

Interpretation of the Electrical Safety Committee – September 2005

Operation of Circuit Breakers and Disconnect Switches Arc-Flash Hazard Analysis - Required PPE

No industry findings have yet been developed to provide an understanding of the ability of circuit breaker panels and disconnect switches to withstand and contain the forces of an arc-flash. Factors that would have to be considered in addition to the expected incident energy level include:

- material of construction
- the location, size and number of any vents
- age and condition of equipment
- volume of the enclosure

However, even without specific information it is reasonable to conclude that some level of containment would occur. It is also reasonable to conclude that if sufficient energy were available, the energy could cause sufficient deformation of the enclosure that the integrity enclosure could be compromised with subsequent release of that energy. Release of this energy could pose a hazard to nearby personnel.

Arc-flash protective equipment for Risk Hazard Category 0 or -1 operations such as operation of circuit breakers or fusible disconnect switches with covers on consists of eye protection and natural fiber clothing to ensure that only non-melting fibers are used on the torso. No hand protection is required even though the hands would be the closest point to any arc-flash. When calculating the arc-flash boundary, which then identifies the need for arc-flash PPE, the working distance is based on the distance from the live part to the face or chest areas, per NFPA 70E, 130.3 (B)

130.3 (B) Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis. *Where it has been determined that work will be performed within the Flash Protection Boundary by 130.3(A), the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Flame-resistant (FR) clothing and personal protective equipment (PPE) shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the distance at which the incident energy was determined*

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Further justifying the operation of circuit breakers or disconnect switches at 250 Volts or lower are the conclusions of the testing performed as part of the development of IEEE Standard 1584¹ was that arc-faults could not be easily sustained at 208Volts. The standard states:

While the accuracy of the model at 208 V is not in the same class with the accuracy at 250 V and higher, it will work and will yield conservative results. The arc-flash hazard need only be considered for large 208 V systems: systems fed by transformers smaller than 125 kVA should not be a concern.

Using BNL's SKM Electrical System Analysis Software it was determined that for electrical switches and panels connected to 30kVA or less transformers that no arc-flash hazard could exist outside the panel enclosure. Table 1 shows the arc-flash boundary at the panel to be 60", which considering a closed panel and only 5 cal/cm² of energy should not require any protection. Antidotal evidence suggests it takes 20 cal/cm² to violate a panel, however that may not be true for aged panels in less than optimum condition. Table 2, which reflects use of a 75 kVA transformer, indicates an arc-flash boundary of 90" with 10 cal/cm² of available energy. The committee does not recommend dropping the requirement to meet Hazard Cat 0 PPE requirements at this time but will further review this situation.

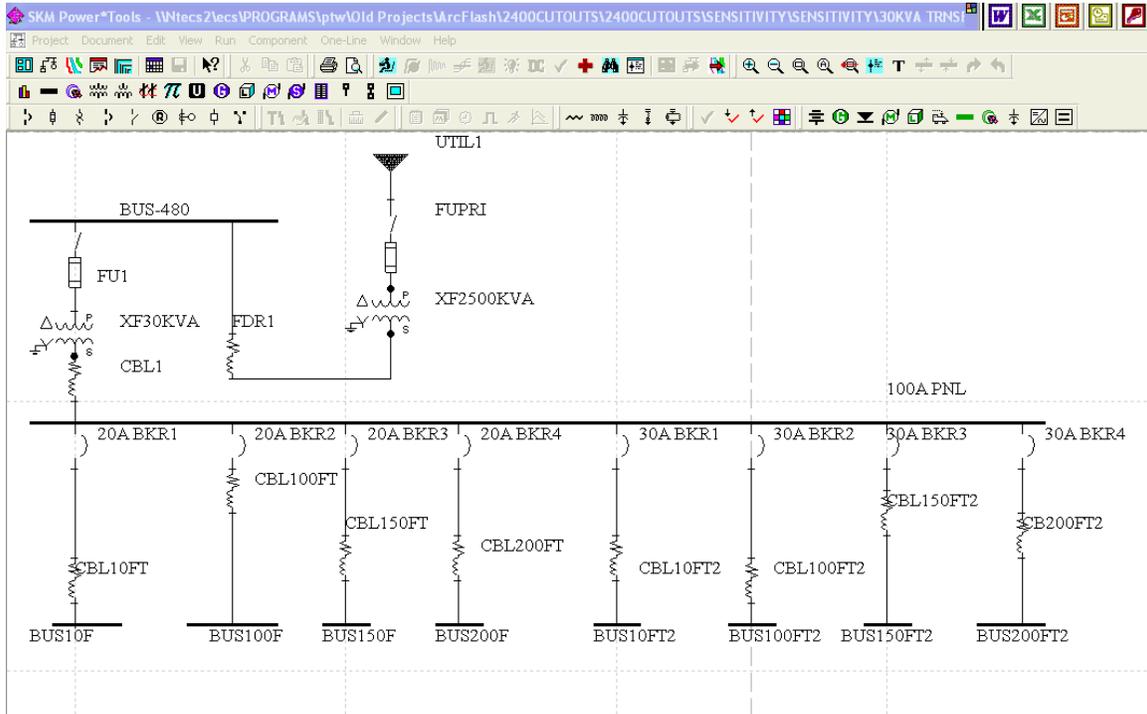
Conclusions:

