Electrical Safety Guide

Helping Employers Protect Workers from Arc Flash and other Electrical Hazards
Why an Effective Safety Program is Essential

The Hazards are Real

Electrical Shocks

National Safety Council statistics show that electrical injuries still occur in U.S. industry with alarming frequency:

▼ 30,000 non-fatal electrical shock accidents occur each year
▼ 1,000 fatalities due to electrocution occur each year

Recent studies also indicate that more than half of all fatal electrocutions occurred during routine construction, maintenance, cleaning, inspection, or painting activities at industrial facilities.

Although electrical shock accidents are frequent and electrocutions are the fourth leading cause of industrial fatalities, few are aware of how little current is actually required to cause severe injury or death. In this regard, even the current required to light just a 7 1/2 watt, 120 volt lamp is enough to cause a fatality – if it passes across a person’s chest.

Arc Flash and Arc Blasts

The arc flash and arc blasts that occur when short circuit currents flow through the air are violent and deadly events.

▼ Temperatures shoot up dramatically, reaching up to 35,000 degrees Fahrenheit and instantly vaporizing surrounding components.

▼ Ionized gases, molten metal from vaporized conductors and shrapnel from damaged equipment explode through the air under enormous pressure.

Anyone or anything in the path of an arc flash or arc blast is likely to be severely injured or damaged.

Statistics from the National Institute for Occupational Safety and Health indicate that five to 10 arc flash explosions occur in electrical equipment every day in the United States; these accidents send more than 2,000 workers to burn centers with severe injuries each year.²

²Capschell, Inc.

Consequences of an Arc Fault Event

- Copper vapor instantly expands to 67,000 times the volume of copper
- Blinding light causes vision damage
- Expelled shrapnel causes physical trauma
- Thermoacoustic shock waves cause ruptured ear drums, collapsed lungs or other fatal injuries
- 35,000°F temperatures cause severe burns
It’s Your Responsibility and It’s the Law

As an official act of Congress, the Occupational Safety and Health Act of 1970 is the law. Section 5(a) mandates that each employer shall:

1. Furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious harm to his employees.

2. Comply with occupational safety and health standards promulgated under the act.

One of the key OSHA regulations that employers must comply with is 29 CFR 1910 ‘Occupational Safety & Health Standards.’ These standards establish the legal obligation requiring employers to proactively assess workplace hazards and take appropriate actions to advise and protect their employees from the hazards.

In situations where electrical injury has occurred, OSHA uses compliance with NFPA 70E as a key test in determining whether or not appropriate precautions have been taken. If they have not been, the employer may be subject to substantial fines and management personnel may be held criminally liable.

The Costs of Electrical Accidents can be Enormous

Injury Costs
When serious electrical accidents occur, the cost to a business often exceeds $1 million, and the cost to the injured person is immeasurable.

OSHA Citations
On average, OSHA issues 40,000 safety citations per year. Penalties for serious violations may be tens or even hundreds of thousands of dollars, depending upon the situation.

Lawsuits
In addition to the financial impacts of legal and settlement costs, the lost time and productivity disruptions caused by personal injury lawsuits can be a significant burden.
As the standard for electrical safety in the workplace, NFPA 70E addresses the safety-related work practices, maintenance requirements, and administrative controls necessary to protect employees from electrical energy hazards. It serves several important purposes:

- It is the primary resource and guide for employers to use in determining how to comply with OSHA’s electrical safety regulations.
- It is also used by OSHA and the courts in workplace injury investigations to assess whether or not the involved employers took reasonable and appropriate precautions to protect their employees.

Failure to comply with NFPA 70E may prove very expensive if injury occurs.

### Key Elements of the Standard

The NFPA 70E standard was developed in the U.S., but has been largely adopted in Canada’s CSA Z462 ‘Workplace Electrical Safety’ standard and is also increasingly recognized and used in Mexico, so the key elements summarized below will generally apply in all three countries. Consult the standards for complete details.

### Article 110 – General Requirements for Electrical Safety–Related Work Practices

#### Electrical Safety Program

Employers are required to maintain a documented electrical safety program to direct employee activities in a manner appropriate for the different voltage, energy level, and circuit conditions that may be encountered. The program must address inspections, maintenance conditions, employee awareness, electrical safety procedures, risk assessment and control, job planning and communication, incident investigations, audits, and lockout/tagout.

Risk control methods are to be implemented according to the following hierarchy, which clearly indicates that eliminating the potential hazard should be the first priority, while using PPE to protect against it as the last line of defense.


