NRC Response to NEI concerns dated July 28, 2016 on Draft NUREG-2180

This enclosure contains the responses to concerns presented in the July 28, 2016, letter from Victoria K. Anderson of the Nuclear Energy Institute (NEI) to Richard Correia of the Nuclear Regulatory Commission (NRC). The letter contained three general concerns, which are identified as Statements 1, 2, and 3. A response is provided for each statement. The attachments to the letter were also reviewed by the staff and feedback on the information contained in those documents is provided under the heading titled "Feedback on Specific Attachments." The responses presented in this enclosure were also communicated in detail to NEI during a September 20, 2016 public meeting.

Statement 1: "…installation of incipient detection would result in detection of very early degradation and would enhance plant safety, the draft NUREG, as written, does not reflect this, and as a consequence, plants would be less likely to install and continually maintain VEWFDS."

Response 1: Earlier detection through the successful use of very early warning fire detection (VEWFD) systems can allow for additional time to response to potential fire threats. However, detection by itself, without appropriate automatic or manual actions to remove the potential fire threat does not equate to enhanced plant safety. The NRC is unaware of any VEWFD system that initiates an automatic fire suppression system to control and possibly extinguish the fire hazard. As such, NUREG-2180 assesses the human performance aspect that is required to enhance plant safety. This assessment is described in Sections 9 and 10 of the report and are based off of current operational practices as communicated to the staff during several site visits and phone interviews and used to develop a human reliability analysis (HRA).

Attachment 2 of the NEI submittal documents the results provided from the tabletop pilot using NUREG-2180. Even without detailed fire scenario information to allow the staff to perform an independent review, the results show a risk reduction when applying NUREG-2180. For utility 1, with the exception of one compartment, the compartment core damage frequency comparison between the current FAQ and NUREG-2180 were on the same order of magnitude. For utility 2, the application of NUREG-2180 indicates a risk improvement from a factor of 20 to a factor of 32 between halon only and halon with VEWFD systems using NUREG-2180 information. These results show a benefit (risk reduction) for installation of VEWFD systems when using NUREG-2180. An additional risk reduction of approximately a factor of 2 could be achieved when NUREG-2180 is used in conjunction with NUREG-2178, Vol.1., "Refining and Characterizing Heat Release Rates from Electrical Enclosures During Fire." Therefore, the NEI pilot results demonstrate that NUREG-2180 quantifies this enhancement to plant safety (i.e., risk reduction).

Statement 2: "Several aspects of the incompleteness are noted in the draft NUREG itself. For example, in Appendix D, the NUREG notes that the estimate included therein "likely does not represent the informed technical community's viewpoint. …"

Response 2: The statement, as written, does not reflect the staff's position or intent. The intent of this reference to expert elicitation is accurately reflected in the main body of the report (Section 15).

The purpose of this statement was to identify that a structured and facilitated process such as an expert elicitation (i.e., "informed technical community viewpoint") was not conducted. However, an extensive effort was undertaken to understand and characterize the duration of the incipient stage for electrical components. This was carried out by first identifying and collecting all available information from industries where applicable data exists. Then that dataset was reviewed to extract quantitative information to support the human reliability analysis

documented in Section 10 of NUREG-2180. The staff believes using relevant data is preferable to expert elicitation in PRA. However, expert elicitation is an approach that could have been used and is identified as a possible alternative approach (see Section 15 of NUREG-2180). Had a formal expert elicitation process been conducted, the process would have included collecting and reviewing all available information, as was done in the NUREG. Conducting an expert elicitation would likely have encountered some difficulties in identifying appropriate experts for this topic and may not yield better or different results. Since a formal expert elicitation was not conducted, the authors cannot predict what the results of such an effort would have been. Therefore, the statement was made in error and has been fixed for final publication.

