



OSHA PUBLISHED FIRST-EVER ARC FLASH PROTECTION REQUIREMENTS FOR THE ELECTRIC POWER INDUSTRY

Significant changes and
unprecedented compliance
deadlines require
high-voltage facilities to take
immediate action

Executive Summary

Over the last decade, the Occupational Safety and Health Administration (OSHA) and the electrical power generation, transmission and distribution industry have become increasingly aware of the frequency and the severity of the electrical arc flash hazard.

As a result, in June 2005, OSHA issued a proposed rule to make significant changes to 29 CFR 1910.269, the Electric Power Generation, Transmission and Distribution Standard, which covers electrical safety requirements and procedures for utilities, as well as for industrial establishments with equivalent equipment and working conditions. OSHA proposed the changes to these 'high voltage rules' for the purpose of providing greater arc flash protection for workers in higher voltage environments.

Nearly nine years after the initial proposal, OSHA published its final rule on standard 1910.269 in the Federal Register on April 11, 2014. The new standard incorporates a number of important updates, including significant changes to training, host employer requirements, fall protection, the requirements to estimate arc flash energy, minimum approach distances, personal protective equipment (PPE) and a number of other work practices.

Not only do the changes to the standard represent the first time OSHA is mandating specific arc flash related requirements that go beyond general hazard awareness; OSHA has also set unprecedented mandatory compliance deadlines. Initially, the standards were to go into effect on July 10, 2014. However, OSHA extended the compliance date for all requirements through October 31, 2014. In addition, the final standards contain delayed effective dates for some provisions until January 1, 2015 and April 1, 2015.

Yet, despite the extension and the delays on some provisions, the magnitude of the changes and the rapidly approaching compliance deadlines require affected utilities and facilities to take immediate action. Facilities should consider partnering with electrical engineering service experts who have up-to-date training and a solid understanding of the new requirements. Doing so can help ensure compliance, avoid non-compliance penalties and fines, and afford the best protection for workers in high voltage environments.

Severity of Arc Flash Hazards

Arc flash happens when electric current leaves its intended path and travels through the air from one conductor to another, or to ground. The concentrated radiant thermal energy that results from the arcing fault can lead to potentially devastating arc flash incidents or events that injure or kill between five and 10 people every day and that account for as many as eight in 10 electrical injuries.

Beyond the risk of personal injury or death to employees and contractors, arc flashes can also lead to business disruption, costly damage to equipment and facilities, legal liability, increased insurance premiums and hefty regulatory fines.

Unfortunately, the danger of exposure to arc flash hazards is on the rise and increasing steadily, due in part to greater overall energy usage as well as higher system voltages and available fault currents. In general, energy utilization increased 13 times from 1949 to 2002 to over 3,450 billion KWH (excluding co-generation). Larger loads, higher service voltage, on-site generation and medium voltage equipment in more work environments have also contributed to increased risk and a rising number of arc flash incidents.

History of Arc Flash Regulation

Arc flash concerns were first publicized in the early 1980s with the release of a paper by Ralph Lee titled, “The Other Electrical Hazard: Electric Arc Blast Burns.” As more and more industries and safety officials realized that too many people were suffering injuries as a result of arc flash incidents, industry standards, such as National Fire Protection Association (NFPA) 70E Standard for Electrical Safety in the Workplace®, were designed to reduce exposure to the hazards of shock, electrocution, arc flash, and arc blast while working on or near exposed electrical conductors or circuit parts that are or become energized.

While NFPA 70E was originally developed at OSHA’s request, OSHA does not enforce the NFPA 70E standard directly. However, the organization has always recognized it as industry practice and OSHA field inspectors carry copies of NFPA 70E for use in addressing safety procedures related to arc flash. In addition, OSHA Electrical Low Voltage Standards often mirror the requirements in NFPA 70E.

Interestingly, NFPA 70E provides guidance on implementing appropriate work practices to safeguard workers in low- and medium-voltage environments. However, no such standards have previously existed for higher voltage utilities and industrial facilities. When the new revisions to the OSHA Standard 1910.269 become effective on October 31, 2014, OSHA will mandate and enforce its own arc flash-related requirements for higher voltage facilities for the first time.

