



RESA
POWER™

Arc Flash Hazard Risk Assessment



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Arc Flash Overview

An Arc Flash is an electrical explosion due to a fault condition or short circuit when either a phase to ground or phase to phase conductor is connected and current flows through the air.

Arc Flashes cause electrical equipment to explode, resulting in an arc-plasma fireball. Temperatures may exceed 35,000° F (the surface of the sun is 9,000° F). These high temperatures cause rapid heating of surrounding air and extreme pressures, resulting in an arc blast. The Arc Flash / Blast will likely vaporize all solid copper conductors which will expand up to 67,000 times its original volume when it is vaporized. The Arc Flash / Blast produces fire, intense light, pressure waves and flying shrapnel.

When an Arc Flash happens, it does so without warning and is lightning quick. The result of this violent event is usually destruction of the equipment involved, fire, and severe injury or death to any nearby people. Proper safety and protection measures must be taken to limit the damage from an Arc Flash, which include; conducting an Arc Flash Incident Energy Analysis, Short Circuit Study, Protective Device Coordination Study, Equipment Maintenance, and NFPA 70E required Electrical Safety Training.

Why an Arc Flash Happens

There are a variety of reasons why an Arc Flash can occur, but most of them are human error and preventable. Many Arc Flashes happen when maintenance workers are manipulating live equipment for testing or repair and accidentally cause a fault or short circuit. Improper tools, improper electrical equipment, corrosion of equipment, improper work techniques and lack of electrical safety training are just some of the events that can lead to a devastating Arc Flash or Arc Blast.

Arc faults are generally limited to systems where the bus voltage is in excess of 120 Volts. Lower voltage levels normally will not sustain an arc. An arc fault is similar to the arc obtained during electric welding and the fault has to be manually started by something creating the path of conduction or a failure such as a breakdown in insulation

The arc fault current is usually much less than the available bolted fault current and below the rating of circuit breakers. Unless these devices have been selected to handle the arc fault condition, they will not trip and the full force of an Arc Flash will occur. The electrical equation for energy is volts x current x time. The transition from arc fault to Arc Flash takes a finite time, increasing in intensity as the pressure wave develops. The challenge is to sense the arc fault current and shut off the voltage in a timely manner before it develops into a serious Arc Flash condition.

Arc Flash Compliance

OSHA mandates that employers identify electrical hazards, warn employees about the hazards and provide them proper protection and training regarding the hazards. Compliance with OSHA is mandatory for all US companies. While OSHA tells you "what to do" for Arc Flash, they don't tell you "how to do it". The role of NFPA 70E, IEEE 1584 and NFPA 70 (NEC) is to provide guidance on "how" to properly implement the OSHA regulations.

The regulations that govern Arc Flash are:

1. OSHA Standards 29-CFR, Part 1910. Occupational Safety and Health Standards. 1910 sub part S (electrical) Standard number 1910.333 specifically addresses Standards for Work Practices and references NFPA 70E. OSHA 29CFR 1910.335 (a) (1)(i) requires the use of protective equipment when working where a potential electrical hazard exists and 29CFR 1910.132(d)(1) which requires the employer assess the workplace for hazards and the need for personal protective equipment.
2. NFPA 70E provides guidance on implementing appropriate work practices that are required to safeguard workers from injury while working on or near exposed electrical conductors or circuit parts that could become energized. Article 130.5 Arc Flash Risk Assessment – requires an Arc Flash Risk Assessment be performed to determine if an Arc Flash Hazard exists, determine the level of Personal Protection Equipment (PPE) that a worker must use, determine the Arc Flash Boundary, and determine the appropriate safety-related work practices required. Each panel must be marked with an ANSI z535 approved Arc Flash Hazard Warning Label.
3. The National Fire Protection Association (NFPA) Standard 70 - “The National Electrical Code” (NEC) contains requirements for warning labels, including ANSI compliance.
4. The Institute of Electronics and Electrical Engineers (IEEE) 1584 – Provides the Guide to Performing Arc Flash Hazard Study Calculations.

