section. Failure of the body belt shall be indicated by any breakage, or slippage sufficient to permit the bag to fall free of the body belt.

§ 1926.960 Definitions applicable to this subpart.

(a) *Alive or live (energized).* The term means electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of the earth in the vicinity. The term "live" is sometimes used in place of the term "current-carrying," where the intent is clear, to avoid repetition of the longer term.

(b) *Automatic circuit recloser.* The term means a self-controlled device for automatically interrupting and reclosing an alternating current circuit with a predetermined sequence of opening and reclosing followed by resetting, hold closed, or lockout operation.

(c) *Barrier.* The term means a physical obstruction which is intended to prevent contact with energized lines or equipment.

(d) *Barricade.* The term means a physical obstruction such as tapes, screens, or cones intended to warn and limit access to a hazardous area.

(e) *Bond.* The term means an electrical connection from one conductive element to another for the purpose of minimizing potential differences or providing suitable conductivity for fault current or for mitigation of leakage current and electrolytic action.

(f) *Bushing.* The term means an insulating structure including a through conductor, or providing a passageway for such a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

(g) *Cable.* The term means a conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable) or a combination of conductors insulated from one another (multiple-conductor cable).

(h) *Cable sheath.* The term means a protective covering applied to cables.

NOTE: A cable sheath may consist of multiple layers of which one or more is conductive.

(i) *Circuit.* The term means a conductor or system of conductors through which an electric current is intended to flow.

(j) *Communication lines.* The term means the conductors and their supporting or containing structures which are used for public or private signal or communication service, and which operate at potentials not exceeding 400 volts to ground or 750 volts between any two points of the circuit, and the transmitted power of which does not exceed 150 watts. When operating at less than 150 volts no limit is placed on the capacity of the system.

NOTE: Telephone, telegraph, railroad signal, data, clock, fire, police-alarm, community television antenna, and other systems conforming with the above are included. Lines used for signaling purposes, but not included under the above definition, are considered as supply lines of the same voltage and are to be so run.

(k) *Conductor.* The term means a material, usually in the form of a wire, cable, or bus bar suitable for carrying an electric current.

(l) *Conductor shielding.* The term means an envelope which encloses the conductor of a cable and provides an equipotential surface in contact with the cable insulation.

(m) *Current-carrying part.* The term means a conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

(n) *Dead (deenergized).* The term means free from any electrical connection to a source of potential difference and from electrical charges: Not having a potential difference from that of earth.

NOTE: The term is used only with reference to current-carrying parts which are sometimes alive (energized).

(o) *Designated employee.* The term means a qualified person delegated to perform specific duties under the conditions existing.

(p) *Effectively grounded.* The term means intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages which may result in undue hazard to connected equipment or to persons.

(q) *Electric line trucks.* The term means a truck used to transport men, tools, and material, and to serve as a traveling workshop for electric power line construction and maintenance work. It is sometimes equipped with a boom and auxiliary equipment for setting poles, digging holes, and elevating material or men.

(r) *Enclosed.* The term means surrounded by a case, cage, or fence, which will protect the contained equipment and prevent accidental contact of a person with live parts.

(s) *Equipment.* This is a general term which includes fittings, devices, appliances, fixtures, apparatus, and the like, used as part of, or in connection with, an electrical power transmission and distribution system, or communication systems.

(t) *Exposed.* The term means not isolated or guarded.

(u) *Electric supply lines.* The term means those conductors used to transmit electric energy and their necessary supporting or containing structures. Signal lines of more than 400 volts to ground are always supply lines within the meaning of the rules, and those of less than 400 volts to ground may be considered as supply lines, if so run and operated throughout.

(v) *Guarded.* The term means protected by personnel, covered, fenced, or enclosed by means of suitable casings, barrier rails, screens, mats, platforms, or other suitable devices in accordance with standard barricading techniques designed to prevent dangerous approach or contact by persons or objects.

NOTE: Wires, which are insulated but not otherwise protected, are not considered as guarded.

(w) *Ground. (Reference).* The term means that conductive body, usually earth, to which an electric potential is referenced.

(x) *Ground (as a noun).* The term means a conductive connection whether intentional or accidental, by which an electric circuit or equipment is connected to reference ground.

(y) *Ground (as a verb).* The term means the connecting or establishment of a connection, whether by intention or accident of an electric circuit or equipment to reference ground.

(z) *Grounding electrode (ground electrode).* The term grounding electrode means a conductor embedded in the earth, used for maintaining ground potential on conductors connected to it, and for dissipating into the earth current conducted to it.

(aa) *Grounding electrode resistance.* The term means the resistance of the grounding electrode to earth.

(bb) *Grounding electrode conductor (grounding conductor).* The term means a conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode.

(cc) *Grounded conductor.* The term means a system or circuit conductor which is intentionally grounded.

(dd) *Grounded system.* The term means a system of conductors in which at least one conductor or point (usually the middle wire, or neutral point of transformer or generator windings) is intentionally grounded, either solidly or through a current-limiting device (not a current-interrupting device).

(ee) *Hotline tools and ropes.* The term means those tools and ropes which are especially designed for work on energized high voltage lines and equipment. Insulated aerial equipment especially designed for work on energized high voltage lines and equipment shall be considered hot line.

(ff) *Insulated.* The term means separated from other conducting surfaces by a dielectric substance (including air space) offering a high resistance to the passage of current.

NOTE: When any object is said to be insulated, it is understood to be insulated in suitable manner for the conditions to which it is subjected. Otherwise, it is within the purpose of this subpart, uninsulated. Insulating covering of conductors is one means of making the conductor insulated.

(gg) *Insulation (as applied to cable).* The term means that which is relied upon to insulate the conductor from other conductors or conducting parts or from ground.

(hh) *Insulation shielding.* The term means an envelope which encloses the insulation of a cable and provides an equipotential surface in contact with cable insulation.

(ii) *Isolated.* The term means an object that is not readily accessible to persons unless special means of access are used.

(jj) *Manhole.* The term means a subsurface enclosure which personnel may enter and which is used for the purpose of installing, operating, and maintaining equipment and/or cable.

(kk) *Pulling tension.* The term means the longitudinal force exerted on a cable during installation.

(ll) *Qualified person.* The term means a person who by reason of experience or training is familiar with the operation to be performed and the hazards involved.

(mm) *Switch.* The term means a device for opening and closing or changing the connection of a circuit. In these rules, a switch is understood to be manually operable, unless otherwise stated.

(nn) *Tag.* The term means a system or method of identifying circuits, systems or equipment for the purpose of alerting persons that the circuit, system or equipment is being worked on.

(oo) *Unstable material.* The term means earth material, other than running, that because of its nature or the influence of related conditions, cannot be depended upon to remain in place without extra support, such as would be furnished by a system of shoring.

(pp) *Vault.* The term means an enclosure above or below ground which personnel may enter and is used for the purpose of installing, operating, and/or maintaining equipment and/or cable.

(qq) *Voltage.* The term means the effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

(rr) *Voltage of an effectively grounded circuit.* The term means the voltage between any conductor and ground unless otherwise indicated.

(ss) *Voltage of a circuit not effectively grounded.* The term means the voltage between any two conductors. If one circuit is directly connected to and supplied from another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of lower voltage is effectively grounded, in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.

Subpart W—Rollover Protective Structures; Overhead Protection

AUTHORITY: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable.

§ 1926.1000 Rollover protective structures (ROPS) for material handling equipment.

(a) *Coverage.* (1) This section applies to the following types of material handling equipment: To all rubber-tired, self-propelled scrapers, rubber-tired front-end loaders, rubber-tired dozers, wheel-type agricultural and industrial tractors, crawler tractors, crawler-type loaders, and motor graders, with or without attachments, that are used in construction work. This requirement does not apply to sideboom pipelaying tractors.

(2) The promulgation of specific standards for rollover protective structures for compactors and rubber-tired

APPENDIX E

DOE TASK GROUP ON ELECTRICAL SAFETY REVIEW GUIDE

U.S. Department of Energy
Office of Environment, Safety and Health
Office of Safety and Quality Assurance

DOE TASK GROUP ON ELECTRICAL SAFETY REVIEW GUIDE

1.0 SCOPE

This Review Guide for electrical safety will be used to carry out the responsibilities of the DOE Task Group On Electrical Safety. It is prepared to assist in conducting performance-based assessments of DOE contractor and subcontractor implementation of the DOE electrical safety program, and DOE's and contractor's oversight of that program. DOE line management must ensure that its contractors and subcontractors comply with the electrical safety requirements of OSHA Regulations 29 CFR 1910 Subpart S, and 29 CFR 1926 Subparts E and V.

The objective of the electrical safety program is to ensure electrical safety requirements, that are necessary for a practical safeguarding of DOE and contractor personnel, are being implemented. Practical safe work procedures include training of skilled and unskilled personnel who have a risk of electrical shock. For exposure to energized components, safety measures shall protect personnel against either direct bodily contact or indirectly through some conducting medium such as a pole, ladder or an effective energy isolation program, where applicable, such as lockout/tagout. In addition, only qualified persons who are capable of working safely on energized circuits, and are familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding material and insulated tools, may work on energized equipment.

This review of electrical safety will include examination of management's role in the electrical safety program, electrical safety policies and procedures, electrical safety culture and conduct of operations, post-Tiger Team corrective actions, the surveillance program, the expertise and qualification of electrical safety personnel, electrical safety training, review of electrical safety incidents, post-incident response, and application of generic Lessons Learned.

