Taylor, Gabriel

From: POLLOCK, Joseph <jep@nei.org>
Sent: Thursday, May 17, 2018 10:31 AM
To: Ma, May
Cc: Weber, Michael; Salley, MarkHenry; Taylor, Gabriel

Subject: [External_Sender] NEI Comments on "Aluminum High Energy Arc Fault (HEAF) Particle Size Characterization Test Plan – Draft Test Plan;" 83 FR 9334; Docket ID NRC-2018-0040
Attachments: 05-17-18_NRC NEI Comments on "Aluminum High Energy Arc Fault (HEAF) Part....pdf

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THE ATTACHMENT CONTAINS THE COMPLETE CONTENTS OF THE LETTER

May 17, 2018

Ms. May Ma
Chief, Program Management, Announcements, and Editing Branch
Office of Administration, MS TWFN-7-A60M
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: NEI Comments on "Aluminum High Energy Arc Fault (HEAF) Particle Size Characterization Test Plan – Draft Test Plan;" 83 FR 9334; Docket ID NRC-2018-0040

Project Number: 689

Dear Ms. Ma:

The Nuclear Energy Institute (NEI) on behalf of its members appreciates the opportunity to provide comments on the subject draft test plan, "Aluminum High Energy Arc Fault (HEAF) Particle Size Characterization Test Plan – Draft Test Plan." Given the attention to previous testing related to HEAF events, including CNSI-R2017-7, "Report on the Testing Phase (2014-2016) of the High Energy Arcing Fault Events (HEAF) Project: Experimental Results from the International Energy Arcing Fault Research Programme," it is critical that any follow-on testing involve configurations that accurately reflect plant design and operations in order to provide realistic insights.

In addition to NEI's concerns regarding the premise of this testing plan, several aspects of this testing plan are not reflective of realistic plant operating configurations. Thus, any results from testing under this plan as written would be of minimal application to operating reactors. Detailed comments regarding the undue conservatisms included in the draft test plan are attached to this letter. Should the NRC ultimately decide to pursue this testing program despite stakeholder concerns regarding this testing program, these comments should be incorporated prior to finalizing the testing plan.

Should you have any questions regarding our comments, please contact me or Victoria Anderson (202-739-8101, vka@nei.org).

Sincerely,

Joseph Pollock
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NEI is concerned that the genesis of the current effort, CNSI-R2017-7, which spurred issuance of NRC Information Notice 2017-04, "High Energy Arcing Faults in Electrical Equipment Containing Aluminum Components," involved several conservative and unrealistic practices that did not reflect plant configurations. As such, our position is that the identified follow-on testing is unnecessary, and conduct of the test plan as currently written would involve dedication of resources to an issue with little or no safety significance. NEI recommends that this testing program be halted in favor of a more detailed review of the CNSI-R2017-7 results by a joint panel of experts from industry and NRC to better inform any follow-on testing justified by a realistic evaluation of those test results in the context of plant operations.

[1]The Nuclear Energy Institute (NEI) is the organization responsible for establishing unified industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all entities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel cycle facilities, nuclear materials licensees, and other organizations and entities involved in the nuclear energy industry.

In addition to NEI's concerns regarding the premise of this testing plan, several aspects of this testing plan are not reflective of realistic plant operating configurations. Thus, any results from testing under this plan as written would be of minimal application to operating reactors. Detailed comments regarding the undue conservatisms included in the draft test plan are attached to this letter. Should the NRC ultimately decide to pursue this testing program despite stakeholder concerns regarding this testing program, these comments should be incorporated prior to finalizing the testing plan.

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Sincerely,

Joseph E. Pollock

Joe Pollock

C: Mr. Michael Weber, RES
Mr. Mark Henry Salley, RES
Mr. Gabriel Taylor, RES

Attachment: Comments on NRC HEAF Testing Plan

General Comments on Approach to Support Realism in HEAF Testing

These tests should be performed using as realistic as possible fault conditions (e.g., fault current magnitude, duration, DC offset, decay, etc.). The NRC should consider HEAF testing to incorporate monitoring for parameters that are used as input for commercially available arc-flash protection relays. These parameters typically include light intensity (sensed by point sensors or fiber optic cable) and sound pressure (by point sensors).