If work on or near energized electrical conductors and circuit parts operating at 50V or more is required, the safety program must:

- Include procedures that define requirements and provide guidance for workers as they perform work on or near live parts.
- Identify the hazard/risk evaluation procedure to be used before work is started within the limited approach boundary of energized electrical conductors and circuit parts.
Include a job briefing process to inform employees of the hazards, proper procedures, special precautions, energy source controls, and PPE requirements.

Training Requirements

Employees who may be exposed to electrical hazards must be specifically trained to understand the hazards associated with electrical energy as well as the safety-related work practices and procedures required to provide protection from them. The level of training an employee receives determines the tasks he/she is qualified to perform.

Only ‘Qualified Persons’ may perform work on or near exposed and energized electrical conductors or circuit parts. The training requirements include:

- Recognizing the potential hazards that exist
- Distinguishing energized from non-energized parts
- Determining the voltage of exposed energized electrical conductors
- Understanding the relationship between the hazard and potential injury
- Hazard/risk assessment and control methods
- Selecting appropriate personal protective equipment
- Specific work practices and procedures to be followed
- Lockout/tagout procedures
- Emergency procedures for assisting victims of electrical incidents
- Determining approach and flash protection boundaries

Article 120– Establishing an Electrically Safe Work Condition

The most effective way to prevent electrical injury is to completely remove the source of electrical energy and eliminate the possibility of its reappearance. To do so, workers must identify and disconnect all possible sources of electricity and employ effective lockout/tagout procedures.

Process of Establishing and Verifying an Electrically Safe Work Condition

1. Identify and locate all possible sources of electric supply. Care should be taken to identify possible secondary sources.

2. Properly interrupt the load current(s) and open the disconnecting device(s). Not all disconnecting devices are rated to interrupt load currents; this should only be done with a properly rated device.

3. Verify deenergization through visual inspection of the disconnect contacts. Disconnecting means may sometimes fail to open all phase conductors when the handle is operated, so it is necessary to verify physical contact separation. If this requires removing the disconnect door or cover, appropriate PPE must be used.
(4) Release stored electrical energy.

(5) Release or block mechanical energy.

(6) Apply lockout/tagout devices. *This should be done in accordance with a formally established company policy.*

(7) Use an adequately rated portable test instrument to test each conductor to which the worker may be exposed in order to verify deenergization. *The voltage detecting device must be functionally tested both before and after taking the measurements in order to ensure that it is working satisfactorily.*

(8) Circuit parts with induced voltages or stored electrical energy must be grounded. *If the conductors being deenergized could contact other energized conductors or circuit parts, temporary grounding devices rated for the available fault duty should be applied.*

**Article 130 – Work Involving Electrical Hazards**

**Justification**

Deciding to work on or near energized electrical conductors and circuit parts should be a last resort in the workplace, after all other opportunities for establishing an electrically safe work condition have been exhausted. Work on energized parts at 50V or more should only be performed if the employer can demonstrate that deenergizing will introduce additional hazards or is not feasible due to equipment design or operational limitations.

**Work Permit**

When non-routine work must be performed on energized parts, a detailed work permit must be prepared before the work can start. The work permit must document the following elements and be approved by a responsible owner, manager, or safety officer:

- A description of the circuit and equipment to be worked on and its location
- A description of the work to be performed
- Justification for performing the work in an energized condition
- A description of the safe work practices to be employed
- Results of the shock risk assessment
- Determination of shock protection boundaries
- Results of the arc flash risk assessment
- The flash protection boundary
- The personal protective equipment required for worker safety
- Restricted access of unqualified persons from the work area
- Evidence that the job briefing has been completed
Shock Risk Assessment and Approach Boundaries

A shock risk assessment must be performed to determine the extent to which shock hazards exist and the associated required protective measures. Because personnel will approach energized electrical conductors or other live circuit parts, limited and restricted approach boundaries must be determined in order to identify safe approach distances and the precautions required to minimize the possibility of shock. These boundaries are described in the illustration in the left margin and can be determined from tables in the standard.

Arc Flash Risk Assessment

An arc flash risk assessment shall also be performed by a qualified person in order to determine the level of risk and any precautions that are required to protect personnel from the possibility of being injured by an arc flash. As part of this analysis, flash protection boundaries must be determined based on available bolted fault currents and the incident energy exposure level for personnel working within this boundary must be calculated.

Personal and Other Protective Equipment

Employees working in areas where electrical hazards are present must be qualified to perform the work and must be provided with, and use, protective equipment designed and constructed for the specific part of the body to be protected and for the work to be performed.

