September 26, 2007

MEMORANDUM To: AFPB File

FROM: Alex R. Klein, Acting Branch Chief ***/RA/***
Fire Protection Branch
Division of Risk Assessment
Office of Nuclear Reactor Regulation

SUBJECT: CLOSE-OUT OF NATIONAL FIRE PROTECTION ASSOCIATION 805 FREQUENTLY ASKED QUESTION 06-0017 ON CLARIFYING/ENHANCING GUIDANCE FOR COUNTING HIGH ENERGY ARCING FAULTS IN NUREG/CR-6850

Frequently asked question (FAQ) 06-0017, Revision 0, was proposed to clarify the guidance from NUREG/CR-6850 (EPRI TR-1011989), "EPRI/NRC-RES Fire Probabilistic Risk Assessment Methodology for Nuclear Power Facilities," on counting High Energy Arcing Faults (HEAFs) for National Fire Protection Association 805 transition applicants (see enclosure; Agency-wide Documents Access and Management System [ADAMS] Accession No. ML070030383). The authors of NUREG/CR-6850, i.e., the Office of Nuclear Regulatory Research (RES) and its contractors and the Electric Power Research Institute (EPRI), were subsequently consulted to provide this clarification. They provided their response via "Preliminary Team Response to FAQ 06-0017 on NUREG/CR-6850, EPRI TR-1011989, *Draft Revision 2*," dated April 26, 2007 (ADAMS Accession No. ML071560159).

Subsequently, this FAQ was split into two parts. Part one, labeled as Revision 1 to FAQ 06-0017 and the subject of this memorandum, addresses the guidance for counting HEAFs associated with switchgear and load centers (ADAMS Accession No. ML071350432). Part two, the subject of a new FAQ, addresses the guidance for counting HEAFs associated with bus ducts and junctions. This is treated separately and not as part of this memorandum. Extracted from the "Final Revision" ("Preliminary Team Response to FAQ 06-0017 on NUREG/CR-6850, EPRI TR-1011989, *Final Revision*," dated June 19, 2007, [see enclosure; ADAMS Accession No. ML071730038]) of the NUREG/CR-6850 authors' response to Revision 0 of FAQ 06-0017 (Revision 1 is identical to "Part one" of Revision 0) is the section dealing with counting HEAFs for switchgear and load centers (Enclosure 1). In the course of providing this response, the U.S. Nuclear Regulatory Commission (NRC) staff and the RES contractors raised the related issue of whether or not motor control centers (MCCs) should be included as potential sources of HEAFs along with the switchgear and load centers when counting sources. While not explicitly mentioned in NUREG/CR-6850, inclusion of MCCs when counting HEAF sources is explicit in the Fire Protection Significance Determination Process (Inspection Manual Chapter 609F). Consensus was reached regarding this, with the following guidance:

> *Only MCCs with switchgear that is used to directly operate equipment such as load centers should be counted as HEAF sources.*

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This guidance on when to count MCCs as HEAF sources, along with that for counting switchgear and load centers as HEAF sources, has been incorporated into subsequently submitted Revision 2 to FAQ 06-0017 (June 1, 2007; ADAMS Accession No. ML071570255). The NRC endorses Revision 2 to FAQ 06-0017.

Enclosures:
1. As stated
2. Preliminary Team Response to FAQ 06-0017, Draft Revision 2
3. Preliminary Team Response to FAQ 06-0017, Final Revision
4. FAQ 06-0017, Revision 0
5. FAQ 06-0017, Revision 1
6. FAQ 06-0017, Revision 2

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REVISION 1 TO FAQ 06-0017, ACCESSION NO.: ML071350432
REVISION 2 TO FAQ 06-0017, ACCESSION NO.: ML071570255

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(The following has been extracted from “Preliminary Team Response to frequently asked questions (FAQ) 06-0017 on NUREG/CR-6850, EPRI TR-1011989; Final Revision – 6/19/2007; Prepared by: S. Nowlen, B. Najafi, D. Funk, F. Joglar and M. Kazarians)

High Energy Arcing Faults (HEAF) Fires in Electrical Panels

With respect to counting of electrical panels for the purposes of the HEAF fire events, the team disagrees with the proposed alternate counting method for load centers and low voltage switchgear. Our disagreement is based on the fact that no clear rules of application have been specified so that it may not be applied consistently by analysts. The counting approach also appears rather arbitrary. That said, the state of knowledge regarding HEAF fires continues to evolve. New insights developed since publication of the methodology do indicate that an adjustment of fire frequencies between low- and medium-voltage equipment is warranted.