The 4 and 8 second durations at Low-Voltage (LV; 480V) should be replaced with 2 and 4 second durations.

- The OE doesn't support the "realism" of an 8 second arcing event at this voltage level. Out of the OE that is being referenced, only the Fort Calhoun event had a long fault duration at the 480V level. That fault duration itself (42 seconds) was due to a severe design deficiency (misaligned stabs and zone select interface jumpers not being disabled). This event is not representative of an actual fault event where one or even two protection levels misoperate. For this reason performing the 8 second test does not follow the mission for phase 2 testing, which is "realism." In addition, considering all the OE, the Fort Calhoun event at 42 seconds is obviously an anomaly (next longest is 12 seconds), and thus would normally be removed from any statistical sample.

- In a scenario with single breaker misoperation, the protection upstream of the supply transformer will typically operate much faster than 8 seconds. While it is true that upstream protection will operate in the thermal region, for high fault current levels detailed in the test plan the trip times will be closer to 4 seconds or even much shorter.

- A test at 2 seconds would be more interesting to the industry since the switchgear is designed for a 2 second fault event. Most testing is done with a duration of 0.1 -1 second per IEEE C37 hence it would be a new test and not repetitive.

- NRC representatives mentioned during the April 18-19 workshop that the longer testing, exceeding 4 seconds, could not be performed at the Medium Voltage level (MV) due to testing center limitations. Since the testing center is able to test for longer durations at LV, a longer test (8 seconds) was being done at LV. No testing should be done for sake of testing without OE basis. If the test is performed at 8 seconds at LV, it should be categorized as 'experimental' and not utilized to develop revised ZOI (Zone of Influence) and frequency for PRA.

Multiple licensees use a high impedance grounding system to limit the fault current. This test plan does not specify the ground configuration, and so no comparison to the installed plant configuration can be made.

The test methodology eliminates any component but the tested material/simulated bus bars. No bus bars are used in nuclear plants that are not connected to something else – transformers, buses with other components etc. Additionally, the bus bars are typically the strong part of the circuit, not the weak link.

The testing plan should be revised following consideration of other sources of analysis, research, design, and protection relating to HEAF, specifically IEEE Standard C37.20.7, IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults (may be relevant as to future test parameters – arc-duration, current decay, DC offset, fault current, energy dissipation, etc.; may also be relevant as to effectiveness of energy dissipation features such as intended by provision of directed vents, louvers, lifting panels, blowout panels, etc.)

Issues Related to Lack of Realism in Previous Testing

Regarding test results as reported in CNSI-R2017-7:

- Several of the “extraordinary” test results call for additional scrutiny:
    - Test 4, 5, & 6, Westinghouse DS (480V) w/ aluminum – tests results were not extraordinary, arc duration was 9, 300+, & 300+ milliseconds
    - Test 23, “IP-20” (480V) w/ aluminum – test result was “extraordinary”, arc duration was 7000+ milliseconds
    - Test 26, copper bus bars (4160V) w/ aluminum duct – test result was “extraordinary” arc duration was 4000+ milliseconds
    - It is legitimate to question the “extraordinary” test results where the arc duration was maintained for more than a couple of seconds, specifically for Test 23, where a typical plant design would provide electrical protection for the switchgear (e.g., one or two upstream breakers with protective relaying, etc.). It is legitimate that the arc duration for Test 26 may represent actual conditions, as a typical plant design may provide power to the bus bar directly from the power source (e.g., Main Generator, etc.) without any in-between electrical protection.
- Correlation of CNSI-R2017-7 (Test 23, IP-20) with the testing documented in KEMA 15201-B (trial 16, Finland Cabinet 1 LV Switchgear) is based on test date 10/16/2015, since there is no “Test 23” identified in KEMA 15201-B, and since no specific manufacturer or model number is provided for the applicable switchgear associated with Test 23 in CNSI-R2017-7 or KEMA 15201-B. The Test 23 specimen is identified as “IP-20,” which represents a generic international Ingress Protection (IP) rating, equivalent to a NEMA enclosure rating in the USA.
    - IP20 signifies protection from touch by fingers and objects greater than 12 millimeters, not protection from liquids. IP20 is not waterproof or even spray proof, and may not be typical of US installations, which would likely use no less than IP22, protected from touch by fingers and objects greater than 12 millimeters; protected from water spray less than 15 degrees from vertical.
- Test 23 and Test 26 were performed in an open test cell (open to outdoor environment) in the month of October. The documentation in CNSI-R2017-7 and KEMA 15201-B does not specify how the test specimens and/or monitoring instruments were stored or when the test rig was set up in the test cell. One must wonder if condensation might have occurred on the test cell walls, the test specimens, and/or the monitoring instruments given the typical Pennsylvania weather in October (cold nights, warm days). Furthermore, one also must wonder if condensation, if present, played

