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APPENDIX IX

Specific Arc Flash Procedures

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IX. Specific Arc Flash Procedures

TEAMWORKnet, Inc. has carefully reviewed the potentially Arc Flash hazardous working areas at the Project Site. The Model Arc Flash Study is designed to insure compliance with NFPA, NEC and OSHA safety standards and to better protect field personnel. Arc Flash provides the latest calculation procedures for determining potentially hazardous working areas and for applying proper flame resistant clothing requirements.

A. Arc Flash Study Procedures

Model Arc Flash calculations are based on the IEEE 1584 "Standard for Electrical Safety Requirements for Employee Workplaces", IEEE papers on Arc Flash and applicable ANSI Standards. These calculations provide specific incident energies and arc flash boundaries for each protective equipment area at the studied facility. IEEE 1584 is used as a basis for evaluating and providing electrical safety in the workplace and is compatible with Occupational Safety and Health Administration (OSHA), Code 29 and the National Electrical Code requirements. Model Arc Flash also provides its own proprietary algorithm. This algorithm adds needed conservatism for some data ranges and better accuracy over a wider degree of voltage ranges than found in NFPA 70E.

The Arc Flash Study determines the Limited, Prohibited and Restricted Approach Boundaries (distance from live parts). These minimum approach boundaries safeguard workers from the dangers of fire, shock, arc flash and arc blast. Additionally, this study states the necessary Personal Protective Equipment (PPE) qualified and unqualified personnel must wear when working within the approach boundaries.

B. Qualified & Unqualified Personnel

1. Employee Training

A qualified person(s) shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others. Such persons permitted to work within limited approach of exposed energized conductors and circuit parts shall, at a minimum, be additionally trained in all of the following:

- a) The skills and techniques necessary to distinguish exposed energized parts from other parts of electric equipment.
- b) The skills and techniques necessary to determine the nominal voltage of exposed energized parts.
- c) The approach distances specified and the corresponding voltages to which the qualified person(s) will be exposed.
- d) The decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely.

NOTE: 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(s) shall be considered to be a qualified person(s) for the performance of those duties

2. Unqualified Persons(s)

An unqualified person(s) is a person who is not a qualified person(s). Unqualified person(s) shall be trained in and be familiar with any of the electrical safety-related practices that might not be addressed specifically, but are necessary for their safety. Unqualified person(s) are safe when they maintain a distance from the exposed energized conductors or circuit parts, including the longest conductive object being handled, so that they cannot contact or enter a specified air insulation distance to the exposed energized electrical conductors or circuit parts. This safe approach distance is the limited approach boundary. Further, an unqualified person(s) must not cross the flash protection boundary unless they are wearing appropriate personal protective clothing and are under the close supervision of a qualified person(s).

Where an unqualified person(s) is (are) working at or close to the limited approach boundary, the designated person in charge of the work space where the electrical hazard exists shall cooperate with the designated person in charge of the unqualified person(s) to ensure that all work can be done safely. This shall include advising the unqualified person(s) of the electrical hazard and warning him or her to stay outside of the limited approach boundary.

3. Qualified Persons(s)

No qualified person(s) shall approach or take any conductive object closer to live parts than the Restricted Approach boundary unless:

- a) The qualified person(s) is insulated or guarded from the live parts (insulating gloves or insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is being performed) and no un-insulated part of the qualified person's body enters the prohibited space.
- b) The live part is insulated from the qualified person(s) and from any other conductive object at a different potential, or
- c) The qualified person(s) is insulated from any other conductive object as during live-line bare-hand work.

C. Limited Approach Boundary & Live Parts

1. Limited Approach Boundaries

A shock protection boundary to be crossed by only qualified persons (at a distance from a live part), which is not to be crossed by unqualified persons unless escorted by a qualified person(s).

2. Live Parts

Electric conductors, buses, terminals, or components that are un-insulated or exposed and a shock hazard exists.

D. Prohibited & Restricted Approach Boundaries

1. Prohibited Approach Boundary

A shock protection boundary to be crossed by only qualified person(s) (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.