2.0 ATTRIBUTES AND LINES OF INQUIRY

The following attributes and lines of inquiry are intended to guide the reviewer in conducting a performance-based review of electrical safety. These guidelines are not intended to be all inclusive nor to inhibit the review team from deviating from these guidelines to more thoroughly probe these or other areas.

2.1 Management Role

2.1.1 DOE site management has issued policy statement(s) regarding importance of electrical safety for DOE, contractors and subcontractors.

2.1.2 DOE site management has periodically conducted audits of the implementation of DOE and OSHA electrical safety requirements.

2.1.3 Contractor site management has issued policy statement(s) regarding importance of electrical safety for themselves and their subcontractors.

2.1.4 Contractor site management has periodically conducted audits of the implementation of electrical safety requirements at their own and subcontractor operations.

2.1.5 DOE site management is aware of electrical safety deficiencies and has implemented a system to ensure that deficiencies are tracked, trended, prioritized, corrected, and verified.

2.1.6 Contractor site management is aware of electrical safety deficiencies and has implemented a system to ensure that deficiencies are tracked, trended, prioritized, corrected, and verified.

2.1.7 DOE, contractor, and subcontractor management actively participate in electrical safety programs.

2.1.8 DOE and site management demonstrate management support of electrical safety through the dedication of adequate resources to identify and promptly correct electrical safety deficiencies.

2.2 Policy and Procedures

2.2.1 Electrical safety procedures incorporate all appropriate DOE and OSHA requirements.

2.2.2 Operations procedures incorporate all appropriate electrical safety requirements.

2.2.3 Maintenance procedures incorporate all appropriate electrical safety requirements.

2.2.4 Calibration procedures incorporate all appropriate electrical safety requirements.

2.2.5 Responsibility for the contractor and subcontractor electrical safety program has been clearly defined and accountability for implementation of that program has been established.

2.2.6 Responsibility for contractor and DOE oversight of the contractor and subcontractor electrical safety programs have been clearly defined and accountability for implementation of that oversight has been established.

2.2.7 The scopes of the electrical safety program and of the DOE and contractor electrical safety oversight program include all potentially hazardous electrical safety sources.

2.2.8 The electrical safety program and DOE and contractor oversight programs incorporate all applicable DOE and OSHA requirements regarding electrical safety.

2.2.9 Design modifications by DOE, contractors, and subcontractors include a review for electrical safety implications.

2.2.10 Contractor and subcontractor work control systems include a review for electrical safety implications.

2.2.11 The contractor and subcontractor work controls system includes control of work on energized equipment or near high voltage sources including specifying special procedures and precautions.

2.2.12 Oversight of work control systems includes oversight of electrical work activities.

2.2.13 The contractor has a program to periodically inspect their own and subcontractor electrical systems and equipment.

2.3 Electrical Safety Culture and Conduct of Operations

2.3.1 DOE and contractor line management and staff responsibility and accountability for electrical safety have been clearly established.

2.3.2 DOE and contractor site management actively participate in the electrical safety program.

2.3.3 Interviews indicate that site personnel at all levels including subcontractors are aware of, and follow, electrical safety requirements.

2.3.4 Proper isolation boundaries are established prior to commencing work on electrical equipment. Live parts are de-energized prior to commencing work unless it is demonstrated that de-energizing introduces additional or increased hazards or is not feasible due to other limitations.

NOTE: In general, live parts at less than 50 volts need not be de-energized for safety purposes.

2.3.5 Compensatory safety measures are taken, for live circuits to which workers are exposed, to protect workers from electrical shock. Such practices are those that prevent direct or indirect contact with the live circuit.

2.3.6 The site has an effective lockout/tagout program that includes electrical safety.

2.3.7 The site allows only qualified personnel to work on energized circuits.

2.3.8 Personnel are aware of the safe approach distances to overhead lines.

2.3.9 Personnel working near energized overhead lines are aware of clearance and insulating requirements.

2.3.10 The site ensures that qualified personnel working or monitoring near overhead lines are briefed and protected.

2.3.11 Personnel are aware of clearance/voltage requirements for vehicle or mechanical equipment operating near overhead lines.

2.3.12 The site provides protective shields, protective barriers or insulating materials, as necessary, to avoid inadvertent contact with live parts while personnel are working in confined spaces.

2.3.13 The site takes compensatory action to prevent electrical shock to personnel working with conductive materials, such as duct work and pipes, near exposed electrical circuits. Ladders with nonconductive siderails are used near exposed energized sources.

2.3.14 The site prohibits the wearing of conductive apparel (rings, watch bands, bracelets etc.) when personnel are working near exposed energized parts unless the apparel is rendered non-conductive by insulating means.

2.3.15 The site ensures that only qualified personnel defeat an electrical interlock.

2.3.16 The site ensures that portable equipment is properly handled; free of visible defects; properly grounded and operated in a conducive work location.

2.3.17 The site maintains protective equipment in a safe, reliable condition and it is periodically inspected or tested.

2.3.18 Personnel wear nonconductive head and other electrical protective equipment wherever there is a danger of head injury, shock, or burns due to contact with exposed energized electrical equipment.

2.3.19 When working near exposed energized circuits, arcing or dangerous electric heating, the site ensures that all applicable equipment is properly insulated (including nonconductive ropes and handlines), or protective shields or protective barriers (safety signs, barricades, or attendants) are established where applicable.

2.3.20 Electrical schematics used for lockout/tagout electrical safety precautions have been verified to be accurate.

2.3.21 Electrical sources and hazards are properly labeled, warning signs are provided as required, and access to electric sources is secured as required.

2.3.22 Electrical equipment is approved by a nationally recognized testing laboratory or has been approved through an alternate program approved by DOE.

2.4 Post-Tiger Team Corrective Actions

2.4.1 All post-Tiger Team electrical safety corrective actions have been tracked, trended, and prioritized. Completed corrective actions have had closure verified.

2.4.2 DOE and contractor oversight organizations have audited closure of post-Tiger Team electrical safety corrective actions.

2.4.3 DOE and contractor management are aware of status of post-Tiger Team electrical safety corrective actions.

2.4.4 Post-Tiger Team electrical safety corrective actions have been completed or are scheduled for completion in a time frame commensurate with the potential hazard.

2.4.5 Post-Tiger Team electrical safety corrective actions have been accelerated for completion based on repetitive events since completion of the Tiger team.

2.5 Surveillance Program

2.5.1 The contractor conducts routine surveillance of the full scope of their own and their subcontractors' electrical safety activities (including lockout and tagout).

2.5.2 Findings from electrical safety surveillance activities are documented, tracked, trended, prioritized, corrected, and verified to be closed.

2.5.3 DOE and contractor oversight organizations conduct routine oversight of the full scope of electrical safety activities.

2.5.4 Findings from DOE and contractor oversight organization audits of electrical safety activities are documented, tracked, trended, prioritized, corrected, and verified to be closed.

2.5.5 Programmatic changes to the electrical safety program are made as indicated by findings from DOE and contractor line and oversight findings.

2.5.6 DOE and contractor evaluations of status of the site electrical safety program are consistent with the evaluation by this Task Group.

2.5.7 Electrical safety findings from this Task Group review are consistent with findings from DOE and contractor organizations.

2.5.8 DOE and contractor line oversight of the electrical safety program has the appropriate level of staffing as evidenced by frequent oversight of the full scope of electrical safety activities.

2.6 Expertise/Qualifications of Electrical Safety Personnel

2.6.1 DOE and contractor line and oversight personnel with responsibilities for electrical safety have well-defined qualification and expertise standards and meet those standards.

2.6.2 DOE and contractor line and oversight personnel responsible for electrical safety activities understand their responsibilities and have the appropriate expertise and qualification to carry out those responsibilities.

2.7 Electrical Safety Training

2.7.1 Electrical Safety Training is conducted periodically for all site personnel.

2.7.2 Electrical safety training is formally scheduled in a documented training program for all personnel assigned electrical safety activities.

2.7.3 Electrical safety training incorporates all pertinent DOE and OSHA requirements.

2.7.4 Training is conducted as required for those workers who face risk of electrical shock, with emphasis on those with increased risk.

2.8 Electrical Safety Incidents

2.8.1 The site has a program for thorough investigation of electrical safety incidents.

2.8.2 The root causes for electrical safety incidents are identified and the root causes, not just the symptoms are corrected.

2.8.3 The number of electrical safety incidents are minimized and incidents or root causes of incidents are not repetitive.

2.9 Post-Incident Response

2.9.1 The site has a documented program for responding to electrical safety incidents including securing of personnel hazards, ensuring availability of medical assistance as needed, and restoration of the facility and equipment to a safe condition.

2.9.2 The site has a program for investigation and critique of all electrical safety incidents.

2.9.3 Root causes for electrical safety incidents are promptly identified and corrected.

2.9.4 Critiques are conducted with affected personnel for all electrical safety incidents.

2.9.5 Lessons learned are developed from electrical safety incidents and are communicated to facility personnel through training programs.

2.10 Generic Lessons Learned

2.10.1 The site has a program to trend electrical safety at the site.

2.10.2 The site has an electrical safety review program to incorporate information from findings and lessons learned from on-site assessments and incidents, from DOE-wide electrical safety sources, and from industry electrical safety sources.

2.10.3 Results from the electrical safety review program are used to modify the site electrical safety program and are incorporated in the various site electrical safety training programs.

3.0 STANDARDS AND REQUIREMENTS

3.1 Specific DOE Orders and Standards.

- DOE 5480.4, "Environmental Protection, Safety, and Health Protection Standards."
- DOE 5483.1A, "Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities."
- DOE Electrical Safety Manual.