any part in the “extraordinary” test results noted in Test 23 and Test 26. This may be a similar concern for future testing.

- Test 23 and Test 26 were performed in an open test cell (open to outdoor environment) in the month of October. One must wonder how and if the relative humidity played any part in the “extraordinary” test results noted in Test 23 and Test 26. The level of relative humidity may impact how easily an arc can be established. In plant application, the test specimens such as these (switchgear and some bus bars) are typically located in areas where the relative humidity is maintained relatively constant. The test facility is capable of “allows breakdown testing as a function of gas composition and atmospheric/surface contaminants (e.g. humidity, saltwater spray, oil vapors and other atmospheric contaminants).” Humidity is not specified. Is what has been seen in Phase 1 actually metal water reaction? Results may vary widely depending on humidity or other contaminants. This may be a similar concern for future testing.

- The documentation in CNSI-R2017-7 and KEMA 15201-B does not specify how the test specimens were procured or maintained, their service life, service conditions, or service history, or if and how the test specimens were modified to accommodate testing. These variables might have an influence on the “extraordinary” test results noted in Test 23 and Test 26. This may be a similar concern for future testing.

- The documentation in CNSI-R2017-7 and KEMA 15201-B does not specify if electromagnetic interference (EMI) or electromagnetic pulse (EPM) was monitored during testing. It is possible that either or both phenomena impacted the HEAF energy release, and if either or both phenomena had any influence on the “extraordinary” test results noted in Test 23 and Test 26. This may be a similar concern for future testing.

- There exists a concern regarding plants which credit ERFBS which is located within the HEAF ZOI (copper or aluminum) as part of their fire protection program, deterministic or performance based. Specifically, the concern is for the impact of HEAF explosion and subsequent fire to ERFBS located within the ZOI. This event may cause damage to the ERFBS and may also damage (due to HEAF explosion and subsequent fire) the circuits protected by the ERFBS, thereby resulting in spurious operation or loss of required function. It does not appear that this failure mode and adverse impact is considered by deterministic regulation (Appendix R), since Appendix R fire area analyses are based on an assumed “worst-case” whole area burn from a floor-based fire and the deterministic analysis does not consider HEAF explosion. Furthermore, it does not appear that this failure mode and adverse impact is adequately addressed in the performance-based HEAF ZOI treatment guidance (NUREG/CR-6850), since performance-based treatment guidance may only address failure of ERFBS with respect to fire propagation, but not failure of circuits protected by ERFBS thereby resulting in spurious operation or loss of required function.

    - The test results as reported in CNSI-R2017-7 are not appropriately characterized. It is not 2 of 2 tests involving aluminum that exhibited “extraordinary” test results. There were 5 tests involving aluminum, and 3 of these tests did not exhibit any “extraordinary” test results beyond the current Fire PRA treatment for HEAF ZOI in NUREG/CR-6850. Furthermore, the “white haze” attributed with electrical failures in the “extraordinary” aluminum tests has not yet been confirmed as the actual cause of these electrical failures, nor to my knowledge is there any experience of “whitewashing the entire room with the white haze” in any of the recorded plant HEAFs, although some localized aluminum oxide, splatter, slag, etc. has been noted in the associated fire event reports.

- o Furthermore, any future NRC discussion or presentation regarding industry HEAF events should endeavor to accurately note that the long duration of the arc-fault events at Fort Calhoun and Robinson were caused or compounded by human performance errors.