2. Restricted Approach Boundary

A shock protection boundary to be crossed by only qualified person(s) (at a distance from a live part) who, due to its proximity to a shock hazard, require the use of shock protection techniques and equipment when crossed.

Approach Boundaries to Live Parts for Shock Protection

Table 130.2(C) Approach Boundaries to Energized Electrical Conductors or Circuit Parts for Shock Protection

(All Dimensions are distance from energized electrical conductor or circuit part)

(1)	(2)	(3)	(4)	(5)
Nominal System Voltage Range, Phase to Phase ²	Limited Approach Boundary ¹		Restricted Approach Boundary ¹ ; Includes Inadvertent Movement Adder	Prohibited Approach Boundary ¹
	Exposed Movable Conductor ³	Exposed Fixed Circuit Part		
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 to 750	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1 ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5 ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	.990 m (3 ft 3 in.)	660 mm (2 ft 2 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	1.016 m (3 ft 4 in.)	838 mm (2 ft 9 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.168 m (3 ft 10 in.)	.965 m (3 ft 4 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.29 m (4 ft 3 in.)	1.14 m (3 ft 9 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.721 m (5 ft 8 in.)	1.57 m (5 ft 2 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.794 m (9 ft 2 in.)	2.641 m (8 ft 8 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.61 m (11 ft 10 in.)	3.45 m (11 ft 4 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.851 m (15 ft 11 in.)	4.7 m (15 ft 5 in.)
Note: For Arc Flash Protection Boundary, see 130.3(A). ¹ See definition in Article 100 and text in 130.2(D)(2) and Annex C for elaboration. ² For single-phase systems, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732. ³ A condition in which the distance between the conductor and a person is not under the control of the person. The term is normally applied to overhead line conductors supported by poles.				

E. Hazard Risk Category Classifications

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated and Insulating Hand Tools
Panelboards or Other Equipment Rated 240 V and Below — Note 1			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	0	N	N
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	0	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	1	Y	Y
Panelboards or Switchboards Rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) — Note 1			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	1	N	N
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	Y	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard	2*	Y	Y
600 V Class Motor Control Centers (MCCs) — Note 2 (except as indicated)			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	1	N	N
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	

CB or fused switch or starter operation with enclosure doors open	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	2*	Y	Y
Insertion or removal of individual starter "buckets" from MCC — Note 3	4	Y	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts) — Note 3	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts) — Note 3	1	N	N
Work on energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the motor control center	2*	Y	Y
600 V Class Switchgear (with power circuit breakers or fused switches) — Note 4			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	2	N	N
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	2	N	N
Other 600 V Class (277 V through 600 V, nominal) Equipment — Note 2			

(except as indicated)			
Lighting or small power transformers (600 V, maximum)			
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	2*	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
Revenue meters (kW-hour, at primary voltage and current) Insertion or removal	2*	Y	N
Cable trough or tray cover removal or installation	1	N	N
Miscellaneous equipment cover removal or installation	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
Insertion or removal of plug-in devices into or from busways	2*	Y	N
NEMA E2 (fused contactor) Motor Starters, 2.3 kV Through 7.2 kV			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
Contactor operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contactor operation with enclosure doors open	2*	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	3	Y	Y
Insertion or removal (racking) of starters from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	3	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N

Insertion or removal (racking) of starters from cubicles of arc-resistant construction, tested in accordance with IEEE C37.20.7, doors closed only	0	N	N
Metal Clad Switchgear, 1 kV Through 38 kV			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
CB operation with enclosure doors closed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB operation with enclosure doors open	4	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	2	Y	Y
Work on control circuits with energized electrical conductors and circuit parts >120 V, exposed	4	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	4	Y	N
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N
Opening voltage transformer or control power transformer compartments	4	N	N
Arc-Resistant Switchgear Type 1 or 2 (for clearing times of <0.5 sec with a perspective fault current not to exceed the arc resistant rating of the equipment)			
CB operation with enclosure door closed	0	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	0	N	N
Insertion or removal of CBs from cubicles with door open	4	N	N
Work on control circuits with energized electrical conductors and circuit parts 120 V or below, exposed	2	Y	Y
Insertion or removal (racking) of ground and test device with door closed	0	N	N
Insertion or removal (racking) of voltage transformers on or off the bus door closed	0	N	N
Other Equipment 1 kV Through 38 kV			
Metal-enclosed interrupter switchgear, fused or unfused			
Switch operation of arc-resistant-type construction, tested in accordance	0	N	N

