**EFCOG Best Practice #173**

**Best Practice Title:** Compensatory Arc Flash Controls

**Facility:** DOE Complex

**Point of Contact:**

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**Brief Description of Best Practice:** Improper or inadequate maintenance can result in increased opening time of the over current protection device (OCPD), thus increasing the incident energy to which the worker is exposed. In cases where maintenance has not been performed in accordance with manufacturers’ instructions or industry consensus standards, compensatory arc flash control measures may be deployed.

**Why the best practice was used:** Arc flash analysis can be impacted by conditions of maintenance.

**What are the benefits of the best practice:** This Best Practice provides compensatory arc flash controls for conditions of maintenance to meet the intent of NFPA 70E 2018.

**What problems/issues were associated with the best practice:** This Best Practice provides consistent guidance for the complex.

**How the success of the Best Practice was measured:** Success will be measured by the use of this Best Practice into complex site operating procedures.

**Description of process experience using the Best Practice:** N/A

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**Compensatory Arc Flash Controls**

Improper or inadequate maintenance can result in increased opening time of the over current protection device (OCPD), thus increasing the incident energy to which the worker is exposed. In cases where equipment is not properly installed or maintenance has not been performed in accordance with manufacturers’ instructions or industry consensus standards compensatory arc flash control measures may be deployed.

It is assumed these controls are necessary until the inadequate condition is corrected (OCPD has been maintained, refurbished or replaced).

**Compensatory Controls**

It is recognized, that the Incident Energy Analysis Method or the application of the PPE Categories Method may be inadequate in cases where equipment has not been properly installed or maintenance is inadequate. The 2018 Edition of NFPA 70E indicates where conditions are present that increase the likelihood or severity of an arc flash event, the Hierarchy of Controls needs to be considered. Compensatory actions are based on consideration and application of the Hierarchy of Controls for which some examples are provided below:

* Engineered solutions to reduce the actual incident energy level,
* Increase the working distance from energized circuit parts to reduce incident energy exposure, and/or
* Increasing the level of personal protective equipment (PPE).

Selection of the specific control is based on feasibility. A combination of controls may be necessary.

1) Increase Working Distance or reduce incident energy levels with engineering/administrative controls.

a. Use remote actuation device to actuate the OCPD

b. Operate OCPD that has been maintained upstream of the device to be controlled

c. Reduce available fault current (i.e., eliminate parallel system, etc.)

d. Use hot stick or other means to increase distance and thereby reduce incident energy exposure level.

NOTE: The incident energy from a potential arc flash source varies by the inverse square of the distance. For example if the working distance is 18 inches, increasing the distance to 36 inches reduces the incident energy to approximately ¼ of the former value. See Best Practice #163 for further information.

The aforementioned controls are not intended to be all inclusive or preclude alternate measures from being used if available.

2) Increase the level of PPE and/or add barriers/shielding

a. Escalate arc analysis - incorporate a 2 second maximum clearing time, as applicable, into the arc analysis. Based on escalation, prescribe arc rated clothing and PPE, OR

b. If the arcing current is unknown, conduct a preliminary analysis. The maximum bolted fault, three-phase short-circuit current available at the equipment and the minimum fault level at which the arc will self-sustain is one of the parameters needed to conduct incident energy analysis. There are various methods available for estimating the fault current of an electrical system. See NFPA 70E Annex D Incident Energy and Arc Flash Boundary Calculation Methods. For additional info see Short Circuit Current Calculations – Bussman.

c. Install barriers- i.e. shielding, blankets, etc., as appropriate.

Use of the 2 second maximum clearing time is based on the following statement from IEEE 1584, *Guide for Performing Arc Flash Hazard Calculations*:

“If the time is longer than two seconds, consider how long a person is likely to remain in the location of the arc flash. It is likely that a person exposed to an arc flash will move away quickly if it is physically possible and two seconds is a reasonable maximum time for calculations.”

Sound engineering judgment should be used in applying the 2 second maximum clearing time, because there could be circumstances where an employee’s egress is inhibited. For example, a person in a bucket truck or a person who has crawled into equipment will need more time to move away.

Since the condition of the equipment is unknown or degraded, the 2 second rule is used. Two seconds is well founded by the IEEE-1584 standard which establishes the basis for arc analysis.

If an arc-flash analysis is performed using the 2 second rule and the resulting incident energy is less than 40 cal/cm2, PPE that is rated to the calculated incident energy may be worn to mitigate the arc flash hazard. However, it is recognized upstream isolation or remote operations is a superior control if there is a greater likelihood of an arc flash event due to a deteriorated condition.

When degraded conditions exist, or when incident energy exceeds 40 cal/cm2 at the working distance, work scope should be limited to de-energizing and removal of electrical hazards before working on or near electrical conductors or circuit parts.

Upstream device incident energy analysis:

For energized electrical work at a point in a distribution system protected by a breaker that has not been maintained, the incident energy calculated at an upstream breaker that has been maintained may be used for work on or downstream of the non-maintained breaker(s) if :

a) There are no transformers between the upstream maintained breaker and the downstream point of work and,

b) The increase in impedance due to wire length and wire size between the maintained device and the point of work does not limit the fault current so low that the upstream maintained breaker will not trip in the instantaneous region. There is a point in any power system where the fault current will decrease to a point that is below the instantaneous setting of the upstream over current device causing an increase in clearing time and available incident energy. There is also a point in the system where, despite the increase in clearing time, the fault current is so low that the incident energy will not be higher than that of the upstream device. The engineer performing the analysis will need to exercise judgment for these conditions. Some evaluation may be required but it is not intended that a detailed evaluation be performed for every point in the system.

NOTE: Compensatory measures do not apply to fused disconnect switches, however, the switch mechanism, spring clips, etc. are required to be maintained.

Thermal imaging and photography are noncontact activities that do not involve interaction with the equipment and therefore have a decreased risk of initiation of an arc event when performed outside of the Restricted Approach Boundary.

The flash protection boundary (FPB) should be established and controlled at a the distance that has been estimated (see BP #163 Field Tool for Estimating Incident Energy at Distance Using the Inverse Square Law).

Compensatory arc flash control measures are not needed for low energy electrical distribution systems (see BP #48).

The above measures are to be used to compensate for the lack of or limited maintenance of OCPDs that are relied upon to operate in the event of equipment failure. It should be noted that de-energization of electrical systems is the preferred option when degraded conditions exist.