Issues Related to Interpretation of Test Results

The HEAF frequencies need to be developed to reflect both the testing configuration and the plant configuration. For example, large HEAF ZOI events only protected by a single breaker should be not be apply to HEAF events protected by two breakers. Large HEAF ZOI that have durations of faults greater than 4 seconds should only count events where the fault was greater than 4 seconds. It appears that the target fault durations were orders of magnitude greater than what industry protection schemes would allow. They were also greater than the short-circuit rating of the transformers themselves. It is not physically possible to get these faults.

The criteria for the new bin classifications needs enhancement to reduce subjectivity as much as is possible. The criteria need to bound and bin, without ambiguity, subjectivity, or debate, all relevant arc fault events to date.

- No damage to component itself – no fire internal, no fire external
- Damage to component itself – no fire internal, no fire external, damage to external components
- Damage to component itself – no fire internal, no fire external
- Damage to component itself – fire internal, no fire external
- Damage to component itself – fire internal, fire external
- Event compounded by human error (Fort Calhoun, Robinson)
- Others

The use of “energy” as a metric may be one enhancement to the bin classification criteria, but this may also be misleading given that arc-fault energy is released over time. Total energy release may meet or exceed a set threshold, but the impact from this energy release will depend on the arc-fault duration and the changing arc-current.

For the population of plant circuit breakers that, if failed, could allow propagation of an arc-fault into a HEAF event (a challenging fire event), presumably breaker failures within this population are already counted as “fail to trip on valid demand” random component failures in the Internal Events PRA. The implications of possible double counting of these failures in the Fire PRA should be addressed

As previously documented, many of the HEAF events that contribute to the HEAF frequency involve one or more breaker malfunctions that fail to clear the fault – it is requested that this statement is reflected in revised frequency for PRA. It is further suggested that a revised ZOI only be documented hand-in-hand with the revised frequency for PRA.

Issues Regarding Interpretation of Other OE

During the Turkey Point event, it is notable that no other mechanical damage was identified within the effective radius of the pressure wave generated by the HEAF. It is likely there are several other components and features located within the effective radius of the pressure wave that could possibly have been damaged (e.g., electrical penetrations, junction and terminal boxes, placards and signs, etc.). It seems odd that a fire door was the only component located outside of the switchgear that was adversely impacted by the pressure wave.

The previously-discussed test results were compared to the 2010 Robinson Fire and having inspected the Robinson Fire damage. The Robinson HEAF damage was significantly less than predicted with the current HEAF model. For example thermoplastic cables about 3 inches from the HEAF Cabinet were undamaged, but did show evidence of some heating. These cables were sent to NRC Research, where the lack of cable damage was confirmed. The letter provided by NRC Research stated that based upon the cables it summarized that "NUREG/CR 6850 is likely overstating the damage in the zone of influence".

Comments Regarding the Premise of USNRC IN 2017-04:

The information notice states:

> This program has shown that HEAF tests involving aluminum resulted in a significantly larger release of energy than HEAF tests involving copper. This aluminum involvement includes components, subcomponents, or parts that form part of the normal current-carrying pathway (such as bus bars, breaker armatures, contacts, cable, etc.), or components, subcomponents, or parts that could become involved in the fault current pathway as a result of a ground fault (housings, structural framework, adapters, cradles, wireways, conduits, draw-out or racking mechanisms, etc.). In addition to larger energy release during the HEAF event when aluminum is involved, RES staff also observed dispersal of electrically conductive aluminum byproducts throughout the area. This byproduct was conductive and caused short circuiting and grounding of electrical equipment in the area. Through the testing program, RES staff observed that HEAF tests involving aluminum damaged test measurement and recording equipment and the electrical supply of the test facility well beyond the damage limits approximated in NUREG/CR-6850 (EPRI 1011989).

The second part of the paragraph appears to be too broadly worded and vague: “or components, subcomponents, or parts that could become involved in the fault current pathway.” There is no guidance provided or specific test data that points to “what could become involved in the fault current pathway.” It would be hard to tell which miscellaneous aluminum parts became involved in the fault current pathway from inspecting a breaker cubicle that has exploded/vaporized - to tell if any of the miscellaneous aluminum parts vaporized/ejected due to becoming involved in the fault current pathway, or as a consequence of the resulting explosion and/or temperature rise in the cubicle.