with IEEE C37.20.7, doors closed only			
Switch operation, doors closed	2	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized electrical conductors and circuit parts)	4	N	N
Opening hinged covers (to expose bare, energized electrical conductors and circuit parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	2	Y	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

General Notes (applicable to the entire table):

- (a) Rubber insulating gloves are gloves rated for the maximum line-to-line voltage upon which work will be done.
- (b) Insulated and insulating hand tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done, and are manufactured and tested in accordance with ASTM F 1505, *Standard Specification for Insulated and Insulating Hand Tools*.
- (c) Y = yes (required), N = no (not required).
- (d) For systems rated less than 1000 volts, the fault currents and upstream protective device clearing times are based on an 18 in. working distance.
- (e) For systems rated 1 kV and greater, the Hazard/Risk Categories are based on a 36 in. working distance.
- (f) For equipment protected by upstream current limiting fuses with arcing fault current in their current limiting range (½ cycle fault clearing time or less), the hazard/risk category required may be reduced by one number.

Specific Notes (as referenced in the table):

- 1. Maximum of 25 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.
- 2. Maximum of 65 kA short circuit current available; maximum of 0.03 sec (2 cycle) fault clearing time.
- 3. Maximum of 42 kA short circuit current available; maximum of 0.33 sec (20 cycle) fault clearing time.
- 4. Maximum of 35 kA short circuit current available; maximum of up to 0.5 sec (30 cycle) fault clearing time.

F. Protective Clothing & PPE Matrix

Table 130.7(C)(10) Protective Clothing and Personal Protective Equipment (PPE)

Hazard/Risk Category	Protective Clothing and PPE
Hazard/Risk Category 0 Protective Clothing, Nonmelting (according to ASTM F 1506-00) or Untreated Natural Fiber FR Protective Equipment	Shirt (long sleeve) Pants (long) Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather gloves (AN) (Note 2)
Hazard/Risk Category 1 FR Clothing, Minimum Arc Rating of 4 (Note 1) FR Protective Equipment	Arc-rated long-sleeve shirt (Note 3) Arc-rated pants (Note 3) Arc-rated coverall (Note 4) Arc-rated face shield or arc flash suit hood (Note 7) Arc-rated jacket, parka, or rainwear (AN) Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather gloves (Note 2) Leather work shoes (AN)
Hazard/Risk Category 2 FR Clothing, Minimum Arc Rating of 8 (Note 1) FR Protective Equipment	Arc-rated long-sleeve shirt (Note 5) Arc-rated pants (Note 5) Arc-rated coverall (Note 6) Arc-rated face shield or arc flash suit hood (Note 7) Arc rated jacket, parka, or rainwear (AN) Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather gloves (Note 2) Leather work shoes
Hazard/Risk Category 2 * FR Clothing, Minimum Arc Rating of 8 (Note 1)	Arc-rated long-sleeve shirt (Note 5) Arc-rated pants (Note 5) Arc-rated coverall (Note 6) Arc-rated arc flash suit hood (Note 10) Arc-rated jacket, parka, or rainwear (AN)

FR Protective Equipment

Hard hat
Safety glasses or safety goggles (SR)
Hearing protection (ear canal inserts)
Leather gloves (Note 2)
Leather work shoes

Hazard/Risk Category 3

FR Clothing, Minimum Arc Rating of 25 (Note 1)

Arc-rated long-sleeve shirt (AR) (Note 8)
Arc-rated pants (AR) (Note 8)
Arc-rated coverall (AR) (Note 8)
Arc-rated arc flash suit jacket (AR) (Note 8)
Arc-rated arc flash suit pants (AR) (Note 8)
Arc-rated arc flash suit hood (Note 8)
Arc-rated jacket, parka, or rainwear (AN)

