## 1. Description of the proposed generic issue

As a result of international high energy arcing fault (HEAF) testing in 2017, the U.S. Nuclear Regulatory Commission (NRC) staff identified that a potential generic issue (GI) exists for plants that have electrical equipment containing aluminum components in areas susceptible to HEAF events. A HEAF event involving aluminum may damage more surrounding components than previous analyses indicated. Recent test results indicate that the zone of influence (ZOI) around the initiating fault location may be larger than postulated in the current methodology for HEAF analysis described in NUREG/CR-6850, Electric Power Research Institute (EPRI) 1011989, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities, Volume 2: Detailed Methodology," issued September 2005, and in NUREG/CR-6850 Supplement 1, EPRI 1019259, "Fire Probabilistic Risk Assessment Methods Enhancements," issued September 2010. The current methodology in NUREG/CR-6850 supports plant-specific fire probabilistic risk assessment (PRA) performed by licensees using the National Fire Protection Association (NFPA) Standard 805 (NFPA 805), "Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants," to meet fire protection regulations (e.g., Title 10 of the *Code of Federal Regulations* (10 CFR) 50.48(c)).

In addition, a HEAF event involving aluminum may challenge the technical basis of the current deterministic fire protection physical separation requirements described in Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Section III.G.2.b of Appendix R states in part the following:

> Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustible or fire hazards. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area….

Based on detailed risk information provided by the NFPA 805 plants, the staff found that HEAF-initiated scenarios were significant contributors to fire risk at some plants. From a survey sample of 10 original NFPA 805 License Amendment Requests (LARs) surveyed, the staff found that fire risk contributed by HEAF-initiated fire scenarios ranged from 1 percent to 27 percent. The staff estimated the average per unit risk contribution was approximately 15 percent for these plants. Based on a Nuclear Energy Institute survey (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17165A140), aluminum components were found to be prevalent in some HEAF-susceptible equipment located in areas of the plants evaluated in fire analyses. Qualitatively, the staff concluded that the risk of a HEAF involving aluminum could potentially increase the plant's core damage frequency (CDF) for some fire scenarios based on a larger damage footprint or ZOI. However, any increase in risk will be highly scenario dependent and highly influenced by room configuration.

## 2. Objective of the assessment plan

This assessment plan describes the steps necessary for the staff to assess the risk resulting from the influence of aluminum on a HEAF inside a nuclear power plant. Based on the assessment results, the staff should be able to recommend whether the GI should proceed to the Regulatory Office Implementation (ROI) stage of the GI process.

**3. Members of the assessment team**

The following staff members were selected to be on the assessment team:

- Stanley Gardocki (RES)
- Nicholas Melly (RES)
- Gabriel Taylor (RES)

The following staff will provide additional support:

- JS Hyslop (Office of Nuclear Reactor Regulation (NRR))
- Hari Kodali (NRR)
- Brian Metzger (NRR)
- Thinh Dinh (NRO)

**4. Specific tasks required from the team members**

Team members will perform the following specific tasks:

- Perform risk assessment.
- Perform safety assessment.
- Perform regulatory assessment.
- Complete GI assessment report and recommendations.

**5. Schedule of proposed actions to be explored during the assessment, as appropriate, such as an industry initiative, or development of new risk tools or methods for a safety/risk assessment. Include a schedule for implementation of proposed actions to be explored during the assessment, as appropriate.**

Enclosure 2 provides a timeline showing the milestones supporting this assessment. It also describes the tasks and milestones identified in the screening report along with projected dates.

**6. Discussion on formulation of new regulations, policy positions, generic communications, Commission paper, or other regulatory actions**

The screening report identified the following long-term actions that may occur during the ROI stage if the Generic Issues Review Panel (GIRP) determines that the GI should proceed:

Task 6a: Issue generic communications, requests for information, or orders, as deemed necessary.

Objective: Inform industry and other stakeholders of findings, request plant-specific information, or direct licensees to make necessary changes.

Task 6b: Revise technical guidance.

Objective: Revise or supplement NUREG/CR-6850 and other associated guidance documents to reflect new information and methods. This may involve getting support from industry (EPRI).

Task 6c: Assess risk through long-term performance monitoring.

Objectives:

I. Review existing inspection activities to determine if adding aluminum HEAF inspections to existing fire protection programs is appropriate.