However, the empirical test results would suggest that if aluminum components, subcomponents, or parts were contained within the representative “typical” switchgear that was tested containing only copper “bus bars, breaker armatures, contacts, cable,” then these aluminum components, subcomponents, or parts apparently did not contribute to HEAF damage beyond that which was expected (prior to test) for switchgear only containing copper “bus bars, breaker armatures, contacts, cable.” Thus, any such aluminum components, subcomponents, or parts should not be considered to “become involved in the fault current pathway,” where said items are contained within a “typical” switchgear containing only copper “bus bars, breaker armatures, contacts, cable.” The empirical test results would also suggest that any such aluminum items did not also contribute to the unexpected HEAF damage that was observed in tests of switchgear containing only aluminum “bus bars, breaker armatures, contacts, cable.”

Rather than the above statement from the information notice, the position based on the empirical test results presented in the body of CSNI-R-2017-7 should be: If the switchgear does not contain aluminum “bus bars, breaker armatures, contacts, cable,” then the HEAF event should be selected for copper. The other miscellaneous “components, subcomponents, or parts” do not influence the HEAF damage any differently, regardless of what material the “bus bars, breaker armatures, contacts, cable” are constructed of.

Detailed Comments on Test Plan

- Since bus bar spacing is dependent on the gear that is available for testing, and can vary from what is installed at nuclear plants in the US, when the test results and PRA frequencies are documented the deviation in bus bar spacing with respect to those in IEEE 1584 and in the industry should be documented and evaluated.

- The bus bar to be used is 3mm x 1mm, which is undersized for any commercial power plant.

- The plan states that the test setup will be in an enclosure. Several figures depict the dimensions. If these figures are accurate, the enclosure is snugged up to the bus bar and will reflect the blast back on the bus bar, effectively doubling it.

- No artificial enclosures should be used on end of buses. If the bus does not terminate in a cabinet, then do not cap the ends. The buses at the plants are generally long runs with no blanked off ends.

- The ground intend to be placed in the cabinet is 2.6mm, roughly the same size as the bus bar. Again, this is not consistent with grounding used in a commercial power plant installation.

- The fault current profile utilized for testing at MV should resemble a typical generator behavior (ie. decrement curve). Typically MV gears have grounding transformers or grounding resistors on the neutral. This limits the phase to ground fault current to lower levels. Since NRC is performing phase to phase testing and the ground resistors only limit the phase to ground current, the testing procedure is not impacted by the presence of the ground resistor. However, presence of these phase-to-ground current limiting devices should be used to lower the probability of an arcing event at the MV voltage level.

- Regarding "widely used high voltage bus bars," the bus widely used in NPPs is either low or medium voltage but not high. However, that depends on your definition. The high voltage terminology is not well defined even among industry standards. Many IEEE standards use high voltage to apply to anything greater than 1000V. NEMA C84.1 2016 defines high voltage as greater than 100kV. Reference NEMA C84.1 or some other standard for Voltage Class definitions. It is recommended that the voltage classes be defined in the test plan so that it is more clear what voltage ranges are being discussed

- Consider matching the location of the instrument racks being used to monitor the HEAF to match the existing ZOI's that were used in 6850 and FAQ 35. The material coupons on the instrument rack should include both steel and aluminum.

- Regarding the tests exceeding equipment ratings, it seems the duration of fault currents would exceed the equipment ratings. Provide more specifics for this statement and the ratings discussed.

- For system voltages not specifically tested, there should be a method to extrapolate results to different voltages, e.g., 600V, 4.16kV for enclosure testing or 480V, 6.9kV for bus ducts.

- Provide specifics on the type of cables that will be tested, i.e., thermoset, thermoplastic, IEEE 383 or not, etc. Alternatively, include in the test plan the requirement to document the relevant properties of the cable(s) that were tested.

- Several sections reference IEEE standards meant for the testing of a first-off-the-line piece of switchgear, not a test rig.