FR Protective Equipment

Hard hat
FR hard hat liner (AR)
Safety glasses or safety goggles (SR)
Hearing protection (ear canal inserts)
Arc-rated gloves (Note 2)
Leather work shoes

Hazard/Risk Category 4

FR Clothing, Minimum Arc Rating of 40 (Note 1)

Arc-rated long-sleeve shirt (AR) (Note 9)
Arc-rated pants (AR) (Note 9)
Arc-rated coverall (AR) (Note 9)
Arc-rated arc flash suit jacket (AR) (Note 9)
Arc-rated arc flash suit pants (AR) (Note 9)
Arc-rated arc flash suit hood (Note 9)
Arc-rated jacket, parka, or rainwear (AN)

FR Protective Equipment

Hard hat
FR hard hat liner (AR)
Safety glasses or safety goggles (SR)
Hearing protection (ear canal inserts)
Arc-rated gloves (Note 2)
Leather work shoes

AN = As needed (optional)

AR = As required

SR = Selection required

Notes:

1. See Table 130.7(C)(11). Arc rating for a garment or system of garments is expressed in cal/cm².
2. If rubber insulating gloves with leather protectors are required by Table 130.7(C)(9), additional leather or arc-rated gloves are not required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.
3. The FR shirt and pants used for Hazard/ Risk Category 1 shall have a minimum arc rating of 4.
4. Alternate is to use FR coveralls (minimum arc rating of 4) instead of FR shirt and FR pants.
5. FR shirt and FR pants used for Hazard/ Risk Category 2 shall have a minimum arc rating of 8.
6. Alternate is to use FR coveralls (minimum arc rating of 8) instead of FR shirt and FR pants.
7. A face shield with a minimum arc rating of 4 for Hazard/Risk Category 1 or a minimum arc rating of 8 for Hazard/Risk Category 2, with wrap-around guarding to protect not only the face, but also the forehead, ears, and neck (or, alternatively, an arc-rated arc flash suit hood), is required.
8. An alternate is to use a total FR clothing system and hood, which shall have a minimum arc rating of 25 for Hazard/Risk Category 3.
9. The total clothing system consisting of FR shirt and pants and/or FR coveralls and/or arc flash coat and pants and hood shall have a minimum arc rating of 40 for Hazard/Risk Category 4.
10. Alternate is to use a face shield with a minimum arc rating of 8 and a balaclava (sock hood) with a minimum arc rating of 8 and which covers the face, head and neck except for the eye and nose areas.

G. Arc Flash Labeling Practice

TEAMWORKnet arc flash labeling practice will be used for this job. Labels for each piece of equipment, or for each section of multi-section equipment, will consist of a Arc Flash Information label. The Arc Flash Information label is printed with values produced by the arc flash hazard analysis and is field installed.

The Arc Flash Information is printed on a two color vinyl label that is resistant to chemicals, water and UV light. Each label is approximately 4 inches in height and 6 inches in width. Each label works appropriately on surfaces up to 200 degree F. Each label will have an orange strip approximately 1 3/16 inch in height.

The following information is included on each label:

- a) "Arc Flash Information" banner on the top of the label
- b) Flash Protection Boundary in inches
- c) Incident Energy in cal/cm²
- d) Working Distance in inches
- e) PPE Category per NFPA 70E
- f) Shock hazard when cover is open
- g) Limited Approach in inches
- h) Restricted Approach in inches
- i) Prohibited Approach in inches

The standard Arc Flash Information label will report the maximum incident energy and flash protection boundary for each PPE category number and equipment type, unless voltage is greater than 15kV, or if incident energy is above 40 cal/cm². Generally no equipment name is printed on the label, unless the voltage is greater than 15kV, or if incident energy is greater than 40 cal/cm². This type of Arc Flash information label may reduce the need to replace arc flash labels due to changes in the electrical system that change the incident energy and flash protection boundary values but do not affect the PPE category at a given piece of equipment.