Significant Changes to 1910.269

Published by OSHA on April 11, 2014, the revisions to OSHA 1910.269 address the frequency and magnitude of arc flash hazards in high-voltage utilities and industrial facilities that operate power generation, transmission and distribution equipment. The revisions were patterned after the latest consensus standards, such as NFPA 70E, American National Standards Institute/Institute for Electrical and Electronics Engineers (ANSI/ IEEE) C2 National Electrical Safety Code, and other improvements in electrical safety technology. In addition, OSHA 1910.269 is now harmonized with OSHA 1910.301-399 (Subpart S), OSHA 1926.400-449 (Subpart K), and OSHA 1926.950-960 (Subpart V), so that the same guidelines apply to all types of work on generation, transmission and distribution equipment, regardless of whether the work is new construction, equipment maintenance, or other in nature.

This paper addresses the most significant requirements (and their effective dates) as provided in the final rule, but is not inclusive of all OSHA 1910.269 revisions

For a comprehensive review of all changes to the standard, please visit www.OSHA.gov.

General Training

The existing OSHA 1910.269 standard stipulates that the degree of training must be determined by the risk to the worker for the hazard involved. In order to meet this requirement, employers will be responsible for identifying the risks to each worker, and for providing the appropriate training to enable workers to handle or mitigate those risks.

Specifically, the standard states that “qualified” workers must have training:

- To recognize electrical hazards present at the worksite, which now must include recognizing arc flash hazards as well as shock hazards.

A note on defining “qualified” workers:

It is important to note that not every electrical worker is necessarily qualified on every piece of equipment or every system. “Qualified” electrical workers now must demonstrate the appropriate skills and abilities to determine what hazards are faced, the magnitude of the hazards, the proper work techniques to avoid the hazards, or the proper PPE to mitigate the hazards. Demonstration of skill sets is usually accomplished through an annual observation or audit, similar to the annual audit requirements for other safety-related programs, such as lock out/tag out. Even if an employer hires a worker who has been considered “qualified” by another employer, the new employer must still verify the skill sets, provide additional site-specific training and closely monitor the new employee’s activities before considering the worker “qualified.”

- To develop skills and techniques necessary to control or avoid those hazards, or to determine the appropriate PPE needed to mitigate the hazards. Appropriate work techniques, and selection and use of appropriate PPE for arc flash protection, will be predicated on the severity of the arc flash hazard, meaning the employer must determine through one of several engineering analysis tools the severity of the arc flash hazard and communicate that information to the workforce.

In addition, line-clearance workers or tree trimmers must be trained to distinguish exposed live parts and to determine the voltage on those parts. They must also be trained in minimum approach distances and how to maintain them. There are three existing voltage-based approach boundaries, and now an arc flash protection boundary will have to be calculated to compliment the voltage boundaries. These boundaries must be included in “qualified electrical worker” training.

Host Employers and Contractors

The new standard dictates that host and contract employers must share with each other information related to safety matters. Additionally, hosts and contractors need to coordinate work rules and procedures to improve safety for all workers.

Specifically, it falls to the host employer to make contract employers aware of any known hazards that are related to the contractors' work and that the contract employer or its employees might not recognize. For example, the host employer may be aware that a power pole is rotting or has questionable integrity. However, to the contractor, that power pole may visually appear safe to climb. It is up to the host employer to ensure the contractor understands the unsafe condition of the pole.

Other situations that require communication include multiple crews working within grid tie point; situations where backfeed potential exists; or situations that require sizing, placement, and application of protective grounds. Below are examples of each scenario.

HOST EMPLOYER	
■	Site specific training is typically the responsibility of the host employer
■	Recordkeeping—properly recording and reporting of injuries and illnesses (determined by day-to-day supervision)

CONTRACTOR	
■	Contractor is expected to inform employees of applicable standards and requirements
■	Maintain communication with contractor and host employer
■	Verify scope of work is being upheld

JOINT/SHARED RESPONSIBILITIES	
■	Provide hazard communication training
■	Provide a written safety and health program
■	Define scope of work
■	Conduct project orientation
■	Perform worksite hazard assessments
■	Address potential hazards to which contractor may be exposed

First, it is possible that a crew working on a line in one area of the grid could affect the safety of another crew working within the same grid zone, but out of sight of the first crew. In such a case, it is imperative that the crews work together as one crew, or that they have communication and supervision through the owner to work as if they are one crew.

Second, if a crew is working on a de-energized line, and somewhere else in the same grid another crew is clearing trees from a power line, a branch falls between the overhead line and underhanging (de-energized) line, then the de-energized line could be re-energized accidentally. In other instances, an operator could revise a switching plan and re-energize a part of the grid that is out of service (backfeeding).

