Electric Power Generation, Transmission, and Distribution

Electrical Protective Equipment
Electric Power System

Color Key:
Black:  Generation
Blue:  Transmission
Green: Distribution

Generating Station
Generating Step Up Transformer
Transmission Customer 138kV or 230kV
Transmission lines 765, 500, 345, 230, and 138 kV
Substation Step Down Transformer

Subtransmission Customer 26kV and 69kV
Primary Customer 13kV and 4kV
Secondary Customer 120V and 240V
Existing Standards

- General industry (1994)
  - §1910.137—Electrical protective equipment
  - §1910.269—Electric power generation, transmission, and distribution

- Construction (1972)
  - Subpart V—Power transmission and distribution
Final Rule

- General industry
  - §1910.137—Electrical protective equipment
  - §1910.269—Electric power generation, transmission, and distribution
- Construction
  - §1926.97—Electrical protective equipment
  - Subpart V—Electric power transmission and distribution
Goals

- Update standards based on latest consensus standards
- Provide additional protection beyond current standards
  - Information transfer (host-contractor and job briefing)
  - Fall protection
  - Minimum approach distances (MAD)
  - Protection from electric arcs
- Make the two sets of standards the same
# Costs and Benefits

## Annualized Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of Appropriate Protective Clothing</td>
<td>$2.2 million</td>
</tr>
<tr>
<td>Provision of Appropriate Protective Clothing</td>
<td>$17.3 million</td>
</tr>
<tr>
<td>Fall Arrest Equipment</td>
<td>$0.6 million</td>
</tr>
<tr>
<td>Host/Contractor Communications</td>
<td>$17.8 million</td>
</tr>
<tr>
<td>Expanded Job Briefings</td>
<td>$6.7 million</td>
</tr>
<tr>
<td>Additional Training</td>
<td>$3.0 million</td>
</tr>
<tr>
<td>Other Costs for Work Not Already Covered by §1910.269</td>
<td>$0.2 million</td>
</tr>
<tr>
<td>MAD Costs</td>
<td>$1.8 million</td>
</tr>
<tr>
<td><strong>Total Annual Costs</strong></td>
<td><strong>$49.5 million</strong></td>
</tr>
</tbody>
</table>
Costs and Benefits

Annual Benefits

Number of Injuries Prevented
118.5

Number of Fatalities Prevented
19.75

Monetized Benefits (Assuming $62,000 per Injury and $8.7 million per Fatality Prevented)
$179.2 million

OSHA Standards That Are Updated and Consistent
Unquantified

Net Benefits (Benefits minus Costs):
$129.7 million
Costs and Benefits

- Compliance with the final rule will result in the prevention of one fatality and 6 injuries per $2.5 million in costs, or, alternatively, $3.62 of benefits per dollar of costs.
Information Transfer
Information Transfer

- Existing conditions (§§1910.269(a)(4) and 1926.950(d))
- Host-contractor provisions (§§1910.269(a)(3) and 1926.950(c))
- Job briefing (§§1910.269(c) and 1926.952)
Existing Conditions

- Characteristics of the system related to safety
  - Voltage, maximum overvoltage, induced voltage
  - Presence of grounds
  - Location of circuits and equipment

- Conditions of the installation related to safety
  - Condition of grounds and poles
  - Environmental conditions

§§1910.269(a)(4) & 1926.950(d)
Host-Contractor

Host employer:

An employer that operates, or that controls the operating procedures for, an electric power generation, transmission, or distribution installation on which a contract employer is performing work covered by [the standard].

Contract employer:

An employer, other than a host employer, that performs work covered by [the standard] under contract.