3.2 OSHA Title 29 CFR Requirements.

- 29 CFR 1910, "Occupational Safety and Health Standards for General Industry," Subpart S.
- 29 CFR 1926, "Safety and Health Standards for Construction," Subparts K and V.

3.3 Industry Standards

- ANSI/NFPA 70-1981, "National Electrical Code."

4.0 GUIDANCE TO REVIEWER

This review guide is intended to assist in conducting a performance-based review of electrical safety at DOE facilities. It is not to be considered as all inclusive, inflexible or limiting reasonable assessment concentration when lines of inquiry responses dictate that an area must be more thoroughly probed.

APPENDIX F

PERSONNEL INTERVIEWED

APPENDIX F

PERSONNEL INTERVIEWED

Hanford Reservation

Alan Aunspaugh	WHC
B. Baker	WHC
R.H. Beers	KEH
J.R. Bell	WHC
R.J. Bliss	WHC
Mike Boger	WHC
Kris Bonewell	WHC
John Cavanaugh	DOE
K.L. Davie	WHC
G.W. Duve	WHC
R.T. French	KEH
B.J. Gray	WHC
Phil Hamric	DOE
Ed Harding	WHC
Susan Harrington	WHC
A.R. Hawkins	WHC
V.Y. Herndon	WHC
Don Huddleson	KEH
Kathy Irish	KEH
Bill Johnson	WHC
K. Jordon	WHC
M.A. Kelley	WHC
G.N. Knight	KEH
J.R. Knight	WHC
Dennis Kubie	WHC
John B. Levine	WHC
Erv Martin	KEH
David McCulley	WHC
Ron McMuffy	KEH
D.W. McMyler	KEH
C.M. Monasmith	WHC
Tim Nearing	WHC
Frank Orsag	WHC
Dan Ridgley	WHC
Mike Robbins	KEH

Jay Roberts	WHC
Tom Schildknesht	WHC
Mark Schwartz	WHC
W.F. Sheely	WHC
Steve Sherman	KEH
Rich Slocum	WHC
David Smith	KEH
W.L. Smoot	WHC
Randy Spanial	KEH
Jack Strait	WHC
D.E. Trail	KEH
Frank Turner	WHC
Rick Wible	DOE
Bert Winschell	WHC
Doug Wright	KEH

Idaho National Engineering Laboratory

Doug Airmet	WINCO
Brent Avery	EG&G
Bill Baxter	EG&G
Jeff Beasley	EG&G
Brett Belnap	EG&G
Gerry Bowman	DOE
Jeff Bradford	EG&G
Gary Braun	EG&G
Brad Briggs	EG&G
Rod Briscoe	EG&G
Randy Burns	MK-FIC
W.E. Chalk	MK-FIC
W.K. Clegg	WINCO
John Collins	WINCO
P.H. Contreras	DOE
D. Cooper	WINCO
John Cox	EG&G
David Daniels	EG&G
George Dials	DOE
Mike Findley	MK-FIC
Frank Fogarty	EG&G
J.K. Ford	DOE

J.C. Givens	WINCO
Bill Gray	EG&G
Jim Gregory	EG&G
D. Guili	EG&G
Wayne Halcomb	MK-FIC
J. Hall	EG&G
Kevin Harris	MK-FIC
R.B. Hatch	MK-FIC
Gene Hicks	MK-FIC
Terry Howard	WINCO
D.R. Johnson	MK-FIC
J.A. Jones	DOE
T. Kavran	EG&G
Gary Keith	MK-FIC
J.O. Keson	EG&G
David King	EG&G
D. Larson	WINCO
W.H. Leake	DOE
Alex Lisson	MK-FIC
Bob Lopex	EG&G
W.R. MacFarlane	WINCO
Mike Mann	WINCO
R.J. Marcinko	WINCO
Steve Martinsen	EG&G
Wayne McLerran	WINCO
J.W. McNeel	EG&G
W.C. Moffitt	WINCO
R.J. Nertney	EG&G
K. Norman	Wheeler Electric
Paul North	EG&G
Kate O'Donnell	EG&G
Les Parsons	EG&G
D. Perry	WINCO
T.M. Pierce	EG&G
A. Pitrolo	DOE
M. Platt	EG&G
Brent Powell	EG&G
R.E. Renbury	WINCO
Darren Simper	EG&G
M.C. Smith	EG&G
D. Snyder	MK-FIC

Bob Stallman	DOE
Kim Steed	WINCO
Dell Summers	EG&G
P.S. Uela	WINCO
A.M. Umek	WINCO
Hazen Waddoups	WINCO
R.S. Watkins	EG&G
Ed Willmott	DOE
Ed Zemanski	DOE

Nevada Test Site

J.W. Bartlett	Raytheon
Glend Cates	EG&G
Debra Chalko	DOE
D.G. Chiodinni	WSI
Audrey Clarke	DOE
Gina Cook	Raytheon
Wayne Crane	DOE
Jim DeLong	DOE
Bill Endow	EG&G
Bill Flangers	REECo
Phil Frank	REECo
Boyd Groesbeck	REECo
Don Grove	REECo
D.D. Harris	Raytheon
Dick Josa	REECo
Steve Jones	REECo
G.W. Kronsbein	Raytheon
Barry Langendorf	DOE
J.D. MacMullen	Raytheon
Ben Marcias	REECo
C.L. Meyer	EG&G
Terry Morris	WSI
Russel Powell	EG&G/EM
Al Reiken	REECo
J.D. Ross	DOE
John Schoppmann	REECo
Russell Scott	REECo
John Snow	REECo

Fauls Spenia	REECo
Joe Stevenson	REECo
Melton Terrell	REECo

Oak Ridge National Laboratory

Larry Admonds	
A. Basset	DOE
Andy Bassett	DOE
Jewel Brown	MMES
J.S. Brown	MMES
Sewell Brown	MMES
C.E. Bruce	MMES
Dean Campbell	MMES
Fred Chattin	MMES
Jerry Coker	MMES
Don Creekmore	MMES
S. Davis	DOE
R.L. Egler	DOE
Steve Giles	ORNL
J.L. Hammontree	MMES
Donald Howard	MMES
R.O. Hultgren	DOE
Jim Kilbore	
C.R. Kirkpatrick	MMES
Edwin Kreig, Jr.	MMES
Nate Langley	MMES
C. Matthews	DOE
Rob McKeehan	MMES
Larry Merryman	MMES
D.R. Miller	MMES
Kerry Miller	MMES
O.B. Morgan	MMES
R.R. Nelson	DOE
L.R. Nolan	MMES
D. Norris	MMES
G.W. Oliphant	MMES
Jim Poston	MMES
M.W. Rosenthal	MMES
J.H. Sevanks	MMES

Joe Sewell	MMES
Ann M. Shirley	MMES
Robert Stephens	MMES
J.G. Stradley	MMES
Larry Triplett	MMES
A.W. Trivelpiece	MMES
Alan White	MMES
Charles William	DOE
Gerry Young	MMES

Savannah River Site

Joe Andrews	WSRC
Wanda Barr	WSI
Bob Bills	BSRI
T. Burmeister	WSRC
Tom Cool	BSRI
Dave Drury	DOE
Brian A. Givens	WSRC
Dave Hawver	WSRC
Dean Hayden	WSRC
W.N. Lewis	WSRC
John Martin	
Barry McDonald	
Randy Moore	WSRC
Walt Mylrea	WSRC
Sam Newton	WSRC
Ray Russell	WSRC
N.J. Seguine	WSRC
T.J. Spears	DOE
Robert Williams	

Stanford Linear Accelerator Center

M. Allen	SLAC
Dan Alzofan	SLAC
Bob Bell	SLAC
Marty Breidenbach	SLAC
Frank Brenkus	SLAC

John Brown	SLAC
J. Cerino	SLAC
R. Challman	SLAC
Edward Clay	SLAC
Clay Corvin	SLAC
Ken Crook	SLAC
Toney Donaldson	SLAC
S. Drell	SLAC
Sal Fazzino	SLAC
Irene A. Flick	SLAC
Peter Gallego	SLAC
Iswar Garg	SLAC
Ed Garrwin	SLAC
David Gordon	SLAC
Jack Hahn	SLAC
Richard Jones	SLAC
Marvin Jones	SLAC
James Kang	SLAC
Joe Kenny	SLAC
Glen Kerr	SLAC
K. Lathrop	SLAC
Ed Loens	SLAC
Ruth McDunn	SLAC
Jim McGowan	SLAC
John Muhleston	DOE
Joe Praxel	SLAC
Joe Rehacck	SLAC
B. Richter	SLAC
Mary Ross	SLAC
Burl Skaggs	SLAC
Knuth Skarpaas	SLAC
Phil Smith	SLAC
H. Steckel	SLAC
G. Warren	SLAC
Julia Weiler	SLAC

Uranium Mill Tailings Remedial Action Project

Charlene Esperanza-Baea	DOE
Lon Baldwin	MK-Ferguson
Ron Beethe	Weston
C.M. Bull	MK-Ferguson
Ken Coburn	Magnum Electric
John L. Huff	MK-Ferguson
D.R. Johnson	MK-Ferguson
Syd Kaschke	ICC
Nancy Miller	MK-Ferguson
Jack Morris	ICC
Claude Pettingel	MK-Ferguson
Kathy Pinnt	Chem Waste

APPENDIX G

KEY DOCUMENTS REVIEWED

APPENDIX G
KEY DOCUMENTS REVIEWED

The Task Group on Electrical Safety at Department of Energy Facilities reviewed a large number and a wide variety of documents during the course of its activities. The documents listed in this appendix are representative of that review and are intended to support the issues and recommendations of this report. In addition to the items cited below, the Task Group reviewed many other documents that are not included in this list, such as organizational charts, personnel records, training records, certifications, course curricula, lesson plans, site bulletins and newsletters, logbooks, Tiger Team corrective action plans, and maintenance records.