Arc Flash Risk Assessment / Incident Energy Analysis

An Arc Flash Risk Assessment / Incident Energy Analysis is a calculation performed by a Licensed Professional Engineer to determine the incident energy found at each location which determines the Arc Flash Boundaries and what Personal Protective Equipment (PPE) must be used by the employee. As part of the study, the engineer should also provide recommendations to reduce the incident energy exposure. An Arc Flash Risk Assessment / Incident Energy Analysis should only be performed by experienced and qualified licensed electrical engineers familiar with power quality, short circuit studies, NFPA 70E, and IEEE 1584.

What are the Qualifications to Conduct Arc Flash Studies?

Let's begin with state law. The practice of engineering is governed and regulated in all 50 states and the District of Columbia. The language and specifics are somewhat different depending on state law and board rules. It is unlawful to practice engineering or use the title of "Engineer" unless an individual is authorized by the state board that governs the practice. In most states it is also unlawful to practice engineering unless the "firm" offering these engineering services is also registered with the state Engineering Licensing Board.

The "practice of engineering" is defined differently among states. In most states any engineering analysis (*...In order to safeguard life, health, and property, and to promote the public welfare, any person in either public or private capacity practicing, or offering to practice, ..., professional engineering, ...either as an individual, a copartner, or as agent of another, shall be licensed.*) must be performed by a Licensed Professional Engineer (PE). Arc Flash Hazard Analysis, Fault Current Calculations, and Protective Device Coordination Studies are clearly engineering analysis by any recognized standard or rule. It is also required by most states that the PE be a full-time employee and Principal of the firm to be recognized as the "responsible engineer in charge."

It is not adequate for an engineer to only to be licensed in their state of residence. A Professional Engineering License must be active in each state where a facility is located having an engineering study or Arc Flash Hazard Risk Assessment performed.

Customers seeking an Arc Flash Hazard Analysis need to ensure the engineering services offered will be performed by a Licensed Professional Engineer and that the engineering firm is registered in the state where services are provided. Anyone offering engineering services without proper licensing is violating engineering ethics and may be in violation of state law, subject to fines and discipline by the state licensing board.

State professional licensing boards license individuals, not companies. Most states require companies offering engineering services to have: 1) Individual(s) licensed as Professional Engineer(s) in each state work is offered, or performed. And, 2) The Company offering or performing engineering services must be registered with the state engineering board.

RESA Power (or DYMAX Services) currently has full-time individuals holding active engineering licenses in the following (27) states (additional states will be added as needed):

Alabama, California, Colorado, Connecticut, Florida, Illinois, Iowa, Indiana, Kentucky, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Texas, Washington, West Virginia, Wisconsin.

Arc Flash Labeling

The NEC® and NFPA 70E require labeling of equipment to warn of potential Arc Flash Hazards. Each panel must be marked with an ANSI approved Arc Flash Hazard Warning Label to warn and instruct workers of the Arc Flash Hazard containing the following information:

- (1) Nominal System Voltage
- (2) Arc Flash Boundary
- (3) At least one of the following:
 - a. Available incident energy and corresponding working distance, OR
 - b. The Arc Flash PPE category in Table 130.7(C)(15)(A)(b) or Table 130.7(C)(15)(B) for the equipment, but not both.
 - c. Minimum arc rating of clothing
 - d. Site-specific level of PPE

Note: Where a review of the Arc Flash Hazard Assessment identifies a change that renders the label inaccurate, the label shall be updated.

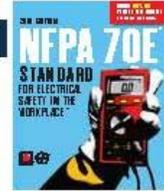
Examples of ANSI Z545 Compliant Arc Flash labels