II. As appropriate, add inspection procedures and determine inspection frequencies.

III. Determine resource loading for region resources, and offset with NRR program office assistance and/or programmatic efficiencies.

**7. Milestones that include tests or research, public meetings, industry meetings, and major review and concurrence**

A. May 2017 — Published report on results from Phase 1 testing of HEAF.

B. August 2017 — Published Phase II test plan for public comment.

C. January 2018 — Published results of the international phenomena identification and ranking table (PIRT) in NUREG-2218, "An International Phenomena Identification and Ranking Table (PIRT) Expert Elicitation Exercise for High Energy Arcing Faults (HEAFs)."

D. April 2018 — The NRC hosted a 2-day public meeting to discuss the proposed large-scale and small-scale HEAF test plans.

E. Summer 2018 — Conduct small-scale testing at Sandia National Laboratories (SNL).

F. Fall 2018 — Begin large-scale testing at the KEMA test facility.

G. Spring 2019 — Initiate EPRI/NRC working group to develop an interim ZOI model (if necessary) based on preliminary test information. This effort doesn't include developing refined frequencies, but should be coordinated with that effort led by EPRI to ensure that the ZOI models correlate to the frequency binning. This interim ZOI will be used for the purposes of the GIRP risk assessment only.

H. Mid 2019 — Publish a report on how aluminum reacts within a HEAF. The staff has contracted with the University of Maryland to develop models and to explain the phenomenon.

I. Fall 2019 — NRC staff will work with a voluntary pilot plant(s) to examine the impact on the plant's risk using recommendations from the EPRI/NRC working group.

J. 2020 — Complete the remainder of the large-scale testing at the KEMA facility.

**8. Estimates of resources required for direct technical staff and contractors. All requests for regulatory office support and review of draft reports or assignment of a program office technical contact for GI safety/risk or regulatory assessments should be sent from the division director to the appropriate managerial level in the program office.**

A. Within RES, Division of Risk Assessment (DRA), 3 FTE staff are assigned to HEAF research. RES/DRA staff is managing contracts with outside agencies to obtain necessary test results, support analytics of those results, and methodology development. Contracts are with:

I. Sandia National Laboratories (SNL) to:
- Perform small-scale testing program to characterize electrical arc particulate.
- Support full-scale testing by providing:
  - high speed / high dynamic range videography,
  - particle capture devices,
  - post-test analytics of video and particles.
- Facilitate aluminum arc energy modeling and exchange of information with University of Maryland.

II. University of Maryland to:
- Develop / modify arc energy models for estimating additional energy from aluminum during an electrical arc event.

III. National Institute of Standards and Technology (NIST) to provide:
- Plate thermometers and thermal capacitance slug calorimeters to measure heat flux,
- High speed thermal imaging (IR),
- High definition videography.

IV. KEMA Powertest, LLC. Experimental facility to provide:
- HEAF experimentation,
- Measurement of heat flux (incident energy),
- Measurements of electrical waveforms during test (voltage, current),
- Provide high speed videography.
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V. BSI, LLC to provide:
- Electrical equipment storage, preparation, installation, and configuration.

B. Resources external to the NRC are also anticipated, including:

I. The NRC staff will work with the nuclear industry to solicit volunteer pilot plant(s) to examine the impact on the plant's risk as a result of an expanded ZOI.

II. The NRC anticipates working with the international nuclear regulatory community under a Nuclear Energy Agency (NEA) Agreement to conduct testing identified in the full-scale Phase II test plan.

III. NRC is actively working with EPRI on several HEAF related initiatives, including development of updated HEAF frequency, and updated ZOI estimates for pilot plant assessment and fire PRA methodology updates.