In addition, the sensitivity study for the scenarios evaluated is presented in Section 12 of the NUREG. That sensitivity study, along with the NEI parameter variation analysis, demonstrates that the human error probabilities (HEPs), which use this timing information have minimal effect on the overall quantification results. Therefore, current operating practices as modeled in the NUREG indicate that changes to the incipient stage duration estimate (if any) will have little impact on the end result.

Statement 3: An additional aspect of the NUREG that requires additional clarification is the characterization of component only end state for fires. In the NUREG and supporting spreadsheet, this end state is not included in the event tree, which substantially limits the utility of VEWFDS and is does not comport with operating experience. The industry believes that this NUREG could be significantly improved by inclusion of operating experience in this area, as well as the previously mentioned area of the incipient phase characterization. To that end, the industry has summarized relevant information from the Fire Events Database (FEDB) to support better characterization of the incipient phase and component-only end state; this information is provided in Attachment 4.

Response 3: We agree that the Fire Events Database (FEDB) contains valuable information regarding fire behavior that has been and will continue to provide meaningful information to support development of realistic fire PRA methods. NUREG-2180 uses the FEDB as the basis for the development of the *fraction of fires that have an incipient stage*[1] and for the estimation of the incipient stage duration to support the human error probability estimate.

The stated concern and supporting information presented in Attachment 4 is not related to the incipient stage, but the post incipient stage, commonly referred to as fire growth or pre-growth stage. Ignition is the demarcation point between the incipient stage and subsequent fire growth stage. The information provided relates to the latter stage and is characterized by assumptions made in fire modeling of the electrical enclosure. NUREG-2180 does not provide fire modeling assumptions for cabinet fire growth and damage, as this activity was undertaken by a joint NRC/RES-EPRI initiative, which published the latest state-of-the-art approach to model electrical enclosure fires (see NUREG-2178 published April 2016). A second phase of this initiative is currently ongoing. NUREG-2180 relies on the latest state of the art methods to predict *time to damage* as an input to the NUREG-2180 non-suppression probability quantification. As such, the approach presented in NUREG-2180 uses the latest state of the art methods to estimate *time to damage*, and can accommodate to changes to modeling electrical enclosure fires, when and if they occur.

Attachment 4 also states that in 66% of the events reviewed the fires were successfully suppressed with damage limited to a single sub-component without any VEWFD system or in-

[1] (1-α) in the event trees shown in Figures 6-4 and 6-5 of NUREG-2180

cabinet smoke detection installed. Based on an independent review performed by the NRC-RES staff of the same events approximately only one-half of the events can be verified that damage was limited to a single sub-component during the fire event. The staff agrees that damage could potentially be limited to single sub-components for some subset of fire events given the installation of VEWFD systems or in-cabinet smoke detection. However, in order to credit this damage scenario a more in-depth evaluation of internal cabinet components would need to be performed.

NUREG-2180 acknowledges in Section 9.2.1 that de-energization is one strategy to respond to incipient fires. This strategy is one in which the end state is removing power from the affected cabinet (or part of the cabinet) and repairing the degraded component. Figure 9-2 of NUREG-2180 provides a generic depiction of this strategy. However, Section 9.2.1.1 notes that the personnel required and the actions needed will vary based on the components/equipment being de-energized (i.e. plant specific) and, thus, can be a simple or complex task depending on the components involved. As stated in Section 9.2.2.7:

> Some of the complexity associated with this task can be mitigated by pre-planning the steps needed to de-energize the cabinets. One strategy would be to "pre-locate" the isolation devices for all ignition sources within each cabinet in an effort to speed up the process. This would include predetermining the isolation devices, conveniently displaying that information for use in response to VEWFD alerts, training responders to rapidly locate and operate the isolation device(s), and conducting drills to periodically demonstrate this ability.

It should also be noted that utility comment on the draft version of NUREG-2180 related to de-energizing indicated:

> Removing power from a piece of equipment requires careful consideration of the operating impacts, Technical Specification compliance, and human performance pitfalls that could occur, all of which will vary based on the current plant conditions. It is unlikely that a plant would be able to generically prescribe actions to remove power from a cabinet or component the way this section suggests. There may only be a handful of components where this is possible.

