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MEMORANDUM TO: Kevin Hsueh, Chief
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Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

FROM: Joseph J. Holonich, Senior Project Manager ***/RA/***
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SUBJECT: SUMMARY OF AUGUST 22, 2016, MEETING TO DISCUSS THE U.S. NUCLEAR REGULATORY COMMISSION STAFF EFFORT TO REVIEW ITS POSITION AND REGULATIONS ON COMMON CAUSE FAILURE

On August 22, 2016, U.S. Nuclear Regulatory Commission (NRC) staff met with representatives from the Nuclear Energy Institute (NEI), industry, and stakeholders. The purpose of the meeting was to discuss the ongoing NRC staff review of regulatory considerations related to the treatment of common cause failures (CCFs) in digital instrumentation and control (I&C) systems. The meeting was a Category 3 workshop with open participation available to all attendees. Information related to the meeting, including presentations and the attendees list, can be found in the Agencywide Documents Access and Management System (ADAMS) package accession number ML16174A049.

In its opening remarks, the NRC staff stated that as part of the meeting it would work through the control room heating, ventilation, and air condition (HVAC) chiller control examples that were discussed at the July 11, 2016, meeting. The purpose was to provide the staff's understanding of how it was possible to perform a defense-in-depth and Diversity (D3) analysis of non-reactor protection system (RPS)/engineered safety features actuation systems (ESFAS) modifications like the control room HVAC chiller control examples. (The minutes for the July 11, 2016, meeting can be found at ADAMS Accession No. ML16194A053). After the meeting, NEI provided additional comments to clarify its presentation. These comments are included in the enclosure to this report. The NRC staff did not have the opportunity to respond or address these comments during the meeting.

Continuing, the NRC staff noted that there was a need for a glossary of terms for use in discussing common cause failure. As an example, the NRC staff discussed how there was a difference in the NRC staff understanding and the NEI definition of bounding analysis. Industry also commented on the ambiguity of the term “D3 analysis.” Industry referred to a meeting held

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on February 24, 2014, and stated NEI and NRC agreed to distinguish the two distinct parts of a D3 analysis, as (1) the CCF vulnerability analysis and (2) the CCF coping analysis (which is conducted only when a CCF vulnerability cannot be precluded). The NRC staff did not agree with this interpretation during the meeting.

The NEI representatives stated in the opening remarks that NEI supported the need for the meeting and the need to discuss the challenges facing industry in addressing CCF. Also, the NEI representatives stated that there was a need for alternate preventive measures, other than those currently defined in Branch Technical Position (BTP) 7-19 (i.e., simplicity and diversity) that can be credited in the CCF vulnerability analysis for determining that a CCF coping analysis is not necessary.

NRC Staff Perspective on the Control Room Chiller Controllers

Using the information provided by NEI at the July 11, 2016, meeting, the NRC staff performed the tabletop exercise in a step-by-step fashion. The objective was to illustrate an approach to perform a D3 assessment for the replacement of analog control room chillers controllers with digital systems. The NRC staff based the exercise on the current guidance in the Staff Requirements Memorandum (SRM) for SECY 93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light Water Reactor (ALWR) Designs” (ADAMS Accession No. ML003708021); BTP 7-19, “Guidance for Evaluation of Diversity and Defense in Depth in Digital Computer Based Instrumentation and Control Systems,” Revision 6 (ADAMS Accession No. ML070550075); and NUREG/CR-6303, “Method for Performing Diversity and Defense-in-Depth Analyses of Reactor Protection Systems” (ADAMS Accession No. ML071790509).

At the end of the presentation, industry representatives commented on their interpretation of Point 1 of Section 1.4 of BTP 7-19, and its relationship to the other points. In particular, industry representatives expressed the desire to include additional preventive measures in Section 1.9 for excluding CCF from further consideration.