* * *

DOE Orders

DOE 4330.4A	Maintenance Management Program (10-17-90)
DOE 5000.3A	Occurrence Reporting System and Processing of Operations Information (5-30-90)
DOE 5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84)
DOE 5480.18	Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities (11-2-89)
DOE 5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90)
DOE 5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities (6-22-83)
DOE 5483.XX	Occupational and Health Program for DOE Contractor Employees (draft)

* * *

Industry Standards

ANSI C2	National Electrical Safety Code
ASTM F 496-90	Standard Specification for the In-Service Care of Insulating Gloves and Sleeves
ASTM F 855-90	Standard Specification for Temporary Grounding Systems to be Used on Deenergized Power Lines and Equipment
NFPA 70B	Recommended Practices for Electrical Equipment Maintenance
NFPA 70E	Electrical Safety Requirements for Employee Workplaces

* * *

Occurrence Reports

Hanford Reservation

RL--PNL-PNLBOPER-1992-0015
RL--WHC-BPLANT-1992-0007
RL--WHC-FFTF-1991-0197
RL--WHC-FFTF-1991-1002
RL--WHC-FFTF-1991-1025
RL--WHC-NREACTOR-1991-1067
RL--WHC-PUREX-1991-1087
RL--WHC-PUREX-1992-0020
RL--WHC-PUREX-1992-0032
RL--WHC-PUREX-1992-0063
RL--WHC-TANKFARM-1991-1053
RL--WHC-TANKFARM-1992-0049
RL--WHC-TANKFARM-1992-0059
RL--WHC-TANKFARM-1992-0061
RL--WHC-TPLANT-1991-1002
RL--WHC-TPLANT-1992-0005
RL--WHC-WHC200EM-1990-0153
RL--WHC-WHC200EM-1992-0007
RL--WHC-WHC200EM-1992-0025
RL--WHC-WHC200EM-1992-0068
RL--WHC-WHC200ERD-1992-0002
RL--WHC-WHC300EM-1992-0026
RL--WHC-WHC300EM-1992-0027
RL--WHC-WHC300EM-1992-0052
RL--WHC-WHC400NE-1990-0324
RL--WHC-WHC400NE-1991-1009
RL--WHC-WHC1100EM-1991-0156
RL--WHC-WHC1100EM-1991-1048

Idaho National Engineering Laboratory

ID--BWI-SMC-1992-0007
ID--EGG-ATR-1990-0008
ID--EGG-ATR-1992-0023
ID--EGG-ATR-1992-0034
ID--EGG-CFA-1990-0004
ID--EGG-CFA-1991-1001
ID--EGG-CFA-1992-0030
ID--EGG-TRA-1991-1004
ID--EGG-TRA-1992-0006

ID--EGG-TRACF-1992-0003
ID--EGG-TRAHC-1992-0011
ID--GOID-DOEID-1990-0001
ID--MKF-CPPFPRAREA-1991-1001
ID--MKF-MOUITEMS-1991-1013
ID--WINC-ICPP-1990-0005
ID--WINC-ICPP-1990-0008
ID--WINC-ICPP-1990-0015
ID--WINC-ICPP-1991-0017
ID--WINC-ICPP-1991-0018
ID--WINC-ICPP-1991-0041
ID--WINC-ICPP-1991-0057
ID--WINC-ICPP-1991-0076
ID--WINC-ICPP-1991-1048
ID--WINC-ICPP-1991-1056
ID--WINC-ICPP-1991-1063
ID--WINC-ICPP-1991-1080
ID--WINC-ICPP-1991-1083
ID--WINC-ICPP-1991-1085

Nevada Test Site

NVOO--EGGO-NLVO-1992-0004
NVOO--LLNV-LLNV-1991-1002
NVOO--REEC-OMDO-1991-1046
NVOO--REEC-OMDO-1992-0009
NVOO--REEC-OMDO-1992-0031
NVOO--REEC-QADO-1990-0003

Oak Ridge National Laboratory

ORO--MK-WSSRAP-1991-1008
ORO--MMES-X10FINMAT-1992-0002

Savannah River Site

SR--WSIS-SECFOR-1990-0002
SR--WSRC-WVIT-1991-1010
SR--WSRC-WVIT-1992-0004
SR--WSRC-WVIT-1992-0009
SR--WSRC-FBLINE-1992-0053
SR--WSRC-FSD-1992-0002
SR--WSRC-ITP-1991-1013
SR--WSRC-ITP-1992-0017
SR--WSRC-POD-1991-0030

SR--WSRC-POD-1991-0039
SR--WSRC-POD-1992-0029
SR--WSRC-REACK-1991-0003
SR--WSRC-REACK-1991-0066
SR--WSRC-REACK-1991-1011
SR--WSRC-REACK-1991-1032
SR--WSRC-REACK-1991-1052
SR--WSRC-REACK-1991-1056
SR--WSRC-REACK-1991-1060
SR--WSRC-REACK-1991-1132
SR--WSRC-REACK-1992-0041
SR--WSRC-REACL-1991-1031
SR--WSRC-REACL-1991-1042
SR--WSRC-REACP-1991-1005
SR--WSRC-RTF-1991-0004
SR--WSRC-WVIT-1991-1010
SR--WSRC-WVIT-1992-0004
SR--WSRC-WVIT-1992-0009

Stanford Linear Accelerator Center

SAN--SU-SLAC-1990-0011
SAN--SU-SLAC-1990-0012
SAN--SU-SLAC-1991-0023
SAN--SU-SLAC-1991-1005
SAN--SU-SLAC-1991-1027
SAN--SU-SLAC-1991-1033
SAN--SU-SLAC-1992-0028

Uranium Mill Tailings Remediation Action Project

ID--BWI-SMC-1992-0007
ID--GEO-GJO-1991-1019
ID--GEO-GJO-1991-1020
ID--MKF-CPPFPRAREA-1991-1001

* * *

EH Site Representative Monthly Reports

ID-91-05	Idaho Regional Office, Monthly Report for November 1991
OR-92-04	Oak Ridge Regional Office, Monthly Report for May 1992
RL-92-04	Richland Regional Office, Monthly Report for April 1992
RL-92-06	Richland Regional Office, Monthly Report for August 1992

SR-92-06	Savannah River Regional Office, Monthly Report for October 1992
12-26-91	Transmittal Letter, P.L. Ziemer to W.H. Young, "EH Site Representative Monthly Reports"

* * *

Hanford Reservation

Key Site Documents

153	KEH Procedure, Pre-Job Safety Planning (10-30-92)
1510L	KEH Procedure, Electrical Safety
CFE 1.5	Installation of Low-Voltage Electrical Wire and Cable (3-28-91)
Form J-1-J8	WHC Work Control Process
IS 3	Prejob Safety Planning (10-30-92)
IS 8	Office Safety (11-20-92)
IS 10L	Electrical Safety (10-30-92)
IS 105.OM1	Lockout/Tagout (12-31-92)
KIP-108	Kaiser Operating Policies, Safety and Health (9-27-90)
MOP # CP25.OM3	KEH Procedure, Lock and Tag Program (3-30-92)
RLIP-1300.1	RL Implementation Procedure, Site Representative Program (9-17-92)
WHC-CM-4-3	Industrial Safety Manual (7-1-87)
WHC-CM-4-3-E1	Industrial Safety Manual (4-30-91); and Industrial Safety Manual Standards (4-30-91); Industrial Safety Manual Safety Guides (4-30-91)
-----	KEH Functional Analysis, Construction Crafts, Electrician (Construction) Foreman, Electrician Journeyman, Wireman
-----	Operational Excellence Performance Indicators, 3rd Qtr. (CY 1992)
-----	Lock and Tag Trending - Documented Lock and Tag Violations (as of 11-18-92)

Memoranda and Letters

10-15-92	J.E. Cavanaugh to R.P. Saget, "Electrical Problems Identified in Surplus Facilities"
7-29-92	R.T. French to J.D. Wagoner, "Lockout/Tagout Safety Program"
4-6-92	W.D. Shaw to G.L. Muth, "Appendix A Agreement(s) - Nuclear Process Operators and Decontamination/Decommission Workers, Seniority Group 004, Local 1-369"
Undated	J.D. Wagoner to W.L. Meader, et al., "Hanford's Get Well Plan"

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Idaho National Engineering Laboratory

Key Site Documents

3.0	WINCO Industrial Safety Manual, Electrical Safety (Rev. 4) (11-30-92)
6-14	WINCO Reportable Occurrence Program (12-7-90)
10-02	ICPP Electrical Distribution Systems (WINCO) (10-6-90)
9200178	WERF Package: Repair Heater Short Circuit (12-1-92)
E.55	Testing and Trouble Shooting of Low Voltage or Low Power Circuits and Equipment (10-2-91)
INEL/ICPP PR-42	Construction Work at TRA-FEH-92-311 (MK-FIC) (11-25-92)
ISM 1.0	General Policies and Administration (WINCO)
Rind-114-90	INEL Safety Training Tip - Electrical Safety (J.A. Rindfleisch, 1-8-91)
SOP	Work on Electrical Systems (WINCO) (6-4-92)
SOP	Testing and Trouble Shooting of Low Voltage or Low Power Circuits and Equipment (WINCO) (10-2-91)
SOP 4.8.0.7	Instrument Calibration (WINCO) (8-5-92)
SOP 4.8.5.1	Work on Electrical Systems (WINCO) (6-4-92)
SOP P.O.69	Deficiency Tagging System (WINCO) (9-4-92)