Thus a worker operating a circuit breaker or disconnect switch with the cover closed is not within the arc-flash boundary. As the worker is not within the arc-flash boundary no PPE would be required by NFPA 70E. However, for electrical breaker panels, the LESC felt there would be a small possibility that if an arc-flash did occur within a panel that a projectile such as a small piece of plastic could be released with possible eye injury. Therefore, the LESC felt that eye protection should be worn for breaker operation.

¹ IEEE 1584-2002, "IEEE Guide for Performing Arc-Flash Calculations" Section 9.3, Page 25

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Figure 1 – One-Line Diagram of 30kVA example



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TABLE 1

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Class
100A PNL	MaxTripTime @2.0s	0.208	1.58			2	.000	No	PNL	25	60	24	5.38	Class 2 (*2)
BUS100F	20A BKR2	0.208	0.52	0.52	0.52	0.017	.000	Yes	PNL	25	1	18	0.00	Class 0 (*1)
BUS100FT2	30A BKR2	0.208	0.72	0.72	0.58	0.502	.000	Yes	PNL	25	14	18	0.77	Class 0 (*3)
BUS10F	20A BKR1	0.208	1.40	1.40	1.09	0.017	.000	Yes	PNL	25	3	18	0.05	Class 0
BUS10FT2	30A BKR1	0.208	1.46	1.46	0.96	0.187	.000	Yes	PNL	25	10	18	0.49	Class 0 (*3)
BUS150F	20A BKR3	0.208	0.37	0.37	0.37	0.019	.000	Yes	PNL	25	1	18	0.00	Class 0 (*1)
BUS150FT2	30A BKR3	0.208	0.54	0.54	0.54	0.587	.000	Yes	PNL	25	7	18	0.16	Class 0 (*1)
BUS200F	20A BKR4	0.208	0.29	0.29	0.29	0.025	.000	Yes	PNL	25	1	18	0.00	Class 0 (*1)
BUS200FT2	30A BKR4	0.208	0.43	0.43	0.43	0.94	.000	Yes	PNL	25	7	18	0.21	Class 0 (*1)

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TABLE 2

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Class
225A PNL	MaxTripTime @2.0s	0.208	3.84			2	.000	No	PNL	25	91	24	10.6	Class 3 (*2)
BUS100F	20A BKR2	0.208	0.60	0.60	0.60	0.017	.000	Yes	PNL	25	1	18	0.01	Class 0 (*1)
BUS100FT2	30A BKR2	0.208	0.90	0.90	0.68	0.367	.000	Yes	PNL	25	13	18	0.67	Class 0 (*3)
BUS10F	20A BKR1	0.208	2.86	2.86	1.81	0.017	.000	Yes	PNL	25	4	18	0.09	Class 0
BUS10FT2	30A BKR1	0.208	3.20	3.20	1.96	0.018	.000	Yes	PNL	25	4	18	0.10	Class 0
BUS150F	20A BKR3	0.208	0.41	0.41	0.41	0.018	.000	Yes	PNL	25	1	18	0.00	Class 0 (*1)
BUS150FT2	30A BKR3	0.208	0.63	0.63	0.63	0.433	.000	Yes	PNL	25	6	18	0.14	Class 0 (*1)
BUS200F	20A BKR4	0.208	0.31	0.31	0.31	0.023	.000	Yes	PNL	25	1	18	0.00	Class 0 (*1)
BUS200FT2	30A BKR4	0.208	0.48	0.48	0.48	0.748	.000	Yes	PNL	25	7	18	0.18	Class 0 (*1)

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