§§1910.269(x) & 1926.968
Host-Contractor

- Host provides information to contractors
  - Characteristics listed in §§1910.269(a)(4) and 1926.950(d)
  - Known conditions listed in §§1910.269(a)(4) and 1926.950(d)
  - System design information needed for assessments
  - Other known system information related to safety and requested by contractor

§§1910.269(a)(3)(i) & 1926.950(c)(1)
## Host-Contractor—Assessments

<table>
<thead>
<tr>
<th>Provision</th>
<th>Assessment Required</th>
<th>Type of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>§1910.269(e), §1926.953(a)</td>
<td>Whether an enclosed space must be entered as a permit-required confined space</td>
<td>Whether an enclosed space contains hazards, other than electrical and atmospheric hazards, that could endanger the life of an entrant or could interfere with escape from the space</td>
</tr>
<tr>
<td>§1910.269(e)(12), §1926.953(m)</td>
<td>Whether forced air ventilation has been maintained long enough that a safe atmosphere exists</td>
<td>The size of the enclosed space</td>
</tr>
</tbody>
</table>
# Host-Contractor—Assessments

<table>
<thead>
<tr>
<th>Provision</th>
<th>Assessment Required</th>
<th>Type of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>§1910.269(l)(3)(i), §1926.960(c)(1)(i)</td>
<td>What is the appropriate minimum approach distance for the work to be performed?</td>
<td>What the operating conditions are for the value of the maximum transient overvoltage provided to the contract employer</td>
</tr>
<tr>
<td>§1910.269(l)(8)(i), §1926.960(g)(1)</td>
<td>Whether employees are exposed to hazards from flames or electric arcs</td>
<td>Information on electric equipment, such as safety information provided by manufacturers, that relates to the required hazard assessment</td>
</tr>
<tr>
<td>Provision</td>
<td>Assessment Required</td>
<td>Type of Information</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>§1910.269(l)(8)(ii), §1926.960(g)(2)</td>
<td>What is the estimated incident energy from an electric arc?</td>
<td>The electrical parameters needed to calculate incident energy, such as maximum fault current, bus spacings, and clearing times</td>
</tr>
<tr>
<td>§1910.269(l)(12), §1926.960(k)</td>
<td>Whether devices are designed to open or close circuits under load conditions</td>
<td>Load current for, and the opening and closing ratings of, devices used to open and close circuits under load</td>
</tr>
<tr>
<td>Provision</td>
<td>Assessment Required</td>
<td>Type of Information</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>§1910.269(m) and (w)(7), §§1926.961 and 1926.967(h)</td>
<td>What are the known sources of electric energy (including known sources of backfeed) supplying electric circuits?</td>
<td>All known sources of electric energy, including known sources of backfeed</td>
</tr>
<tr>
<td>§1910.269(d)</td>
<td>What are the sources of hazardous energy, including sources of potentially hazardous stored or residual energy?</td>
<td>All sources of hazardous energy, including sources of potentially hazardous stored or residual energy, and any conditions that can lead to the reaccumulation of residual or stored energy to a hazardous level</td>
</tr>
</tbody>
</table>
## Host-Contractor—Assessments

<table>
<thead>
<tr>
<th>Provision</th>
<th>Assessment Required</th>
<th>Type of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>§1910.269(n)(4)(i), §1926.962(d)(1)(i)</td>
<td>Whether protective grounds have adequate current-carrying capacity</td>
<td>The maximum fault current and clearing time for the circuit</td>
</tr>
<tr>
<td>§1910.269(n)(7), 1926.962(g)</td>
<td>Whether there is a possibility of hazardous transfer of potential should a fault occur</td>
<td>Potential rise on remote grounds under fault conditions</td>
</tr>
<tr>
<td>Provision</td>
<td>Assessment Required</td>
<td>Type of Information</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>§1910.269(q)(1)(i), 1926.964(a)(2)</td>
<td>Whether overhead structures such as poles and towers are capable of sustaining stresses imposed by the work</td>
<td>The design strength of the pole or structure</td>
</tr>
</tbody>
</table>
Host-Contractor

Contractor instructs its employees in the hazardous conditions, relevant to employees’ work, of which the contractor is aware as a result of information communicated by the host.