SOP WE-7	Formal Design Reviews (WINCO) (9-30-92)
SOP WE-8	Design Changes (WINCO Plant Configuration Changes) (10-2-92)
SOP WP-10	Isolation and Tag-Lockout of ICPP Systems and Equipment (WINCO) (10-3-91)
SOP WP-12	Work Order Control (WINCO) (6-12-92)
SOP WP-23	Shift Turnovers (WINCO) (10-8-92)
SOP WQ-7.1	Methods for Supplier Selection (WINCO) (5-10-91)
SOP WQ-7.2	Requisition and Acceptance of Commercial Grade Items (WINCO) (4-22-91)
SOP WQ 10.1	WINCO Inspection Methods (9-19-91)
SRW #920078	WERF Work Package (12-1-92)
WENG-ET-9205010	Idaho Chemical Processing Plant (ICPP) Electrical Safety Deficiencies, Study and Analysis Report by Area and Building 1991 to 1992 (Rev. 0) (5-92)
WP-10	WINCO Isolation and Lockout/Tagout of ICPP Systems and Equipment (Rev. 10) (10-3-91)
WPD 1-10	WINCO Training (Rev. 6) (10-18-91)
WPD 6-01	Environment Safety and Health Protection (Rev. 5) (7-24-91)
-----	DOE Operational Safety Standards Requirements, ID Appendix 0550, Subpart III L, Electrical
-----	DOE Program Descriptions, 3.2 Safety and Health Programs
-----	DOE Safety Manual, Sections 3.3.13.3 through 13 (draft) (10-9-92)
-----	DOE-ID Architectural Engineering Standards, Electrical Design (9-21-92)
-----	EG&G Electrical Safety (7-1-92)
-----	EG&G Self-Identified Electrical Deficiencies
-----	EG&G Safety Manual (11-18-92)
-----	EG&G Electrical Safety Assistance Review (2-4 thru 15-91)
-----	Industrial Safety Manual

-----	Safety and Health Compliance Inspection and Program Appraisal, Westinghouse Idaho Nuclear Company, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho Falls, Idaho (IT Corporation) (11-15-91)

Memoranda and Letters

12-1-92	J.B. Norman to Task Group, "New Technologies on the INEL Power System"
11-19-92	G.C. Boroman to Distribution, "DOE-ID Occupational Safety Appraisal of EG&G Idaho, Inc. Excluding the Test Reactor Area"
11-3-92	A.A. Pitrolo to J.C. Obeson, "Need for Immediate Compensatory Lockout and Tagout Measures for Electrical Safety (DM-92-111)"
5-28-91	S.P. Gearhart to R.D. Bradley, et al., "Investigation of Unauthorized Modifications of an Evacuation Siren in Building TR-18 (Bunk House) OR 1991-1018"
3-1-91	S.P. Gearhart to R.D. Bradley, et al., "Investigation Report on "Questionable Electrical Safety Practice, Off-normal Occurrence #90015"
11-30-90	S.P. Gearhart to R.D. Klingler, "Root Cause Investigation of UOR 90008, Damage to Safety System Resulting from Excavation"
-----	W.D. Jensen to R.M. Stallman, "DOE-ID Occupational Safety Appraisal of Westinghouse Idaho Nuclear Company, Inc." (0-0-SB-92-14)

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Nevada Test Site

Key Site Documents

6.3.1	High-Voltage Rubber Goods Testing
DOE/NV 11XA.1	Organization and Functions
DOE/NV	CPAF and WAD Milestones
DOE/NV	Training Minimum Essential Requirements and Process Flow Charts
DOE/NV-TC.1-1	Tiger Team Finding

EG&G SOP 49-003.1	Calibration Intervals (8-31-90)
EG&G SOP 49-004.A	Equipment Calibration Requirements (8-31-90)
EG&G/EM	Electrical Safety-Standard Operating Rule (1992)
REECo 2.3.2	ES&H Self-Assessment Program (1991)
REECo 2.4.3	Safety Policy Memo (1991)
-----	NTS Corrective Action Plan Excerpts
-----	Occupational Safety Codes - C-8, Lock and Tagout Requirements - C-8, Proposed Revision - C-12, Electrical Safe Work Practices - G-10, Extension Cords - G-17, Testing of Insulating Rubber Goods and Gloves - H-25, Electrical Utility Operations Near Overhead Power Lines
-----	Power Operations Evaluation
-----	REECo Company Policy and Organization Manual
-----	REECo Company Procedure Manual
-----	REECo Safety Manual
-----	Site Maintenance Department, Operating Procedures

Memoranda and Letters

11-19-92	W. Crane, "Tiger Team Electrical Concerns Status Report"
9-16-92	B.W. Church to Distribution, "Final Compliance Assessment Program Report"
9-4-92	B.W. Church to DOE/NV Directors, "AMESH Coordinated Functional Appraisal Schedule, FY 1993 and FY 1994"

Charters

Labor/Management Electrical Safety Committee Charter

Nevada Test Site Electrical Safety Committee Charter

Electrical Power Management Committee Charter

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Oak Ridge National Laboratory

Key Site Documents

D1.9	Plant and Equipment Procedure, Plant and Equipment Division Work Request Procedures (5-12-88)
E-2.1	Inspection and Testing of Electrical Safety Equipment (7-17-91)
E-2.3	Electrical Safety Standards (6-15-88)
E-3.105	Safety and Safety Equipment Power Systems (10-26-89)
E-3.3	Electrical Work Permits (2.4 kV Equipment and Above) (7-10-91)
EP-E-20	Engineering Procedure, Configuration Management (Rev.1) (4-1-91)
ESONOA-4964A-A1	Engineering Transmittal, OSHA Compliance at ORNL, Subpart 5, Conformance Plan (2-13-90)
GP-42	MMES Policy Document (5-13-91)
IS-5.1	Electrical Safety Guides (8-4-86)
IS-6.1	Use of Safety Work Permits (7-87)
IS-8.1	Use of Locks and Tags (7-29-91)
IS-8.1	Procedure Change Directive for Lockout/Tagout of Hazardous Energy Sources (10-2-92)
M-2132	ORNL Maintenance Implementation Plan (6-92)
ST2080-SAF	Electrical Safety Related Work Practices, Job Specific, Instrument and Controls Division (6-92)
X-ESH-1	Occupational Safety Program (6-13-90)

X-ESH-5 ORNL Safety Manual (4-16-90)

X-ESH-6 ORNL Safety and Health Procedures Central System (6-8-90)

X-ESH-7 Appendix 1 (5-23-90)

----- The ORNL 1992 Communication Survey, a Report to ORNL Staff Members

Charters

Charter of Responsibility, Accountability, and Authority, Electrical Safety Committee (7-25-89)

Charter of Responsibility, Accountability, and Authority, Environment, Safety and Health Committee (10-10-90)

Memoranda and Letters

5-11-92 G.B. Young to A.W. Trivelpiece, "The 1991 Electrical Safety Committee Review of the Transuranium Research Laboratory in Building 5055"

12-6-91 D.R. Norris to J.S. Brown, et al., "ECS Review of the 6000 Complex"

8-26-91 G.B. Young to A.W. Trivelpiece, "The 1991 Electrical Safety Committee Review of the Solid State Division Facilities in Building 2000"

11-28-90 G.B. Young to A.W. Trivelpiece, "The 1990 Electrical Safety Committee Review of the Oak Ridge Research Reactor"

10-25-89 Rosenthal to Addressees, "ES&H Coordination Committee"

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Savannah River Site

Key Site Documents

8Q Employee Safety Manual (WSRC Procedure Manual):

- Procedure 1, Safety Policy and Program Responsibilities (4-1-91)
- Procedure 2, Site Central Safety Committee and Area Central Safety Committees (4-1-91)
- Procedure 6, Safety and Housekeeping Audits (4-1-91)
- Procedure 8, Reporting Unsafe Practices/Conditions
- Procedure 15, Subcontract Safety Administration (4-1-91)

	- Procedure 25, Basic Electrical Safety Awareness (8-92) - Procedure 32, Lockout/Tagout (10-5-92) - Procedure 81, Safety Observer Program (4-1-91)
8Q5	E&I Safety Procedures (WSRC Procedure Manual): - Procedure S-9501, Safety Practices Near Electrical Conductors (Rev. 17) (5-15-92) - Procedure S-9505, Deenergize, Lock, Test, Tag and Ground Electrical Circuits and Substations (Rev. 18) (9-9-91) - Procedure S-9509, Safety Inspection of Electrical Cords, Appliances, and Other Equipment (Rev. 14) (3-2-88)
18Q	Electrical Safety Manual (draft, 11-92)
WSRC-1-01	Management Policies Manual, Section 4.19, Operating Experience Review Program (5-1-92)
-----	E&I Work Procedures (multiple dates)
-----	WSRC Electrical Self-Assessment (11-92)