Finally, when de-energized work is going to take place, special grounding equipment is placed on systems. The grounding equipment has to be sized appropriately based on the available fault current. The owner must provide that information to the crew employing the grounding equipment so that the crew knows what size grounds to use as well as where to place the grounds.

Additionally, host employers are responsible for providing contract employers with installation related information that is needed for making safety-related assessments, including the incident energy (arc flash) estimates. Now, contractors must be made aware of the arc flash severity and calculated boundaries in order to select and use the appropriate work techniques and PPE. Employers can provide contractors with the arc flash energy estimations during required safety tailgate meetings that typically occur first thing each morning before work begins, or whenever circumstances change.

Fall Protection

Per changes to OSHA standard 1910.269, if an employee is exposed to hazards from flames or electric arcs, the personal fall arrest equipment used by the employee must be capable of passing a drop test after exposure to an electric arc with a heat energy of 40 ± 5 calories per square centimeter. This will likely mean replacing fall protection equipment with arc rated equipment that has been tested to meet the new standard, similar to replacing daily workwear with arc rated workwear that is now prevalent in the industry.

Minimum Approach Distances and Insulation

The changes to OSHA 1910.269 revise the minimum approach distances. These provisions become effective on April 1, 2015.

To ensure worker safety, employers are responsible for establishing minimum approach distances for exposed live parts for both “unqualified” and “qualified” workers. (Refer to the General Training section on page 4 for additional information on the requirement to delineate between “qualified” and “unqualified” electrical workers.) Employers also need to calculate the flash protection boundary inside which workers must use appropriate PPE.

Per the new standard, the revised minimum approach distance values are now approximately equal to the restricted approach boundaries, or the area near the exposed live parts that may be crossed only by “qualified” persons using appropriate shock prevention techniques and equipment.

Employers can determine approach boundaries in one of two ways:

1. Given system voltage information, boundaries can be calculated using the formula in the appendices to the standards.
2. Employers can use the established charts, which also appear in the standard appendices.

Protection from Flames and Electric Arc Hazards

Because non-arc rated clothing can be ignited by electric arc flashes, workers without the appropriate protective clothing are at risk for severe injury. As a result, one of the first new OSHA 1910.269 requirements with which utilities and facilities need to comply, is estimating the incident heat energy of arc hazards and providing exposed workers with the appropriate protective clothing and equipment.

Per the new standard, the employer must first assess the workplace to identify which workers are exposed to flame or electric arc hazards. By January 1, 2015, employers must estimate the maximum heat energy to which each worker could be exposed. Finally, by April 1, 2015, exposed workers must be provided with arc-rated clothing and other protective equipment greater than or equal to the estimated heat energy. It is the employer’s responsibility to ensure that protective clothing and equipment is worn by employees.

Specifically per the new standard, the employer needs to provide, and ensure the use of, arc-rated clothing when:

- The employee is exposed to contact with energized circuit parts operating at more than 600 volts.
- An electric arc could ignite flammable material in the work area that in turn, could ignite the employee's clothing.

- Molten metal or electric arcs from faulted conductors in the work area could ignite the employee's clothing.
- The estimated incident heat energy exceeds 2.0 calories per square centimeter.

Because it is likely that any of these four factors could occur while performing tasks in any number of facilities, it is also likely that “qualified” electrical workers will need to wear arc-rated materials as their normal work attire.

Table 3—Selecting a Reasonable Incident-Energy Calculation Method ¹

INCIDENT-ENERGY CALCULATION METHOD	600V AND LESS ²			601V TO 15KV ²			MORE THAN 15KV		
	1Φ	3Φ _a	3Φ _b	1Φ	3Φ _a	3Φ _b	1Φ	3Φ _a	3Φ _b
NFPA 70E-2012 Annex D (Lee equation)	Y-C	Y	N	Y-C	Y-C	N	N ³	N ³	N ³
Doughty, Neal and Floyd	Y-C	Y	Y	N	N	N	N	N	N
IEEE Std 1584b-2011	Y	Y	Y	Y	Y	Y	N	N	N
ARCPRO	Y	N	N	Y	N	N	Y	Y ⁴	Y ⁴

Key:

1Φ: Single-phase arc in open air.

3Φ_a: Three-phase arc in open air.

3Φ_b: Three-phase arc in enclosure (box).

Y: Acceptable; produces a reasonable estimate of incident heat energy from this type of electric arc.

N: Not acceptable; does not produce a reasonable estimate of incident heat energy from this type of electric arc.