Personal Protective Equipment (PPE) requirements can be determined from tables in the standard, based either on the calculated incident energy level or on the PPE category assigned to the type and electrical energy characteristics of the equipment being worked on. Four categories of increasingly protective PPE are defined and specified for use with the various types of equipment.

Example: Selection of PPE using tables: (to check if a disconnect switch is deenergized)

1. Determine if Arc Flash PPE is required: 130.5 (C)

<table>
<thead>
<tr>
<th>Task</th>
<th>Arc Flash PPE Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening hinged door(s) or cover(s) (to expose bare energized electrical conductors and circuit parts)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

2. Determine Arc Flash PPE Category: 130.5 (C)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Arc Flash PPE Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panelboards or other equipment rated &gt;240V and up to 600V</td>
<td>2</td>
</tr>
</tbody>
</table>

3. Determine PPE Requirements: 130.5 (C)

<table>
<thead>
<tr>
<th>PPE Category</th>
<th>PPE (abridged)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Arc-rated (level 8) long sleeve shirt, pants, coverall, jacket, safety glasses, footwear</td>
</tr>
</tbody>
</table>

Connection and disconnection of a MELTRIC Switch-Rated plug and receptacle is a NFPA 70E defined ‘Normal Operation.’

Arc Flash PPE Required: No

NFPA 70E
Section 130.2 Electrically Safe Working Conditions
(A) Energized Work
4) Normal Operation

Normal operation of electric equipment shall be permitted where the equipment; is properly installed and maintained; used in accordance with manufacturer’s instructions; doors are closed and secured; covers are in place and secured; there is no evidence of impending failures.
Provide the Safety of a Switch with Every Plug and Receptacle

MELTRIC’s Switch-Rated plugs and receptacles combine the safety and functionality of a disconnect switch with the convenience of a plug and receptacle. They allow users to safely make and break connections under full load and provide significant protection in overload and short circuit conditions. They are UL and CSA rated for:

- Branch circuit disconnect switching, up to 200A
- Motor circuit disconnect switching, up to 100 hp
- Short circuit closing and withstand, up to 100kA in circuits protected with RK1 current limiting fuses

Prevent Unintended Exposure to Live Parts and Arcing

MELTRIC’s Switch-Rated plugs and receptacles provide the safety and security of true dead front construction.

- Load making and breaking is isolated in enclosed arc chambers.
- A safety shutter automatically closes and blocks access to the live contacts before the plug can be removed.

These features ensure that the plug contacts are deenergized before the plug is removed and they prevent unintended access to live parts and exposure to arcing during product operation.

Provide Consistently Reliable Connections

MELTRIC Switch-Rated plugs and receptacles use DECONTACTOR® technology similar to motor starters.

- Spring-loaded butt-style contacts ensure that optimal contact force is always maintained.
- Solid silver-nickel contact material resists wear, withstands arcing and corrosion, and maintains superior electrical performance.
- Spring-driven operating mechanisms ensure a quick and positive load-break and eject the plug to the OFF position.
MELTRIC DS and DSN series switch-rated plugs and receptacles are designed and rated to function as a switch. Users can safely make and break connections, even in overload conditions.

- Silver-nickel contacts resist wear and maintain superior conductivity even in wet and corrosive environments.
- Silver-nickel butt-style contacts withstand arcing and resist welding, allowing them to close into and withstand short circuit currents as high as 100kA.
- Enclosed arc chambers and dead front construction prevent exposure to arcing and eliminate unintended access to live parts.

Switch-rated plugs and receptacles from MELTRIC provide a secure and foolproof means of ensuring user safety without the need for interlocks and safety switches required with other types of plugs and receptacles. At no time is a user exposed to live contacts while connecting or disconnecting.

Standard pin and sleeve and twist type plugs and receptacles are not intended to be disconnected or connected under load. Doing so can be very hazardous.

- The electrical properties of their brass contacts degrade significantly from oxidation and wear occurring with normal use.
- Because brass cannot withstand arcing, the contacts may vaporize and cause an arc flash if connected or disconnected in overload conditions.
- Live front designs expose users to live parts and also to the arcing or arc blasts that may result from their use in adverse conditions.