§§1910.269(a)(3)(ii)(A) & 1926.950(c)(2)(i)
Host-Contractor

* Contractor advises the host of:
  * Any unique hazardous conditions presented by the contract employer’s work
  * Any unanticipated hazardous conditions not mentioned by the host

§§1910.269(a)(3)(ii)(B), (C) & 1926.950(c)(2)(ii), (iii)
Host-Contractor

- Contractor and host must coordinate work rules and procedures so that each employee is protected

§§1910.269(a)(3)(iii) & 1926.950(c)(3)
Job Briefing

Employer must provide the employee in charge with all available information that relates to the determination of existing characteristics and conditions under §§1910.269(a)(4) and 1926.950(d):

- Information on existing characteristics
- Information about existing conditions

§§1910.269(c)(1)(i) & 1926.952(a)(1)
Fall Protection
Fall Protection—Types

- **Fall restraint system**
  - A system that prevents the user from falling any distance

- **Work positioning equipment**
  - A system rigged to allow an employee to be supported on an elevated vertical surface and work with both hands free while leaning

- **Personal fall arrest equipment**
  - A system used to arrest an employee in a fall from a working level

§§1910.269(x) & 1926.968
Fall Restraint System
Work Positioning Equipment
Personal Fall Arrest Equipment
Fall Protection?
Fall Protection

- Aerial Lifts
  - Fall restraint system, or
  - Personal fall arrest system

§§1910.269(g)(2)(iv)(C) & 1926.954(b)(3)(iii)
Fall Protection

- Poles, towers, and similar structures, more than 1.2 m above the ground
  - Fall restraint system,
  - Work positioning equipment, or
  - Personal fall arrest system
- As appropriate

§§1910.269(g)(2)(iv)(C) & 1926.954(b)(3)(iii)
Fall Protection

- Use fall protection while climbing or changing location
  - Limited exemption
  - Provides anchorage
  - Effective April 1, 2015

§§1910.269(g)(2)(iv)(C) & 1926.954(b)(3)(iii)
§§1910.269(l)(3), (l)(4)(ii), (l)(5)(ii) & 1926.960(c)(1), (c)(2), (d)(2)
MAD

- Employer must establish minimum approach distances based on formulas in the standard.

- For voltages up to 72.5 kV, the default distances are the same as proposed.

- For voltages exceeding 72.5 kV, the distances are based on the equations used to calculate the proposed distances ($D = TOV \times (C + a) + M$).

- MAD is based on probability of 1/1000 of sparkover.

§1910.269(l)(3) & Table R-3, & §1926.960(c)(1) & Table V-2
MAD—Changes for Voltages >72.5 kV

- Maximum transient overvoltage (TOV)
  - Highest is 3.5 rather than 3.0
  - Final rule anticipates that most employers will determine maximum TOV
  - Appendix B includes MAD tables for various values of maximum TOV
- MAD for phase-to-phase exposures increases substantially for voltages >350 kV because of error

§1910.269(l)(3) & Table R-3, & §1926.960(c)(1) & Table V-2
Approach Distance

Put on and take off rubber insulating gloves in a position where the worker cannot reach into MAD.

§§1910.269(l)(4)(ii) & 1926.960(c)(2)(ii)
Approach Distance

- For work near live parts of >600 volts but ≤ 72.5 kV, work from a position where the worker cannot reach into MAD, except:
  - wearing rubber insulating gloves,
  - protected by insulating equipment,
  - using live-line tools, and
  - performing live-line barehand work.

§§1910.269(l)(5)(ii) & 1926.960(d)(2)
Electric Arc Protection
Electric Arc Protection

CON EDISON ARC FLASH DOCUMENTARY
Electric Arc Protection

- Assess workplace for hazards from flames or electric arcs
- If there is exposure, estimate incident energy
- Prohibit clothing when incident energy could ignite clothing
- Require FR under certain conditions
- Select clothing with an arc rating greater than the estimated incident energy

§1910.269(l)(8) & §1926.960(g)
Electric Arc Protection
Appendix E Guidelines

- Assessment guidelines with examples
- Estimating available heat energy
  - Selecting an appropriate calculation method
  - Selecting reasonable input parameters (in particular, distance to arc and arc gap)
  - Tables for single-phase arc in open air
- Selecting protective clothing and other protective equipment