The electrical power community has, over the past two years, gained significant knowledge about HEAFs. This increased awareness and knowledge base was driven by adoption of new arc flash protection requirements in National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety Requirements for Employee Workplaces. Discussions with experts close to the subject, including a member of the Institute of Electrical and Electronics Engineers (IEEE) 1584 standards committee (Guide for Performing Arc-Flash Hazards Calculations) revealed that recorded events of HEAFs are actually dominated by incidences involving 480 volt (V) gear. The experts confirm that the higher incidence of 480V events is partially attributable to the greater population of installed 480V equipment. However, other overlapping factors are also important:

- A majority of arc flash events are initiated by human error.
- Low voltage equipment is worked on/operated more frequently than medium voltage equipment.
- Workers have a more casual attitude when working on 480V gear, i.e., everyone knows that you will probably not get a second chance if you make a mistake working on medium voltage equipment but they tend to perceive 480V gear as less threatening. Additionally, it is more probable that 480V equipment will be worked “hot;” that is, worked on while the equipment is energized.
- Basic design attributes of medium voltage gear decrease the likelihood of initiating a sustained arcing fault. Key elements include insulated bus bars in lieu of open bus bar work, barrier protection, compartmentalization between phases, and increased creepage distances.
- Arcing faults do occur on 208V systems; however, sustained arcing faults at 208V are rare and difficult to reproduce.

With these observations in mind, the intent of the HEAF analysis (per Appendix M) is to capture “higher-consequence” events that may have a substantive impact outside the cabinet of origin. Other arc fault events (e.g., events that did not lead to an impact outside the originating panel) are already treated via the general electrical panel fire frequency and this treatment need not be adjusted. Only the “higher-consequence” events are under question here.
Another observation that is evident from the event records amassed by the IEEE standard groups is that, even though the general incidence of arc faults in low-voltage equipment may actually be higher, the fraction of such events leading to substantive impacts outside the initiating cabinet (i.e., higher-consequence events) is actually lower than for similar incidents in

medium-voltage equipment. In essence, if a sustained arc fault occurs in a 4.16 kilo-volt switchgear, the fault will very likely have an impact beyond the limits of the panel. In contrast, an arc fault in a low voltage panel is more likely to remain confined to the panel and less likely to have impact beyond the panel. This rationale is supported by standardized arc flash calculations; equivalent stand off distances are typically greater for medium voltage equipment, given normal and customary over-current protection.

This contention is consistent with both the broader industry experience and with the specific nuclear industry experience as cataloged in Appendix M. That is, the frequency analysis included three events in medium-voltage equipment, and only ½ of an event (i.e., one uncertain event) for low-voltage equipment. This assessment included consideration of whether each reported event actually had impact outside the panel of origin. There are many other low voltage panel fire events that appear to have involved some degree of arc-flash, but that also remained confined to the panel of origin.

The team's proposed resolution to the underlying issue raised in the FAQ is to split fire ignition frequency Bin 16, HEAF, into two bins; namely, "16a – HEAF for low-voltage panels (480-1000V)" and "16b– HEAF for medium-voltage panels (greater than 1000V)." For each bin, the method of panel counting would then stand unchanged (i.e., count vertical sections). Given the split into two bins, the counting method, and hence the fire frequency apportioning process, need to be self-consistent within each of the two new bins, but there is no longer any cross-over between the low- and medium-voltage equipment. This also maintains consistency with the counting method for general thermal fires (i.e., the non-HEAF panel fires that must also be treated) which is also a highly desirable feature so that analyst need not maintain two separate population counts for the same set of fire ignition sources.

The net result is a re-partitioning of the "higher-consequence" HEAF events between low and medium-to-high voltage equipment in accordance with the event data. The revised fire frequencies for these two new bins are as follows:

16a: HEAF for Low- Voltage Panels (480 – 1000 V)
Mean = 4.8E-04
Variance = 1.4E-03
5% Lower Bound = 1.6E-05
50% (Median) = 2.0E-04
95% Upper Bound = 1.5E-03

16b: HEAF for Medium-Voltage Panels (greater than 1000 V)
Mean = 1.4E-03
Variance = 1.2E-02
5% Lower Bound = 3.8E-05
50% (Median) = 6.2E-04
95% Upper Bound = 4.1E-03