Because nothing prevents these devices from being connected and disconnected under load in many applications, users are often exposed to these hazards. When interlocks are provided, their function is often defeated by the use of extension cords.
Simplify NFPA 70E® Compliance with MELTRIC’s Switch-Rated Plugs and Receptacles featuring DECONTACTOR® Technology

MELTRIC’s Switch-Rated plugs and receptacles simplify compliance with NFPA 70E by eliminating the possibility of exposure to energized parts and arcing when making and breaking the electrical connections required to changeout motors and other equipment. This avoids the need to take many of the special precautions required to ensure that workers are aware of and protected from the shock and arc-flash hazards that exist whenever work is performed on or around energized circuit components.

Switch Ratings Simplify Deenergization

With push button load-breaking, UL and CSA switch ratings for applications up to 200A and short circuit closing and withstand ratings up to 100kA (in circuits protected with RK1 current limiting fuses), switch-rated plugs and receptacles provide a safe, simple, and convenient means of disconnecting the load. There is no need for the interlocks and auxiliary disconnects required with standard plugs and receptacles.

Plug Removal Verifies Deenergization

Removing the plug from the receptacle provides visual verification of contact separation and deenergization. This avoids the need for the voltage testing required with many other disconnect switches that often involves energized electrical work and associated safety precautions.

Dead Front Construction Ensures a Safe Work Condition

The DECONTACTOR® technology ensures that load making and breaking is isolated in enclosed arc chambers and that a safety shutter closes over the live receptacle contacts before the plug can be removed. This prevents user exposure to live parts and arcing, and ensures that a safe work condition is maintained. There is no need to perform a hazard analysis, obtain work permits, use cumbersome PPE, or take the other precautions required when working on or near live parts.

Specialized Electrical Personnel may not be Required on Site

Because there is no electrical work to be performed and no concern about access to live parts when making and breaking connections with switch-rated plugs and receptacles, mechanics can quickly changeout motors with pre-wired replacements.

No Hazard/No PPE Required

Making and breaking electrical connections with MELTRIC’s Switch-Rated plugs and receptacles meet NFPA 70E’s ‘Normal Operation’ definition, so no special personal protective equipment is required. There is no need to ‘suit-up’ with cumbersome PPE.
Motor Change-Out Process Comparison

**MELTRIC Switch-Rated Plug and Receptacle**

1. Switch receptacle to ‘off’ position
2. Remove plug from receptacle
3. Apply lockout/tagout
4. Remove old/install new motor
5. Remove lockout/tagout
6. Insert plug into receptacle

- Changeout downtime is reduced by up to 50%.
- Equipment and installation costs are reduced by eliminating the need for interlocks and safety switches.
- Maintenance efficiency is improved by allowing mechanics to perform changeouts. Pre-wiring can be done at a convenient time in the electrical shop and can help ensure proper motor rotation.

**Typical Disconnect Switch**

1. Switch disconnect to ‘off’ position
2. Apply lockout/tagout
3. Perform Shock/Arc Flash Risk Assessment
4. Obtain permit for energized electrical work
5. Suit up with appropriate PPE
6. Remove the disconnect switch cover
7. Voltage test to verify deenergization
8. Disconnect motor from hard-wiring
9. Remove old/install new motor
10. Connect new motor to hard wiring
11. Remove lockout/tagout
12. Turn disconnect to the ‘ON’ position
13. Remove and store PPE

After operating the disconnect switch, a worker still needs to verify deenergization. Exposure to live parts is inevitable, so PPE is required.

MELTRIC receptacles can be added to existing disconnects to avoid PPE requirements for voltage testing.
Use MELTRIC Switch-Rated Plugs and Receptacles

<table>
<thead>
<tr>
<th>20-150A</th>
<th>20-200A</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSN</td>
<td>DS</td>
</tr>
<tr>
<td>Up to 75 hp</td>
<td>Up to 100 hp</td>
</tr>
</tbody>
</table>

- Compact, lightweight design
- Type 4X, IP69/1P69K
- Up to 6 auxiliary contacts
- Polyester or metal casings
- 100kA* short circuit rated

- Rugged construction
- Type 3R (4X optional)
- Up to 6 auxiliary contacts
- Polyester or metal casings
- Short circuit rated up to 100kA

UL and CSA Listed:
- UL 1682
- UL 2682
- CSA C22.2 No. 182.1

UL and CSA Switch-Rated per UL 2682 and Listed for:
- Motor Circuit Disconnect Switching
- Branch Circuit Disconnect Switching

Short Circuit Rated
- Up to 100kA closing and withstand with RK1 current limiting fuses

Easily update existing equipment with standard MELTRIC adapter plates

Contact MELTRIC or your MELTRIC sales representative for more information about switch-rated plugs and receptacles.