<u>Memoranda and Letters</u>

11-23-92	S.N. Spradlin to T.J. Spears, "SRS Electrical Self-Assessment"
11-6-92	R.L. Raysor to Distribution, "Contractor Inspection/Audit Schedule for December 1992"
9-8-92	R.L. Raysor to Distribution, "WSRC Construction Safety Oversight Responsibilities for SRS Davis-Bacon Contractors"
8-17-92	WSRC Electrical Review Board Memorandum, "Ground Fault Circuit Interrupters for Drinking Fountains" (1-0207-01)
11-90	WSRC Electrical Review Board Memorandum, "Misrepresented Molded Case Circuit Breakers Sold as New, Potentially Hazardous" (2-0302-01)

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Stanford Linear Accelerator Center

<u>Key Site Documents</u>

SLAC-I-086-30400-001	SLAC Lockout/Tagout: Lock and Tag Program for the Control of Hazardous Energy (8-24-92)
SLAC-I-086-30400-001	SPEAR Group Lockout/Tagout: SPEAR Group Lockdown Procedure (11-5-92)

SLAC-I-720-OA29Z-001	SLAC ES&H Manual: Environment, Safety, and Health Manual (5-8-92)
-----	Electrical Policies and Procedures Handbook: PE/PMS Electrical Group Policies and Procedures Handbook (3-14-90)
-----	Electrical Safety Committee Charter (10-28-85)
-----	Power Conversion Department Procedures: ELPs for System (10-92)
-----	SLAC Institutional Quality Assurance Program Plan
-----	SLAC/SSRL Self Assessment, Completion by Division/Hazard Level (11-17-92)

Memoranda and Letters

11-16-92	I. Garg et al, to D.W. Pearman, Jr., "Investigation Report of Electrical Accident, SPEAR Substation 507, October 16, 1992," with attachment
6-30-92	A.H. Saltzberg to Distribution, "Non-Bacon-Davis Construction"
4-25-91	M.A. Allen to Key Managers, "Mission Statement"
4-10-91	M.A. Allen to Department Heads and Group Leaders, "Job Task/Hazard Survey"
Undated	B. Goodman to Open, "Construction Procurements"

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Uranium Mill Tailings Remedial Action Project

Key Site Documents

UMTRA-DOE/AL150224.0006	UMTRA Project Environment, Health, and Safety Plan (2-89)
3.1	ICC Lockout/Tagout Policy
3.1	Westran Lockout/Tagout Policy
SOP 1-5	Cord and Plug Equipment Program (MK-Ferguson) (11-20-92)
MK-Ferguson	Corporate Quarterly Survey (5-5-92)
MK-Ferguson	Safe Conduct of Electrical Work Procedures

MK-Ferguson	UMTRA Project Safety and Health Rules (5-88)
WWTP	P/M Procedures
-----	Cheney Lockout/Tagout Procedure - #1 (6-30-92)
-----	ICC Corporate Safety Policy (10-1-92)

<u>Memoranda and Letters</u>

11-6-92	MK-Ferguson Policy Statement, "Safe Conduct of Electrical Work," memo attachment
11-5-92	J. Huff, "DOE Response to DOE Task Group"
10-27-92	D.R. Johnson, "Electrical Site Surveillance Report [for] Colorado Site"
10-23-92	M.A. Beisel, "Magnum Electric Inspection"
10-20-92	C.M. Best, "Energy Sources Audit"
10-20-92	J. Isham, "Lockout/Tagout"
10-16-92	A.J. McLean, "Assured Equipment Grounding Program/Inspection Records"
9-19-92	L. Boldwin, "Accident Investigation of Electrical Shock"
8-19-92	K. Wright, "UMTRA Instrumentation Program"
7-6-92	K. Crouse, "Training Topics"

APPENDIX H

CHARTER FOR THE DOE ELECTRICAL SAFETY COMMITTEE

DOE ELECTRICAL SAFETY COMMITTEE ORGANIZATION

The DOE Electrical Safety Committee shall be composed of program secretarial officers and one representative from each DOE field office. The committee shall be chaired by the Office of Occupational safety (EH-31) representive and shall report to the Director of EH-31 through the chairperson. DOE contractor personnel shall be allowed to participate on the committee. Committee members shall be knowledgeable in areas of electrical safety, maintenance, utilities, design, or construction.

Each DOE contractor site should establish an Electrical Safety Committee or equivalent which should be responsible for program implementation.

DOE ELECTRICAL SAFETY COMMITTEE CHARTER

I. PURPOSE

The DOE Electrical Safety Committee is established to develop and maintain current electrical safety standards and provide guidelines for the Department in order to affect reduction in the risks associated with electrical energy and to mitigate hazards to employees, the public, and environment.

II. RESPONSIBILITIES

Under the authority delegated from the Office of Occupational Safety (EH-31), the committee shall be responsible to:

1. Provide technical expertise, develop, and maintain current DOE Electrical Safety Guidelines, which incorporates applicable DOE Orders and accepted industrial practices related to electrical safety such as those published in the National Electrical Code, the National Electrical Safety Code, Occupational Safety and Health Administration regulations and standards, and various National Fire Protection Association publications. The Director of EH-31 shall administrate and manage the Electrical Safety Guidelines.

2. Review upon request electrical reports, exemptions, and other submittals and provide recommendations through EH-31.

3. Recommend, through EH-31, standardized training programs for the development of qualified electrical workers.

4. Meet Periodically, as appropriate, to review and evaluate the adequacy of the guidelines and to initiate guidelines changes or revisions as needed.

5. Provide technical expertise, guidance, and interpretations on matters concerning electrical safety, codes and standards and proposed solutions

for electrical issues for DOE.

6. Establish an electrical safety information exchange system and distribution of lessons learned within the DOE system.

7. Provide guidance in the establishment of electrical safety programs at DOE facilities.

III. MEMBERSHIP

The DOE Electrical Safety Committee shall be comprised of a DOE voting member representative and alternate from each of the field office and the following:

1. Office the Occupation Safety (EH-31), serves as chairperson;

2. Office of Administration and Human Resource Management (AD-1); and

3. Program Secretarial Officer of Defense Program (DP), Nuclear Energy (NE), Environmental Waste Management (EM), Energy Research (ER); and Fossil Fuel Energy (FE)

The committee shall meet annually or more often at an appropriate location for the purpose of discussing electrical safety issues, related matters, and concerns within the DOE organization. The committee shall be chaired by the Office of Occupational Safety (EH-31) representative and shall be report directly to the Director of EH-31. Only members officially designated as DOE voting members shall vote on recommending policy issues. DOE contractor personnel are invited and encouraged to participate in the committee meeting and activities. Any items requiring formal DOE Headquarters action/approval shall be presented through established channels of communication by the committee chairperson.

APPENDIX I

CHRONOLOGY OF ELECTRICAL INCIDENT CASUALTIES

APPENDIX I

CHRONOLOGY OF ELECTRICAL INCIDENT CASUALTIES*

Electrical Incident Fatalities

Site	Description
1. WAPA	Employee may have adjusted or removed the traveler ground lead from the structure arm, received an electrical shock, and fell from a 85-foot transmission line tower. (4-19-88)
2. Rocky Flats	Electrician sustained third-degree fire burns over 90 percent of his body and was fatally injured while changing a fuse in a 2,400-volt switchgear. (1-15-87)
3. WAPA	Employee was installing south jumper of an overhead bypass switch (Number 999) to deenergize 345 ungrounded conductor; suffered fatal electrocution. (10-2-86)
4. NPR-C	Employee was killed in a gas explosion in a compressor building due to inappropriate electrical lockout/tagout procedure. (7-13-84)
5. WAPA	Employee was using a hot stick with bare hand while working on a pole-mounted switch. He was using live-line methods when he contacted high voltage and fell off the pole; suffered fatal electrocution. (6-11-84)
6. BPA	Employee was attempting to saw some 2-inch aluminum buses to isolate part of a switch rack in a BPA substation. Employee was unaware that the switch rack was energized; suffered fatal electrocution. (10-5-82)

*** Incidents that have occurred most recently have been listed first in each of the three categories.**

NOTE: The tables included in this appendix have been complied from the best available information contained in the Safety Performance Measurement System, Computerized Accident/Information System, and Occurrence Reporting and Processing System.

Electrical Incident "Lost Work Day" Injuries

Site	Description
1. UMTRA	Employee received a severe electrical shock while testing fuses in the Waste Water Treatment Plant. (9-19-92)
2. Rocky Flats	Employee sustained electrical shock when his foot slipped from the power pedal of a welder. (8-3-92)
3. LANL	Employee received electrical shock when metal pole contacted high-voltage powerline. (7-6-92)
4. ANL	Employee incurred electrical shock in hand when lifting power strip from wet floor. (6-5-92)
5. SSCL	Employee injured when hand contacted an energized part of an air-conditioner. (5-22-92)
6. BNL	Employee received electric shock while using sonicator and touching converter unit. (4-22-92)
7. SSCL	Temporary employee received 110-volt electrical shock from an extension cord; resulted in hospitalization for observation and home rest. (4-6-92)
8. KAPL	Employee contacted 480-volt bus bars and received electric shock while working on a transformer. (9-21-91)
9. SRS	Electrical engineer received flash burns from an electrical arc caused when a wooden ruler he was holding in his hand inadvertently came into proximity to or in contact with an electrical circuit. (8-28-91)
10. LANL	Employee received slight burn to hand caused by an apparent short in the plug that he was pulling out from a socket. (8-6-91)
11. JATL	Journeyman electrician received second-degree flash burns to face and hands while using a 1,000-volt rated meter on 4,160 volts primary. (7-13-91)
12. SSCL	Employee received electrical shock after touching a bare wire during maintenance work. (6-26-91)
13. WAPA	Employee received multiple injuries while splicing wires in a spare transformer; resulted in shock and burns. (4-24-91)
14. SNL	Site Electrician received a serious shock while replacing existing light fixtures. (3-29-91)