 <h1 style="margin: 0;">DANGER</h1>	 <h1 style="margin: 0;">WARNING</h1>
Arc Flash and Shock Hazard Appropriate PPE Required When Energized Parts Are Exposed	Arc Flash and Shock Hazard Appropriate PPE Required When Energized Parts Are Exposed
FLASH PROTECTION Arc Flash Hazard: 117 cal/cm² Arc Flash Hazard at: 18 in Arc Flash Boundary: 294 in Incident Energy Exposure: greater than 12 cal/cm² <small>See Annex H.3(b) of NFPA-70E for required Protective Clothing (PPE).</small> Loc: MSB-MAIN	SHOCK PROTECTION Nominal Voltage: 480 VAC Limited Approach: 42 in Restricted Approach: 12 in Glove Class: 00 Available SC Current: 30.17 kA  <small>April 11, 2016 Proj. #55849</small>
FLASH PROTECTION Arc Flash Hazard: 0.11 cal/cm² Arc Flash Hazard at: 18 in Arc Flash Boundary: 4 in Incident Energy Exposure: 1.2 cal/cm² or less <small>See Annex H.3(b) of NFPA-70E for required Protective Clothing (PPE).</small> Loc: 2A	SHOCK PROTECTION Nominal Voltage: 208 VAC Limited Approach: 42 in Restricted Approach: No Contact Glove Class: 00 Available SC Current: 3.02 kA  <small>April 11, 2016 Proj. #55849</small>

 <h1 style="margin: 0;">WARNING</h1>	 <h1 style="margin: 0;">WARNING</h1>
Arc Flash and Shock Hazard Appropriate PPE Required When Energized Parts Are Exposed	Arc Flash and Shock Hazard Appropriate PPE Required When Energized Parts Are Exposed
FLASH PROTECTION Arc Flash Hazard: 11 cal/cm² Arc Flash Hazard at: 18 in Arc Flash Boundary: 71 in Incident Energy Exposure: greater than 1.2 to 12 cal/cm² <small>See Annex H.3(b) of NFPA-70E for required Protective Clothing (PPE).</small> Loc: RTU MEDIA CTR	SHOCK PROTECTION Nominal Voltage: 208 VAC Limited Approach: 42 in Restricted Approach: No Contact Glove Class: 00 Available SC Current: 3.19 kA  <small>April 11, 2016 Proj. #55849</small>
FLASH PROTECTION Arc Flash Hazard: 28 cal/cm² Arc Flash Hazard at: 18 in Arc Flash Boundary: 123 in Incident Energy Exposure: greater than 12 cal/cm² <small>See Annex H.3(b) of NFPA-70E for required Protective Clothing (PPE).</small> Loc: DP-2	SHOCK PROTECTION Nominal Voltage: 208 VAC Limited Approach: 42 in Restricted Approach: No Contact Glove Class: 00 Available SC Current: 10.46 kA  <small>April 11, 2016 Proj. #55849</small>



**GUIDANCE ON SELECTION OF
 ARC-RATED CLOTHING AND OTHER PPE**
 FOR USE WHEN INCIDENT ENERGY EXPOSURE IS DETERMINED



INCIDENT ENERGY EXPOSURE	PROTECTIVE CLOTHING AND PPE
<p>≤ 1.2 to 12 cal/cm²</p> <p>Protective clothing, non-melting (in accordance with ASTM F 1506) or untreated natural fiber</p>	<p>Shirt (long sleeve) and pants (long) or coverall</p>
<p>Other PPE</p>	<p>Face shield for projectile protection (AN) Safety glasses or safety goggles (SR) Hearing protection Heavy-duty leather gloves or rubber insulating gloves with leather protectors (AN)</p>
<p>≥ 1.2 to 12 cal/cm²</p> <p>Arc-rated clothing and equipment with an arc rating equal to or greater than the determined incident energy (See Note 3.)</p>	<p>Arc-rated long-sleeve shirt and arc-rated pants or arc-rated coverall or arc flash suit (SR) (See Note 3.) Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR) (See Note 1.) Arc-rated jacket, parka, or rainwear (AN)</p>
<p>Other PPE</p>	<p>Hard hat Arc-rated hard hat liner (AN) Safety glasses or safety goggles (SR) Hearing protection Heavy-duty leather gloves or rubber insulating gloves with leather protectors (SR) (See Note 4.) Leather footwear</p>
<p>> 12 cal/cm²</p> <p>Arc-rated clothing and equipment with an arc-rating equal to or greater than the determined incident energy (See Note 3.)</p>	<p>Arc-rated long-sleeve shirt and arc-rated pants or arc-rated coverall and/or arc flash suit (SR) Arc-rated arc flash suit hood Arc-rated gloves Arc-rated jacket, parka, or rainwear (AN) Hard hat</p>
<p>Other PPE</p>	<p>Arc-rated hard hat liner (AN) Safety glasses or safety goggles (SR) Hearing protection Arc-rated gloves or rubber insulating gloves with leather protectors (SR) (See Note 4.) Leather footwear</p>