During this discussion, it was evident that there is disagreement between the NRC staff and industry on the interpretation of Point 1, and in particular Section 1.9. The NRC staff clarified that its interpretation of BTP 7-19 is that it should be assumed that CCF is credible (as stated in Section 1). Therefore, a D3 analysis is necessary to determine CCF vulnerabilities. Industry representatives noted that they understood that the methods in Section 1.9 identify acceptable means for precluding a CCF vulnerability and not performing an additional CCF coping analysis. Therefore, there is a need to evaluate vulnerabilities to CCF, but no need to conduct further analysis if the preventive measures are sufficient to preclude a CCF vulnerability. The NRC staff and the NEI representatives did not align on respective interpretations during the meeting.

Specifically the industry representatives stated that their understanding was that if a CCF is considered "not credible" then Points 2 and 3 of the 4-point position (in Section 1.4 of BTP 7-19) are not applicable. Based on this discussion, participants agree that Point 1 in BTP 7-19 requires clarification. Attendees agreed to add this to the action items of this meeting to work on this item in further interactions.

In its second presentation, the NRC staff provided more specific feedback to the NEI and industry representatives on the chiller examples discussed at the July 11, 2016, meeting. The NRC staff feedback was based on information that was provided by NEI in the July 11, 2016,

presentations. The NRC staff commented that the NEI presentations describing proposed design attributes for determining "CCF unlikely" did not clearly provide a technical basis the staff could credit in identifying an adequate level of assurance. Industry commented that staff is trying to achieve 100 percent assurance, which is not possible. Industry believes the goal should be to drive the likelihood of digital CCF to a level that is equivalent or less than other sources of CCF that are excluded from deterministic safety analysis. This includes CCF sources, such as an earthquake that exceeds the design basis or an environment or EMI source that exceeds the qualification envelope. The goal for CCF prevention must be reasonable assurance, not 100 percent assurance.

In addition, the NRC staff considers that in the short term it would be more efficient to clarify the applicability of the use of bounding and coping analyses (as described in the current guidance) to non-RPS and non-ESFAS applications, than it would be to credit NEI's proposed design attributes enabling applicants to justify a "CCF unlikely" conclusion. However, in the longer term, the NRC staff would consider proposals for technically supported analyses (other than sufficient simplicity and sufficient diversity) to eliminate CCF from further consideration.

The NRC staff stated at the end of its presentation that it needs more information about the industry's challenges associated with BTP 7-19, and how these challenges might be addressed in the NEI guidance, NEI 16-XX, being developed. Finally, the NRC staff stated it would like to explore the reasons why a D3 analysis for a modification like the Control Room Chiller Controllers example is considered overly burdensome. Industry representatives explained that it is not clear how a favorable coping analysis would be addressed in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.59 (especially question 6).

Continuing, the NRC staff provided feedback about the non-concurrent triggers explanation provided by NEI after the June 7, 2016, meeting. The staff stated it did not perceive a technical basis exists to support the non-concurrent trigger argument to eliminate software based or software logic based CCF from further consideration. Also, the NRC staff indicated that it found this concept problematic and not clearly acceptable. Industry responded to the technical questions provided by the staff.

NEI Information Relative to the Chiller Example

NEI provided the following presentations: 1) Address NRC staff questions on the chiller example from the July 11, 2016, meeting; 2) Discuss barriers to implement digital I&C systems at plants; and 3) Provide recommendations for changes to BTP 7-19 to overcome those barriers.

During the first presentation, industry provided responses to the NRC's questions regarding the chiller controllers' example. The NRC's questions were sent to NRC before this meeting. During the discussion, the NRC staff clarified its position that "a conclusion of CCF unlikely or not credible" does not mean that vulnerabilities to CCF have been adequately addressed," as stated in the industry response provided in slide 11 of the presentation "Control Room Chiller Example." Industry responded that a conclusion of digital CCF unlikely is sufficient to preclude further consideration of CCF in deterministic safety analysis, as it is sufficient for other sources of CCF (e.g., a CCF due to an EMI disturbance is sufficiently unlikely to preclude further consideration when the equipment is appropriately qualified); further consideration of CCF due to all sources, including digital, is appropriate for consideration in the PRA.