NUREG-2180 (Section 10.6.4) provides discussion on how de-energization strategies might be modeled with HRA. This discussion includes examples of the specific steps that operators and technicians would need to perform for a successful de-energization. The discussion also emphasizes that de-energization strategies should be pre-planned and identifies key features of such a pre-plan that would be important in such HRA modeling. As discussed in both the July 2016 meeting with industry and the April 2016 public workshop, NUREG-2180 does not provide an illustrative HRA for a de-energization strategy because operational details to support such an analysis are very site specific. However, based on feedback from the September 20, 2016 meeting, additional clarifications regarding incorporation of the de-energization strategy have been added to the NUREG. A de-energization approach would necessitate performing a detailed human reliability analysis based on plant specific information to quantify human error probabilities (HEPs) and risk reduction.

Feedback on specific attachments:

Upon reviewing the provided attachments, the NRC staff has identified several statements that may misrepresent current state of practice. Attachment 1 states that "It is noted that for all methods except the latest NUREG-2180, there is a path that credits incipient detection preventing a fire from developing beyond ignition."

The cabinet damage approach in NUREG-2180 is consistent with the original limitations made in FAQ 08-0046. If licensees are using FAQ 08-0046 as the basis for limiting damage to single components without a more detailed cabinet specific evaluation (i.e., pre-locating isolation devices), a misapplication of the FAQ may be occurring. On the subject of internal cabinet damage prevention FAQ 08-0046 stated:

> To simplify the analysis, δ, the factor for the probability of failure to remove power from the device once it has been located, is set to 1. This is done because of the difficulty in assessing the likelihood of successful prevention.
>
> If a licensee desires to obtain more credit in this process, the more detailed NRC event tree may be used, including the branches with δ (with adequate and appropriate justification in the form of a detailed human reliability analysis). One way a licensee could achieve significant fire prevention credit would be to "pre-locate" the isolation devices for all ignition sources within each cabinet in an effort to speed up the process. If such an effort was taken, additional credit for preventing fires could be allowed. This would need to include predetermining the isolation devices, conveniently displaying that information for use in response to VEWFDS alerts, training responders so that they could rapidly locate and operate the isolation device(s), and conducting drills to periodically demonstrate this ability.

Attachment 1 indicates that "Credit was given to preventing the fire from damaging the source." However, adequate and appropriate justification in the form of a detailed human reliability analysis was not provided to support the using the prevention approach, as specified in FAQ 08-0046. Without adequate and appropriate justification in the form of a detailed human reliability analysis, the staff questions the suitability of crediting prevention and the associated numerical tabletop results.

Attachment 2 states under the "Evaluation using FAQ 08-0046" section that the FAQ 08-0046 non-suppression probability (NSP) of 0.02 is multiplied with Halon system NSP to give a total NSP of 1E-03. This is inconsistent with the FAQ 08-0046 guidance, which uses the "normal" non-suppression probability "ε2" in the event tree to calculate the total scenario non-suppression probability. When the guidance of FAQ 08-0046 is followed, the total NSP for this scenario doubles.

However, given the short time to damage for this scenario (approximately 4 minutes) and the fact that the Halon system is actuated by an ionization type spot detection (possibly cross-zoned), an analysis of the Halon system actuation and suppression of the fire prior to damage must be performed. NUREG/CR-6850 states on page P-6 under the bullet "Pr(failure auto sup)":

> The analyst must first determine that automatic suppression will actuate prior to the predicted time to fire damage or else auto suppression fails.

No supporting information on the success of the Halon system was provided with the tabletop pilot results. Without supporting details on the performance of the Halon system, the staff questions crediting the Halon system in the numerical tabletop results. However, given this limitation, the results from tabletop pilot exercise show that the use of NUREG-2180 provides a risk reduction.