Electrical Incident "Lost Work Day" Injuries (Continued)

Site	Description
15. LLNL	Employee's neck contacted electrical plugs while unplugging a shredder; resulted in burns. (1-29-91)
16. SLAC	Electrician received burns to his arms and head while cleaning components in Substation 7. (12-27-90)
17. Pinellas	Employee received 480-volt shock while running pipe from busway box to work area. (11-5-90)
18. LLNL	Employee received electric shock when metal bar contacted an electric wire fence. (10-19-90)
19. Paducah	Employee received electrical shock while plugging power cord into 110-volt receptacle. (9-21-90)
20. TTR	Employee incurred multiple burns when electrical arc occurred while checking switch. (8-15-90)
21. NTS	Employee incurred multiple burns when electrical arc occurred while checking switch. (8-15-90)
22. Fermilab	Employee experienced electric shock after touching pump line and holding outlet. (7-9-90)
23. WAPA	Employee received a flash burn to hand when a plug shorted during a transformer inspection. (6-30-90)
24. Portsmouth	Employee burned fingers when plug shorted out while testing air-conditioner. (5-29-90)
25. CEBAF	Employee fell from ladder onto energized bushings, incurring electric burns. (3-29-90)
26. LLNL	Employee incurred electric shock while moving a defective immersion heater. (2-6-90)
27. LLNL	Employee fell and incurred multiple injuries after being burned while cutting wire. (12-12-89)
28. CEBAF	Employee incurred a minor burn to his hand after an outlet shorted-out while plugging in a vacuum. (11-27-89)
29. NTS	Employee touched a high-voltage power supply resistor and incurred electrical burn. (11-6-89)

Electrical Incident "Lost Work Day" Injuries (Continued)

Site	Description
30. NPR-C	Employee received burns and lacerations when hand contacted energized 4-kilovolt bus bar. (9-15-89)
31. LANL	Employee received electrical shock while using grinder attached to portable welder. (8-28-89)
32. Mound	Employee incurred shock and burns to hand when screwdriver contacted 480-volt power feed. (5-24-89)
33. METC	Employee received flash burn to eye from an electric arc while fusing metal. (5-3-89)
34. Y-12	Employee fractured heel when jumping from a ladder after contacting a live 440-volt circuit. (3-6-89)
35. NTS	Employee burned hand while pulling energized electrical wire. (10-24-88)
36. LLNL	Employee touched an energized bus strip in a control panel, causing electrical shock. (9-19-88)
37. Rocky Flats	Employee incurred burns to face and arm when his wrench slipped and caused an electrical flash. (6-9-88)
38. LLNL	Employee's wedding ring melted when exposed to an energy source and burned finger. (5-17-88)
39. LLNL	Employee brushed against an energized resistor and received electric shock while testing equipment. (4-28-88)
40. Oak Ridge	Employee's arm/hand burned when 40-year-old power panel arced and exploded into flames. (4-13-88)
41. LBL	Employee contacted an ion pump power supply cable carrying 8 kilovolts and burned hands. (2-29-88)
42. Pinellas	Employee touched 277-volt live wire while installing switchgear, resulting in electrical shock. (2-24-88)
43. Hanford	Employee received electrical burns while checking cables in circuit breaker. (12-31-87)
44. LLNL	Employee incurred a burned hand when a plug and cord assembly came apart while unplugging a heater. (12-18-87)

Electrical Incident "Lost Work Day" Injuries (Continued)

Site	Description
45. LLNL	Employee received electrical shock while connecting wires; resulted in burn to thumb. (12-4-87)
46. LLNL	Employee received electrical shock while testing a power supply on a conductive work surface. (10-16-87)
47. SNL	Employee received electrical shock/burn when hair contacted capacitor on generator. (9-2-87)
48. BNL	Employee lost consciousness after receiving electrical shock from 6,000-volt supply. (5-11-87)
49. LANL	Employee struck an overhead crane power source with shoulder, causing numbness. (3-10-87)
50. Fermilab	Employee became disoriented after using ungrounded tool; potential electrical shock. (3-9-87)
51. Y-12	Employee received electric shock when a fault arc developed in control panel. (11-23-86)
52. SPR	Employee received electrical shock while using a shovel to cut a 4,160-volt cable. (11-10-86)
53. SRS	Employee received electrical flash burns to face and arm while installing a fuse. (11-5-87)
54. BAPL	Employee received radiant burns to hands and arms when he crossed phases on a power feeder. (9-6-86)
55. NTS	Employee received burns to hands when an arc erupted while replacing a safety guard on a control box. (6-2-86)
56. NTS	Employee received burns to hand and leg when an electrical plug arced and shorted blowing molten metal. (6-16-86)
57. Hanford	An electrician received electrical shock when his wrench slipped and brushed an electrical bus. (4-3-86)
58. Amador	Employee sustained burns after touching exposed conduits on electrical heater cord. (3-19-86)
59. SNL	Employee received burns to wrist and hand when pliers shorted to ground while forming hot bus bar. (1-21-86)

Electrical Incident "Lost Work Day" Injuries (Continued)

Site	Description
60. NTS	Employee received flash burns to hand after a terminal shorted during electrical work. (10-4-85)
61. NTS	Employee incurred flash burn to eyes after defective wiring in stove caused electric arc. (9-17-85)
62. ITRI	Employee received electrical shock while operating "open" button on autoclave door. (7-13-85)
63. KCP	Employee contacted energized bus duct with screwdriver. (4-25-85)
64. FUSRAP	Employee cut a hot wire after failing to check panel; resulted in flash burns to both eyes. (4-4-85)
65. LBL	Employee received shock from computer, jumped backward, and wrenched back. (3-6-85)
66. LLNL	Employee incurred electric shock when arm contacted grounded fixture while reloading blast. (9-20-84)
67. NTS	Employee's arm touched base wire during electrical repair, got shocked, and sprained back. (9-4-84)
68. LANL	Employee contacted energized relay and was shocked; failed to deenergize furnace. (8-15-84)
69. LANL	Employee inhaled smoke from phenolic brake shoes when electrical solenoid failed. (6-13-84)
70. LANL	Employee burned hands while reversing contacts on a crane function panel when a lightening flash occurred. (12-20-83)
71. BNL	Employee received electrical shock while dismantling experimental area. (12-12-83)
72. SPR	Employee was injured while cleaning the inside of a 5-kilovolt switchgear. (10-11-83)
73. Pantex	Employee was severely burned when an arc occurred while troubleshooting panel box. (9-1-83)
74. Chicago	Employee's hand struck 270-volt live wires and fell from ladder; resulted in burned hand and injured back. (9-29-83)

Electrical Incident "Lost Work Day" Injuries (Continued)

Site	Description
75. Pantex	Arc occurred while employee was troubleshooting an electrical panel box; suffered severe burns. (9-1-83)
76. LANL	Employee received electrical shock while lubricating well rig due to a lightning strike. (7-26-83)
77. Portsmouth	Employee contacted bus bar with breaker handle; resulted in extensive burns to neck and hands. (7-15-83)
78. Oak Ridge	Employee inadvertently put volt meter on live panel and burned arm and hand. (3-29-83)
79. LLNL	Employee received severe burns and electrical shock while opening an electric cubicle. (1-20-83)

Electrical Incident "Non-Lost Work Day" Injuries

Site	Description
1. FMPC	A split splice connection had rubbed against the messenger cable on the overhead temporary power line at the Dissolved Oxygen Project Trailer. This caused power to go to ground. (12-3-92)
2. CEBAF	Subcontract technician received minor shock after violation of safety manual procedures for electrical work. (11-11-92)
3. Hanford	Employee received electrical shock after contacting a section of 110-volt A/C heat trace wire that was on an uninsulated drain pipe. (10-21-92)
4. K-25	MMES Safety Representative picked up an electrical cord and a shock was received from the plug area of the cord during an inspection of Exterior of Building K-1065-A. (10-1-92)
5. Mound	Construction worker drilled into electrical line. (9-29-92)
6. BNL	Internal machine short circuit in the high-voltage supply of the CTI 931 tomograph caused the burning of a printed circuit board. (9-28-92)
7. ANL-E	Employee experienced electrical shock because of mislabeled wires. (8-27-92)
8. SSCL	Trackhoe struck an overhead electrical line. (7-15-92)
9. Rocky Flats	Shutdown of power to T690 A&B due to an arc at power pole E4 465 lightning arrestor. (6-26-92)
10. SSCL	Raised dump truck bed struck a high-voltage power line. (6-24-92)
11. SNL	Site Contractor employee received electrical shock in a calibration lab while calibrating a Fluke, Model No. 412B, high-voltage power supply (2,100 VDC at 35 milliamps). (6-16-92)
12. BAPL	Employee incurred second-degree burn to arm during an electrical testing of a rectifier. (6-8-92)
13. LLNL	Employee received electrical shock from Reactive Sputtering Deposition System (B-241) while connecting a cable between the high voltage power supply and the equipment without securing the power. (5-22-92)
14. LLNL	Technician received an electrical shock when his hand made contact with the setscrew on an electrical plug and a portion of the equipment that was at ground. (5-22-92)
15. SSCL	Raised bed of a dump truck struck a high-voltage power line. (5-13-92)

Electrical Incident "Non-Lost Work Day" Injuries (Continued)