**9. A list of technical contacts that includes affiliations, titles, addresses, phone numbers, and e-mail addresses**

A. Contacts in RES:

- Stanley Gardocki (RES), Stanley.Gardock@NRC.gov, (301) 415-1067, Senior Reactor Systems Engineer, Regulatory Guidance & Generic Issues Branch
- Nicholas Melly (RES), Nicholas.Melly@NRC.gov, (301) 415-2392, Fire Protection Engineer, Fire & External Hazards Analysis Branch
- Gabriel Taylor (RES), Gabriel.Taylor@NRC.gov, (301) 415-0781, Senior Fire Protection Engineer, Fire & External Hazards Analysis Branch
- Kenneth Hamburger (RES), Kenneth.Hamburger@NRC.gov, (301) 415-2022, Fire Protection Engineer, Fire & External Hazards Analysis Branch

B. Contacts in NRR/NRO:

- JS Hyslop (NRR), JS.Hyslop@NRC.gov, (301) 415-4107, Senior Reliability & Risk Analyst, PRA Licensing Branch
- Brian Metzger (NRR), Brian.Metzger@NRC.gov, (301) 415-3972, Fire Protection Engineer, PRA Licensing Branch
- Hari Kodali (NRR), Hari.Kodali@NRC.gov, (301) 415-2279, Electrical Engineer, Electrical Engineering Op Reactors Branch
- Thinh Dinh (NRO), Thinh.Dinh@nrc.gov, (301) 415-2149, Fire Protection Engineer, Plant Systems Branch

C. Contacts outside the NRC:

- The RES/DRA is actively working with external parties, including:
  - EPRI under its collaborative research agreement
  - NFPA / IEEE working group on arc faults
  - Other agencies with a mutual interest in this research area

**10. A list of appropriate documents specific to the current GI program stage that include documents providing the basis for the GI**

| | | |
|---|---|---|
| • Communication Plan | ML16057A419 | Not public |
| • Commissioners' Assistants Note | ML17221A484 | Not public |
| • Draft Phase 2 Test Plan | ML17201Q551 | 1/30/2018 |
| • GIRP Screening Report | ML16349A027 | 7/15/2017 |

| | | |
|---|---|---|
| • Information Notice (IN) 2017-04 | ML17058A343 | 8/21/2017 |
| • Initial Screening Results | ML16132A415 | 5/17/2016 |
| • RES Appointments to GIRP | ML16209A007 | 8/16/2016 |
| • RES OD Acknowledge Screening Result | ML17194A455 | 8/21/2017 |
| • NRR Appointments to the GIRP | ML16173A183 | 7/06/2016 |
| • Receipt of Issue | ML16132A116 | 5/12/2016 |
| • Submittal Enclosure | ML16126A098 | 5/06/2016 |
| • Submittal Memorandum | ML16126A096 | 5/06/2016 |
| • NRR Immediate Safety Evaluation | ML16064A250 | 3/04/2016 |
| • Small-Scale Test Plan and Comments | ML18163A423 | 6/13/2018 |
| • Result of International PIRT | ML18032A318 | 1/31/2018 |

**11. The assessment plan should complement the issue-specific communication plan.**

The staff issued a communication plan (ADAMS Accession No. ML16057A419; not publicly available) prior to issuing the GIRP final screening report and Information Notice 2017-04, “High Energy Arcing Faults in Electrical Equipment Containing Aluminum Components,” dated August 21, 2017. This assessment plan is consistent with and complements the communication plan.

**12. Since the assessment plan proposes interactions with outside organizations, the staff will consider the following:**

A discussion should be included in the assessment plan to address the planned coordination with outside organizations, e.g, licensees, industry groups, the Advisory Committee on Reactor Safeguards (ACRS), and others as appropriate. The staff should consider involving appropriate industry groups such as the Nuclear Energy Institute (NEI) Owners' Groups, EPRI, or others.

- The NRC plans on making the research as collaborative and transparent as possible with due consideration of the effectiveness and efficiencies of performing this effort. Specific examples of planned / completed interactions include:
    - Public workshop held in April 2018 prior to any testing to present research plans and allow for active feedback and discussion

- Collaboration with EPRI under memorandum of understanding during testing and methodology development / update

- Periodic public meetings to provide status update of testing, preliminary results and planned actions

- Presentations at conferences and forums (e.g., NRC Regulatory Information Conference (RIC), NEI Fire Protection Information Forum, etc.)

B. The preferred approach is to conduct meetings open to the public and place the meeting minutes, with enclosures, in ADAMS.

C. Draft documents that are provided to, or received from, an outside organization should also be placed in ADAMS.

D. A NUREG report documents the results of tests. The RES project manager provides the responsible program office(s) with a copy for information, comments, and a formal technical review may be considered. Participation in the technical review process should be formally requested.