AN: As Needed [in addition to the protective clothing and PPE required by 1305(C)(1)]. SR: Selection of one in group is required by 1305(C)(1).
 NOTE 1: Face shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 1307(C)(10)(c). For full head and neck protection, use a balaclava or an arc flash hood.
 NOTE 2: All items not designated "AN" are required by 1307(C).
 NOTE 3: Arc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system consisting of a combination of arc-rated shirt and pants, coverall, and arc flash suit.
 NOTE 4: Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.

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Arc Flash Awareness / Electrical Safety Training

Arc Flash Hazard & Electrical Safety Training are based on requirements by OSHA and NFPA 70E standards for worker protection. In addition to required core Electrical Safety Training and emergency response training, the required employee Arc Flash Training teaches *qualified* and *unqualified* persons subject to Arc Flash Hazards how to recognize the hazards, avoid accidents, read the Arc Flash Hazard Labels and to use and care for Personal Protective Equipment and other protection devices. There are also requirements for maintaining training documentation.

Although the NFPA standard only mentions employees as needing training, Arc Flash Safety Training should be provided to anyone else who may be exposed to an Arc Flash Hazard, including vendors, contractors, or anyone else who may come in contact or close proximity to potentially hazardous electrical equipment.

Electrical Safety Awareness Training delivered by RESA Power (DYMAX Service) professionals can make your facility a safer place to work. DYMAX training helps ensure that you meet the 2015 NFPA 70E® Standard for Electrical Safety in the Workplace, including the requirements that employees are retrained every three years and that employers provide confirmation of this training. We deliver training that improves employees' electrical safety awareness and practices. All of our training content is augmented by our trainers' years of real-world field experience.

Our classes are designed to give your qualified employees the knowledge they need about the latest changes to safe work practices and other tasks related to prevention of Arc Flash Hazards and mitigation of Arc Flash Incidents, including:

- Release of victims from exposed energized equipment
- Working within the Arc Flash Boundary and Limited Approach Boundary
- Audits of Electrical Safety Programs and implementation of corrective measures
- Determining Arc Flash Analysis needs for three-phase systems
- Employee responsibility for Personal Protective Equipment (PPE)
- Equipment labeling requirements

Our updated training covers all of the critical elements of the Standards, including sections 110, 130 and 340. RESA Power (DYMAX Service) Electrical Safety Training helps you to use and understand NFPA 70E, 2015 edition and its relation to the NEC section 110.16 and OSHA section 1910.269 (iii) (2) Training (ii) Qualified employees (C) & (D).

Process For Completing Arc Flash Hazard Analysis

Step 1: Data Collection -

Qualified RESA personnel conduct a site survey to gather data from all applicable electrical equipment including:

- a. Utility Source; transformer size, impedance, voltages, utility available short circuit.
- b. All Fuses and Circuit Breakers; manufacturer, model, type, size, settings.
- c. Cables; size, length, conductor material, conduit type.
- d. Motors; horsepower rating.
- e. Transformers; pri/sec voltage, impedance, size, configuration.

Step 2: Power Systems Modeling -

Site specific information is developed into ‘active’ one-line diagrams using digital computer software. These detailed models will be used for all analysis and calculations.