Site	Description
16. BNL	Employee received electric shock while using a sonicator and touching a converter unit. (4-22-92)
17. BNL	Employee incurred electrical shock at Building 463 while using a benchtop Sonifier Cell Disrupter Model W185, with cup sonicator attachment installed. (4-22-92)
18. PETC	A researcher received electrical shock and fell from a 30-inch step while holding onto metal lattice that was grounded and simultaneously touching a heat gun switch at 75 volts; resulted in minor head injuries and loss of consciousness. (2-25-92)
19. ANL-E	Employee experienced a "near-miss" electrical shock situation due to mislabeled wires. (2-22-92)
20. Hanford	Employee incurred burns to face and hands when his drill came in contact with an energized bus, resulting in a short. (12-23-91)
21. Ames	Employee incurred second-degree burn to finger while handling energized power cord. (12-9-91)
22. SNL	Electrician was shocked while inserting a metal fish tape into a conduit connected to an energized 480-volt panel board. (10-24-91)
23. KCP	Employee received a potentially dangerous electrical shock due to the fact that the manufacturer's design of the clip securing the safety grounding wire was inadequate and failed. (10-15-91)
24. Fermilab	Employee incurred second-degree burn to finger on circuit while moving probe in rack. (10-1-91)
25. SRS	Employee contacted an electrode and experienced electric shock from temple to chin. (9-24-91)
26. INEL	Construction core drilled into electrical conduit. (9-12-91)
27. Portsmouth	Employee incurred burned wrist when wrist band contacted wire of sweeper, causing power surge. (7-24-91)
28. LANL	Employee cut a 110-volt twisted pair of wires with a diagonal cutter, which arced and splashed molten bits of copper metal into his safety glasses. (6-20-91)
29. Portsmouth	Employee received electric shock when hand contracted metal console of space heater. (5-20-91)

Electrical Incident "Non-Lost Work Day" Injuries (Continued)

Site	Description
30. ANL-E	During a routine lawn mowing operation an energized 1-inch 220-volt cable became entangle in the cutting blade of a lawnmover, resulting in a potential for electrical shock to employee. (5-8-91)
31. SRS	Employee received electrical shock when bare cable wires contacted water in a drain. (5-5-91)
32. Y-12	Employee's wrist was burned by electric spark when battery contacted metal watch band. (4-19-91)
33. SRS	Electrician received a minor electrical shock during the tie in of an emergency lighting battery pack per work package NB-072 due to inadequate lockout/tagout procedure. (4-4-91)
34. LBL	Employee received electric shock after touching a metal fitting housing the electrical input to a room divider (modular wall). (3-26-91)
35. LANL	Employee was adjusting the height of a newly installed laser when he felt a shock across his body. (3-8-91)
36. SRS	Employee received electrical burn on finger while plugging in cord of a typewriter. (3-4-91)
37. BPA	Employee incurred shock from co-worker's weld tool while supporting electric bus. (2-24-91)
38. ANL-E	Employee experienced a "near-miss" electrical exposure. (2-22-91)
39. Pinellas	Employee experienced what was thought to be an electrical shock from an improperly wired transformer while relocating a primary A/C power disconnect. (1-14-91)
40. SLAC	Employee received electric shock while testing energized wire mover assembly. (12-14-90)
41. SNL	Employee received electrical shock/burns while operating unshielded vacuum system. (10-17-90)
42. INEL	Employee got dirt in eye when a energized wire flashed during re-termination. (9-24-90)
43. NTS	Employee received burns to hand and forearm during an electrical arc that occurred while testing switchgear. (8-15-90)
44. Y-12	Employee inadvertently touched 440-volt breaker while marking cubicle and burned hand. (5-22-90)

Electrical Incident "Non-Lost Work Day" Injuries (Continued)

Site	Description
45. SNL	Employee contacted a capacitor while working on a generator and lost consciousness. (3-14-90)
46. LLNL	Employee incurred electric shock while moving a defective immersion heater. (2-6-90)
47. CEBAF	Employee incurred minor burn to hand when an outlet shorted-out while plugging in a vacuum. (12-27-89)
48. Rocky Flats	Employee's finger was burned when voltage from a charger contacted a ring and wrench. (12-4-89)
49. BNL	Employee leaned against energized wireway and received electrical shock to arm. (11-29-89)
50. BNL	Employee reached into electron microscope while troubleshooting and burned fingers. (7-26-89)
51. Princeton	Employee's hand slipped while loosening pipe with wrench and struck heating circuit. (6-9-89)
52. LLNL	Employee received electrical shock while using metal tape to measure switchgear. (6-8-89)
53. NRF	Employee received an electrical shock while removing a power cord from an energized plug. (5-26-89)
54. NTS	Employee fell and contused ribs when shocked by electricity while measuring wire mesh. (5-19-89)
55. BNL	Employee received burns to thumb and finger when a breaker switch failed, causing control panel to arc. (2-6-89)
56. BNL	Employee burned finger due to a hot lead shorting out while separating a cable connector. (9-10-88)
57. Rocky Flats	Employee incurred multiple burns when an inverter cabinet shorted and caused an arc. (9-7-88)
58. Oak Ridge	Employee burned both hands when plug on 480-volt condenser grounded. (8-25-88)
59. DOE HQ	Employee received electrical shock caused by fall on an escalator, resulting in multiple injuries. (7-27-88)

Electrical Incident "Non-Lost Work Day" Injuries (Continued)

Site	Description
60. Oak Ridge	Employee burned face/hand when 40-year-old power panel arced and exploded into flames. (4-13-88)
61. Oak Ridge	Employee's pliers arced after contacting junction box, causing electrical shock. (10-2-87)
62. LANL	Employee's hand contacted an exposed voltmeter probe while adjusting voltage on unit. (8-13-87)
63. Hanford	Employee burned hand when torque wrench shorted a battery circuit to a battery rack. (10-13-86)
64. BNL	Employee placed screwdriver on a terminal output and received electric shock. (1-29-86)
65. SRS	Employee's finger contacted a 5,200-VDC energized connector on tip; resulted in third-degree burn. (12-9-85)
66. LANL	Employee received electrical burn to hand while checking a defective switch that arced. (10-16-85)
67. Ames	Employee attempted to plug in a defective 220-volt AC cord and burned his fingers. (10-10-85)
68. K-25	Employee closed 440-volt breaker and contacts shorted and door exploded; incurred fractured thumb. (9-3-85)
69. Oak Ridge	Employee burned both hands when plug on 440-volt connection grounded. (8-25-88)
70. LLNL	Employee touched exposed metal wire panel and was shocked; caused by inadequate electrical repair. (8-7-85)
71. Hanford	Employee received electric shock while greasing a bearing on a main feeder of a crusher. (7-9-85)
72. Princeton	Employee received electrical burn to thumb while inspecting wiring. (6-10-85)
73. INEL	Employee received burns after a transformer jumper slipped and contacted 480 volts, causing an arc. (5-8-85)
74. SNL	Employee received flash burn to eyes when a capacitor bank arced during use of screwdriver. (3-15-85)

Electrical Incident "Non-Lost Work Day" Injuries (Continued)

Site	Description
75. INEL	Employee burned fingers during inspection due to a flash caused by an untaped splice joint. (2-5-85)
76. LANL	Employee received electric shock/burn while moving an electric heater that shorted out. (1-30-85)
77. ANL	Employee tossed grinder after being shocked and lacerated armpit; short in grinder. (7-27-84)
78. WAPA	Employee did not follow procedure and burned hand while testing a watt-hour meter. (7-5-84)
79. ITRI	Employee burned fingers when a defective electrical plug ignited on contact with outlet. (12-3-83)
80. BPA	Employee burned hand when electric arc started while switching a Mod A-914 in service. (10-11-83)
81. Oak Ridge	Employee's wrench slipped and struck a high-voltage cover; fingers burned on contact. (9-14-83)
82. SRS	Employee accidentally contacted a 13.8-kilovolt electrical line, burning body and hands. (7-27-83)
83. PNL	Employee plugged defective filter into a wall outlet and received electrical shock/burn. (7-25-83)
84. WAPA	Employee incurred flashburn to eyes when an arc occurred as a disconnect switch was opened. (6-3-83)
85. LBL	Employee received electric shock, jerked upward and struck his head after contacting a live capacitor. (4-27-83)
86. Mound	Construction worker drilled into an electrical line. (9-29-82)

SITE CODES

ANL	Argonne National Laboratory
ANL-E	Argonne National Laboratory - East
BAPL	Bettis Atomic Power Laboratory
BNL	Brookhaven National Laboratory
CEBAF	Continuous Electron Beam Accelerator Facility
FMPC	Fernald Environmental Management Center
FUSRAP	Formerly Utilized Sites Remedial Action Programs
INEL	Idaho National Engineering Laboratory
ITRI	Inhalation Toxicology Research Institute
JATL	Johnson Atoll
KAPL	Knowles Atomic Power Laboratory
KCP	Kansas City Plant
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
LTA	Lattice Test Assembly
METC	Morgantown Energy Technology Center
NPR-C	Naval Petroleum Reserve, California
NRF	Naval Reactor Facility
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
PETC	Pittsburgh Energy Technology Center
PNL	Pacific Northwest Laboratory
SLAC	Stanford Linear Accelerator Center
SNL	Sandia National Laboratory
SPR	Strategic Petroleum Reserve
SRS	Savannah River Site
SSCL	Superconducting Super Collider Laboratory
TTR	Tonopah Test Range
WAPA	Western Area Power Administration