Y-C: Acceptable; produces a reasonable, but conservative, estimate of incident heat energy from this type of electric arc.

Notes:

¹ Although the Occupational Safety and Health Administration will consider these methods reasonable for enforcement purposes when employers use the methods in accordance with this table, employers should be aware that the listed methods do not necessarily result in estimates that will provide full protection from internal faults in transformers and similar equipment or from arcs in underground manholes or vaults.

² At these voltages, the presumption is that the arc is three-phase unless the employer can demonstrate that only one phase is present or that the spacing of the phases is sufficient to prevent a multiphase arc from occurring.

³ Although the Occupational Safety and Health Administration will consider this method acceptable for purposes of assessing whether incident energy exceeds 2.0 cal/cm² the results at voltages of more than 15 kilovolts are extremely conservative and unrealistic.

⁴ The Occupational Safety and Health Administration will deem the results of this method reasonable when the employer adjusts them using the conversion factors for three-phase arcs in open air or in an enclosure, as indicated in the program's instructions.

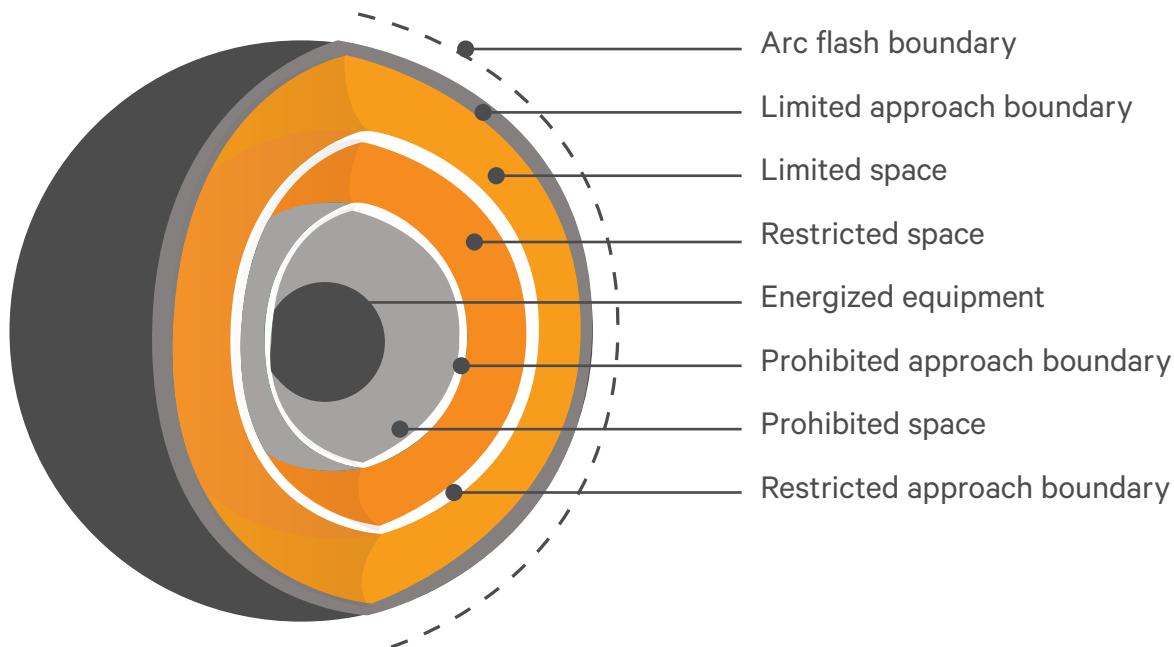


Figure 1: A number of “approach boundaries” exist and both qualified and non-qualified persons must understand these definitions.

For guidance on tools and methods that can be used to estimate available heat energy, employers can refer to the new standards in Appendix E to § 1910.269-Protection From Flames and Electric Arcs.

De-energizing Transmission and Distribution Lines and Equipment

Per the new standard, when more than one crew works together on the same lines or equipment, crews must either work together as if all employees formed a single crew, or they must independently comply with the standards if there is no system operator in charge.

Electrical Protective Equipment

The final rule on OSHA 1910.269 revises the existing standards for electrical protective equipment, which incorporates out-of-date consensus standards. Per the revisions, the Electrical Protective Equipment for Construction standard is now applicable to all construction work, and not just electrical power generation, transmission and distribution work.

The new standard for electrical protective equipment uses performance-oriented requirements that are consistent with the latest revisions of the relevant consensus standards.