In addition, participants agreed that definitions of the following key terms need to be standardized:

- Coping analysis
- Bounding analysis
- D3 Analysis
- Susceptibility analysis
- Vulnerability analysis
- Sufficiently simple

In the second presentation, NEI described the barriers to implement digital upgrades. Using a flowchart, the NEI representatives explained the steps licensees and applicants need to follow to decide on using digital replacements for I&C systems. Based on this discussion, the NRC staff understood that one of the challenges is how to perform a coping analysis to demonstrate that further consideration of CCF is not necessary. Furthermore, NEI noted that applicants are not certain on how a coping analysis can be used when performing an evaluation under 10 CFR 50.59, especially, to answer question number 6 of the criteria.

In the last presentation, NEI presented eight areas for improving BTP 7-19. For each area, NEI described the perceived problem and its desired resolution. With the exception of the recommendation on design attributes to eliminate consideration of CCF (Section 1.9 of BTP 7-19), the NRC staff agreed with the areas suggested. The NRC staff noted that these areas can be addressed in the short-term. Regarding design attributes, the NRC staff reiterated that the proposed methods will require long-term efforts for their evaluation and acceptance. Industry pointed out that their position is the need for long-term efforts should be driven by the need for NRC policy changes; there is no need for an NRC policy change before the staff can add more technical attributes to Section 1.9 of BTP 7-19, since that section already contains two technical attributes that provide a precedent for eliminating consideration of CCF.

Resumption of Chiller Controls Discussions

After the presentations, the NRC staff and industry had individual breakout sessions to discuss items presented and propose resolutions.

When attendees reconvened, the industry offered comments on the NRC staff presentation on the tabletop exercise. These comments are contained in the enclosure to these minutes.

The NRC staff summarized the items discussed during the presentations. Specifically, the NRC staff considers that there was agreement regarding the following:

1) Definition of scope of a CCF vulnerability analysis is needed. This may be handled in guidance.
2) Guidance on CCF is required for licensees, license reviewers, and inspectors.

In addition, the NRC staff described the following items in which further alignment or discussion will be necessary:

1) With respect to the technical adequacy of "CCF unlikely" concept proposed by industry: This may be a long-term technical evaluation issue that may also require a policy change; industry stated they will replace “CCF unlikely” with “CCF requires no further

consideration" for consistency with BTP 7-19 and to thereby avoid any need for a policy change.
2) There is a need to reach alignment on the definitions of the terms previously listed.
3) The acceptance criteria in BTP 7-19 needs clarification (e.g., explain what it means to be "bounded" for 10 CFR 50.59, question 6).

Also, NRC staff and industry further discussed whether Point 1 of the SRM for SECY-93-087 can be fulfilled via Section 1.9 of BTP 7-19 where "design attributes [can be used] to eliminate consideration of CCF." Based on this discussion, participants agreed that clarification on Section 1.9 is needed, as was stated previously.

At the end of this discussion, the NRC staff pointed out that at this time, the NRC staff needs to make a decision on whether to continue with the activity identified in the Integrated Action Plan or to focus on addressing the issues associated with BTP 7-19 in the short-term, and in the long-term continue its evaluation of the current NRC policy. The NRC staff asked industry to provide a recommendation on this issue. This item was included in the action items for this meeting.

The NRC staff stated in its closing remarks that there was a need to identify what path gets to regulatory certainty for the CCF issue most efficiently. The NRC staff also noted that agreeing on terminology was necessary to achieve regulatory certainty. The NRC staff also agreed to work with industry representatives to address the obstacles perceived in BTP 7-19.

The NEI representatives closed by stating that the meeting provided more frank discussions and understanding of the issues than previous meetings. However, they noted that meetings have been held over the past six months on CCF. The industry digital I&C Executive Committee was not certain that meaningful progress is being made or whether resolution was any closer than when the series of meetings started in January. Also, the NEI representatives emphasized that there was a need to make progress and a focus on short-term wins. It was agreed that more frequent interactions would be held. An action from the meeting was to schedule, publically-noticed, open biweekly calls to discuss topics in more depth and more frequently.