Appendix E to §1910.269 & Subpart V
### Electric Arc Protection

**Appendix E Guidelines**

Table 3—Selecting a Reasonable Incident-Energy Calculation Method

<table>
<thead>
<tr>
<th>Incident-Energy Calculation Method</th>
<th>600 V and Less</th>
<th>601 V to 15 kV</th>
<th>More than 15 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1Φ</td>
<td>3Φa</td>
<td>3Φb</td>
</tr>
<tr>
<td>NFPA 70E-2012 Annex D (Lee equation)</td>
<td>Y-C</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Doughty, Neal, and Floyd</td>
<td>Y-C</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>IEEE Std 1584b-2011</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>ARCPRO</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Appendix E to §1910.269 & Subpart V
## Table 5—Selecting a Reasonable Arc Gap

<table>
<thead>
<tr>
<th>Class of Equipment</th>
<th>Single-Phase Arc mm (inches)</th>
<th>Three-Phase Arc mm¹ (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable</td>
<td>NA²</td>
<td>13 (0.5)</td>
</tr>
<tr>
<td>Low voltage MCCs and panelboards</td>
<td>NA</td>
<td>25 (1.0)</td>
</tr>
<tr>
<td>Low-voltage switchgear</td>
<td>NA</td>
<td>32 (1.25)</td>
</tr>
<tr>
<td>5-kV switchgear</td>
<td>NA</td>
<td>104 (4.0)</td>
</tr>
<tr>
<td>15-kV switchgear</td>
<td>NA</td>
<td>152 (6.0)</td>
</tr>
<tr>
<td>Single conductors in air, 15 kV and less</td>
<td>51 (2.0)</td>
<td>Phase conductor spacing</td>
</tr>
<tr>
<td>Single conductor in air, more than 15 kV</td>
<td>Voltage in kV × 2.54 (Voltage in kV × 0.1), but no less than 51 mm (2 inches)</td>
<td>Phase conductor spacing</td>
</tr>
</tbody>
</table>

Appendix E to §1910.269 & Subpart V
Electric Arc Protection

Appendix E Guidelines

Appendix E to §1910.269 & Subpart V

Table 6—Incident Heat Energy for Various Fault Currents, Clearing Times, and Voltages of 4.0 to 46.0 kV: Rubber Insulating Glove Exposures Involving Phase-to-Ground Arcs in Open Air Only

<table>
<thead>
<tr>
<th>Voltage Range (kV)**</th>
<th>Fault Current (kA)</th>
<th>Maximum Clearing Time (cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4 cal/cm²</td>
</tr>
<tr>
<td>4.0 to 15.0</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>15.1 to 25.0</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>25.1 to 36.0</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>36.1 to 46.0</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>3</td>
</tr>
</tbody>
</table>
Electric Arc Protection

- Requires FR clothing for incident energy exceeding 2.0 cal/cm²
- Protection for head and face
  - Starts at 9 cal/cm² for single-phase arcs in air
  - Starts at 5 cal/cm² for other exposures
- Protection for hands (rubber gloves with protectors or, for exposures ≤ 14 cal/cm², heavy-duty (12-oz) leather work gloves)
- Protection for feet (heavy work shoes or boots)

§1910.269(l)(8) & §1926.960(g)
Compliance Deadlines

- Final rule is effective 90 days after publication
- Fall protection—April 1, 2015
- New minimum approach distances—April 1, 2015
- Incident energy estimates—January 1, 2015
- Arc-flash protection—April 1, 2015
Miscellaneous Changes

Training

- Degree of training determined by risk for the hazard involved
- Qualified employees to be able to recognize and control electrical hazards
- Line-clearance tree trimmer’s training similar to qualified employee training
- Records no longer required
Miscellaneous Changes

- Deenergizing distribution and transmission lines
  - Multiple crews working on the same line must either: (1) coordinate under single employee or (2) comply independently

- Protective grounding
  - Expanded appendix information on equipotential zone

- Underground installations
  - Precautions when work could cause cable to fail
Miscellaneous Changes

- Electrical protective equipment
  - Updated consensus standards
  - Class 00 rubber insulating gloves
  - Requirements for equipment other than rubber
- Foot protection
  - Supplementary form of protection
Miscellaneous Changes

- Definitions
- Entry (into enclosed space)—new
- First-aid training—new, includes CPR
- Line-clearance tree trimming—add 0.1 m per 10 kV for voltages over 50 kV
- Statistical sparkover and withstand voltage—new