Complying with the New Standard

Complying with the new OSHA 1910.269 standard will present challenges for utilities and industrial facilities due to the sheer volume of changes that will need to be made in relatively short order. As a result, industry experts, including the engineers and field technicians with Vertiv™’s Electrical Reliability Services who are certified through the InterNational Electrical Testing Association (NETA), strongly recommend partnering with professional electrical engineering service providers that are well trained and well versed in the new requirements.

While there is no legal requirement for a registered Professional Engineer to perform arc flash hazard analysis, such expertise not only ensures compliance with the standards, it can also save lives since improper calculations can put workers in grave danger.

To ensure compliance, meet the challenges of new arc flash safety requirements and protect workers, utilities and facilities should consider implementing professional arc flash solutions, such as:

- A professional site review or compliance assessment to identify areas of risk and noncompliance. As part of the review, electrical service professionals can help utilities and facilities formulate a plan to bring a facility into compliance in the most efficient way possible.
- An arc flash hazard analysis to identify the presence and location of potential hazards. As part of a comprehensive analysis, professionals can help with calculating incident energy, and with providing recommendations for PPE, approach boundaries, flash protection, and other safe work practices.
- An arc flash hazard communication plan that includes hazard labels for switchboards, panelboards, industrial control panels, motor control centers, and hazard communication guidelines for other equipment and components that are likely to require maintenance while energized, such as power generation, transmission and distribution lines.
- A protective scheme design review to evaluate and uncover potential hazards with fault current levels, arc exposure times, operational procedures (such as remote breaker control and remote racking), and system grounding.
- Single-line diagram development or update to ensure compliance with industry requirements. An up-to-date single-line diagram is instrumental in documenting, troubleshooting, and communicating critical information about power systems.

- Short circuit and coordination studies to verify protective device ratings. These studies are also useful for calculating momentary and interrupting currents, establishing settings for all types of protective devices, and coordinating protective devices to minimize downtime.
- A regular preventive maintenance program for electrical equipment that specifically addresses arc flash hazards. A preventive maintenance program is crucial to ensuring that protective devices operate properly, safely and reliably.

 **DANGER**

ARC FLASH and SHOCK HAZARD
PNL 0

1.1 cal/cm² 17 in 480 VAC 00 42 in 12 in	Incident Energy at 18 in Arc Flash Boundary Shock Hazard Class Glove with Leather Protectors Limited Approach (Fixed Circuit) Restricted Approach
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PPE REQUIRED
 Long sleeve shirt & pants or coverall (nonmelting or untreated natural fiber), safety glasses/goggles, hearing protection

Power system changes will invalidate the information on this label


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- Review or development of a comprehensive electrical safety program that supports and compliments the facility's overall site safety program.
- Development of an arc flash training program to ensure workers fully understand electrical and arc flash hazards and how to mitigate risks.
- Development of a PPE plan that provides category requirements and recommendations based on findings of an arc flash analysis.

Additionally, Electrical Reliability Services recommends keeping comprehensive and proper documentation to ensure compliance with OSHA standards and to help facilitate an investigation should an arc flash-related injury occur. Documentation should include results of the arc flash analysis and any other studies, as well as a written recording of incident energy at working distances, flash protection boundary, arc flash PPE category, and other pertinent information such as voltage, available fault current, protective device description and its trip time, arc gap, and arc current. Documentation of worker training is also required.

Finally, to maintain ongoing compliance with the latest arc flash standards, practices and regulations, Electrical Reliability Services recommends an annual review and update of arc flash assessment information and worker training. Such a review ensures that any changes, modifications or expansions to an electrical distribution system meet the latest arc flash requirements. Professional arc flash solutions and reviews aid compliance while improving worker safety, reducing lost worker productivity, and ensuring optimum system performance and efficiency.

Conclusion

While utilities and industrial facilities with high-voltage equipment have always been strongly encouraged to comply with industry standards for protecting workers from arc flash hazards, the new updates to OSHA 1910.269 represent the first time OSHA has mandated and is enforcing compliance with specific arc flash related requirements.

Due to the short timeframe within which electric power generation, transmission and distribution facilities have to comply with the new standards, facilities may want to consider partnering with qualified electrical engineering service providers who are familiar with industry standards and recommended practices. This will allow a facility to implement appropriate arc flash protection measures—including worker training, minimum approach distances, and PPE programs—that can ensure compliance with the new OSHA requirements while preventing the devastating and potentially deadly effects of arc flash incidents.