Step 3: Short Circuit Analysis -

Is required to determine the magnitude of current flowing throughout the power system at critical points at various time intervals after a ‘fault’ occurs. These calculations are used to determine the bolted fault current, which is essential for the calculation of incident energy and interrupting ratings of equipment. Comparison of equipment ratings with calculated available fault current and operating conditions will identify underrated equipment. We conduct these calculations in accordance with ANSI Std. C37 and IEEE Std. 141-1993 (Red Book)

Step 4: Protective Device Coordination -

Is performed to ensure selection and arrangement of protective devices limits the effects of an over-current situation to the smallest area. We perform this study in accordance with IEEE Std. 242-2001 (Buff Book)

Step 5: Arc Flash Calculations -

Are based on available short circuit current, protective device clearing time and distance from the arc. Calculations of incident energy levels and flash protection boundaries are completed for all relevant equipment locations. The magnitude of arc hazards are determined using the ‘Incident Energy Analysis Method’, per NFPA 70E-2015, IEEE Std. 1584 or NESC Tables.

Step 6: Reporting -

Upon completion of the calculations we prepare an Arc Flash Hazard Analysis Report and full size one-line drawings. The report will be certified by our Licensed Engineer (PE).

Step 7: Label Installation -

Arc Flash Warning Labels are generated and installed by RESA personnel. Labels are compliant with NFPA 70E, NFPA 70 (NEC), and ANSI Z535.

NETA Power System Engineering Studies

Arc-Flash Hazard Analysis Studies... *(Requires PE Certification)*

calculate arc-flash incident energy levels and flash protection boundary distances based on the results of the short-circuit and coordination studies. The magnitude of arc hazards are determined using the 'Incident Energy Analysis Method', per NFPA 70E-2015, IEEE Std. 1584 or NESC Tables.

Short Circuit (Available Fault Current) Studies... *(Requires PE Certification)*

calculate the magnitude of current flowing throughout the power system at critical points at various time intervals after a 'fault' occurs. These calculations are used to determine the bolted fault current, which is essential for the calculation of incident energy and interrupting ratings of equipment. Comparison of equipment ratings with calculated available fault current and operating conditions will identify underrated equipment. We conduct these calculations in accordance with ANSI Std. C37 and IEEE Std. 141-1993 (Red Book)

Protective Device Coordination Studies... *(Requires PE Certification)*

determine selection, arrangement, and setting of protective devices to limit the effects of an over-current situation to the smallest area. We perform this study in accordance with IEEE Std. 242-2001 (Buff Book)

Load-Flow Studies...

determine active and reactive power, voltage, current, and power factor throughout the electrical system. Provides an analysis of all possible operating scenarios which will be or have been influenced by the proposed or completed additions or changes to the system

Power Quality Studies...

determine the fitness of electric power to consumer devices. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all.

Infrared Electrical Inspections...

find hot spots caused by defects in connections and components. Infrared thermography is used to find areas of excess heat (caused by increased resistance) so that problems can be corrected before a component fails, causing damage to the component, creating safety hazards and productivity loss.



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Engineering Studies

Proposals – Quotes – Questions

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Arc Flash & Safety Checklist

Description	Yes	No	Not Sure
All persons who operate/maintain energized electrical equipment are trained for the voltage-class equipment they operate/maintain.			
All persons who operate/maintain energized electrical equipment have been trained on both shock and arc flash hazards.			
All persons who operate/maintain energized electrical equipment have access to the proper personal protective equipment (PPE) to protect them from both the shock and arc flash hazards.			
One-line drawings exist, including current protective device settings, and is legible and accurate.			
All persons who operate the power system have access to the current one-line drawings.			
Equipment is labeled correctly and in accordance with existing safe work practices, codes, and standards.			
De-energized procedures and equipment exist and are used.			
Written safety procedures and energized work permitting processes exist and are followed.			
Equipment is grounded and ground system is tested periodically.			
Proper maintenance practices are followed, especially for fault protection equipment.			
Recent (less than five years old) relay/fuse coordination study exists, and relays are calibrated to the settings recommended.			
Arc Flash Analysis has been performed for this site (calculations, labeling, and arc flash boundaries).			

Complete this checklist for a high-level assessment of your risk. If you answer no or not sure to any of the questions, you need to address your arc flash safety program immediately. Your business may be non-compliant with industry safety standards and at risk for an arc flash incident.

RESA Power Representative: _____

