

**ENERGY FACILITY CONTRACTORS GROUP (EFCOG)
ENVIRONMENTAL HEALTH AND SAFETY WORKING GROUP
ELECTRICAL SAFETY SUBGROUP**

ELECTRICAL SAFETY POSITION/GUIDANCE PAPER 2012-01

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This guidance represents the consensus understanding of the Electrical Safety Subgroup of the EFCOG Environmental, Safety and Health Working Group.

REFERENCE

Standard for Electrical Safety in the Workplace NFPA 70E, 2012 edition
Standard for Electrical Safety in the Workplace NFPA 70E, 2004 edition
IEEE Standard 1584b, IEEE Guide for Performing Arc Flash Calculations

QUESTION/ISSUE

No established EFCOG or DOE justification for the use of two seconds for a reasonable maximum time for AC and DC incident energy calculations or for a person to either escape from an arc flash incident or be blown out by the arc blast.

EFCOG POSITION

Battery systems are often not designed with overcurrent protection devices to clear a fault, and some AC system overcurrent protection devices cannot be depended upon due to lack maintenance to clear a fault. NFPA 70E 2012, NFPA 70 2008 and IEEE 1584 provide information to the AHJ for consideration before allowing work on exposed electrical equipment, in order to determine the PPE, adequate working space, guidance for performing arc-flash calculations and time for calculating incident energy.

Technical bases for the using two seconds as reasonable maximum time:

NFPA 70E 2012

Section-Annex D – D.6 (2)

“If the arcing time, t , in Equation D.7.3(c) is longer than 2 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 2 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.”

NFPA 70 2008

Article- 110.26(C) Entrance to Egress from Working Space.

(1) Minimum Requirement. At least one entrance of sufficient area shall be provided to give access to and egress from working space about electrical equipment.

NFPA 70 Note: This section was revised for the 2008 Code. The requirements are intended to provide access to electrical equipment. However, the primary intent is to provide egress from the area so that workers can escape if there is an arc flash incident.

IEEE 1584

Section-B1 IEEE Std. 1584-2002 Arc-flash Calculation

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. A person in a bucket truck or a person who has crawled into equipment will need more time to move away.

Background

NFPA 70E 2004 is a required and accepted standard under DOE. This acceptance was codified with the publishing of 10 CFR 851. In this and subsequent NFPA 70E versions, it is clearly established that working on or near energized circuits under any circumstances increases the risk to the worker. The fundamental acceptance criteria are provided in the NFPA 70E to reduce but not eliminate this risk. These fundamental acceptance criteria include safety by design, safe work practices, training and qualification, and arc flash and shock analysis.

Once the fundamental acceptance criteria for working around energized circuits are met, the NFPA provides information for determining acceptable levels of PPE. These acceptable levels are designed to protect the worker from second-degree burns (1.2 calorie/cm²), not to ensure absolute prevention of any injury.

The use of 2 seconds is a reasonable maximum time for calculations of DC and AC arc flash incident energy as quoted from the IEEE Guide for Performing Arc-Flash Hazard Calculations, IEEE-1584.

“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**. A person in a bucket truck or a person who has crawled into equipment will need more time to move away.” (Annex B.1.2)

As determined from discussions with members of the NFPA 70E and IEEE 1584 committees, including nationally recognized experts in arc flash, the following is determined:

The use of 2 seconds as a conservative default value is based on human factors, not electrical circuit or electrical failure mechanics. Specifically, the 2 seconds is based on human reaction times under automobile conditions. This use of two seconds as a reasonable maximum time for calculations of AC and DC incident energy is regularly a source of significant discussion and contention within the electrical community, including the NFPA 70E 2012 committee. However, continues to pass the NFPA committee as a consensus acceptable approach.

While generally conservative, the use of 2 seconds may increase the risk to the workers. Under both AC and DC conditions, there may be times when the arc flash lasts longer than 2 seconds. This is particularly true under DC current conditions, where many battery systems are not designed to automatically interrupt continued current flow in under 2 seconds. EFCOG acknowledge this risk and site AHJ accepts this risk because this is considered the best generally available information within the electrical community and is considered conservative under most conditions based on workers removing themselves from the area, not interrupting the current.

Another element of this risk is that the fundamental equations used are based upon power output, and do not factor such elements as intense thermal radiation, damaging noise levels, and explosive expansion of surrounding air. These additional risks are more fully described in the IEEE paper, Protective Clothing Guideline for Electric Arc Exposure by Thomas Neal Allen Bingham and Richard Doughty published in 1997. Briefly, It is known that all of the energy produced by an arc fault is distributed into a number of forms, i.e. heat, other EM radiation (visible light, UV), phase change of solid material, blast/pressure wave. Assuming, as the Maximum Power Method does, that all of the energy available goes into heat results in conservatively high incident energy. If some of the energy produced could be correctly accounted for in these other forms, the heat energy would be demonstrated to be less than calculated.

As a side note, these other energy forms are qualitatively accounted for, by equipping workers with tinted face shields for the EM radiation hazard, ear plugs for the blast hazard to eardrums, clothing material which is tested not to ignite when exposed to molten metal droplets, and by limiting exposure to incident energies of less than 40 cal/cm² (regarding this last point, it is considered that the shock wave associated with an arc hazard rated greater than a 40 cal/cm² cannot be protected against).



The EFCOG electrical committee agrees as a consensus, accepts that the use of the fundamental equations, and subsequently published charts, do represent an acceptable approach that allows work to be performed in a manner that minimizes but does not eliminate the risk.

When writing the NFPA 70E standards, the NFPA committee members, many of whom come from the DOE community, understand that the guidance provided must be able to be implemented by personnel qualified as Electrical AHJs covering a broad spectrum of capabilities. As a result, the standard is written at a level that reduces the need for highly specialized personnel to make most decisions. In discussions with NFPA committee members, it is clear that the intent of NFPA 70E as a consensus is that competent Electrical AHJs generally have the ability to determine when the 2 second rule is appropriate. Times when the rule is not appropriate include clear cases of obstruction, including working in a man-lift. It is not the intent of the NFPA 70E committee to require human factors experts or plasma experts to determine each applicable condition. As DOE contractor's employed qualified under the AHJ qualification standard or accepted as AHJ by letter on file, one of AHJ responsibilities is to make these decisions.

Statement of Position/Interpretation:

If the arcing time, t , in Equation (NFPA 70E) D.7.3(c) is longer than 2 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 2 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.

2 seconds is a reasonable maximum time for AC and DC Arc Flash calculations. This reasonable maximum time is acceptable to NFPA 70E, IEEE, EFCOG and the site E-AHJ. This time is based on personnel leaving the immediate area, and is independent of the fault clearing time of the circuits, characteristic of the arc and whether the system is AC or DC.

Sound engineering judgment - use of code and standards, lessons learned, past experience, industry experts and peers to develop a compliant definable basis - will minimize exposure to electrical hazards and is part of the function and responsibility of the AHJ.