The following action items were identified at the meeting:

1) The NRC staff will work to clarify Section 1 of BTP 7-19 considering NEI, industry, and stakeholder involvement and input.
2) NEI will provide a recommendation to move forward on the effort to address CCF.
3) The NRC staff and NEI representatives will arrange publically noticed, open biweekly calls.

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Nuclear Energy Institute Comments on the
U.S. Nuclear Regulatory Commission Staff Presentation
at the August 22, 2016, Common Cause Failure Tabletop Meeting

Nuclear Energy Institute (NEI) Comments on "NRC FEEEDBACK ON NEI/EPRI [Electric Power Research Institute] CCF [Common Cause Failure] EVALUATION METHODS FOR THE CONTROL ROOM HVAC [heating, ventilation, and air condition] CHILLER CONTROLS TABLETOP EXERCISE"

Slide #8

- Completion of a D3 Analysis would demonstrate the CCF is credible, but the consequences of a CCF can be shown to have minimal safety impact. (No new adverse safety impact.)

NEI Comment: A CCF susceptibility analysis could also demonstrate that CCF is not credible thus making a D3 (CCF coping) analysis unnecessary. Starting with the assumption that CCF is credible is not a correct interpretation of BTP 7-19 or SECY 93-087.

- Why not complete the D3 analysis and demonstrate the CCF can be tolerated using manual procedures and/or technical specification actions?

NEI Comment: A D3 (CCF coping) analysis is unnecessary additional work when the CCF susceptibility analysis has demonstrated that a CCF is not credible. Demonstrating manual coping in accordance with SRP 18-A can be very onerous and costly. Also, for many digital upgrades, although it may be possible to demonstrate adequate coping with the CCF, it may not be possible to demonstrate that the resulting malfunction result is bounded by previous analyses.

Slide #11

- Staff Question: What about a residual latent defect in the Application Software or its requirement

NEI Comment: This is a special purpose controller for the chiller. It does not distinguish an operating system and application software, as is typically found in a general purpose controller. Regardless, we have accepted the presence of a software defect regardless of how or where it may reside, or have originated. The point of our methodology is that even with that defect, non-concurrent triggers make the CCF not credible.

Slide #12

- NRC Staff Notes, however, the worked example did not really include all the details of a coping analysis (—assume this was for brevity.)

NEI Comment: Yes, it was omitted for brevity for that meeting. The staff's comment illustrates our concern that a completely justified coping analysis is a very onerous and costly activity that is not necessary when a CCF vulnerability analysis demonstrates that further consideration of a CCF is not required.

Enclosure

Slide #13

- Industry participants stated that for this example (using coping analysis) they did not see a problem with the application of current NRC policy (defined in SRM-SECY 93-087) and guidance in BTP 7-19

  NEI Comment: Yes, but we did identify that it is not clear how to translate coping with the chiller failure into bounded for the answer to 50.59 Question 6.

Slide #14

- The staff does not understand the reasons why, for this example, the control room HVAC chiller controls modification was placed "on hold."

NEI Comment: The primary reason given was to avoid the potential need for a LAR with an uncertain outcome from a technical, cost and schedule basis. Additional reasons included: 1- Uncertainty in the extent of documentation required to demonstrate coping. 2- Uncertainty in understanding how to translate coping to bounded for 50.59 question 6.

Slide #16

- Modified chillers configuration

NEI Comment: There was no modified configuration. We presented two different chiller applications, each with distinct design and operations attributes.

- LOOP consideration – bounded by SBO analysis

NEI Comment: For this example, there is no CCF because only one chiller is in operation at any time. Therefore, a "single failure" of the running chiller during LOOP is a design basis event. This design basis event is managed by the current two division design, in which a high room temperature will start the chiller in the second division automatically. We should not have discussed SBO for this scenario, because SBO is a beyond design basis event.

Slide #17

- What about software failure mechanisms other than the accumulation of a set of internal states responding to external triggers?

NEI Comment: The industry position is that failures can occur due to:

1 - An accumulation of internal state
2 - External triggers
3 - A combination of internal states and external triggers.

These are all transient conditions with a very narrow activation window. Since 1, 2, and 3 are different (or diverse) in both divisions, a concurrent trigger is not credible.
We believe the staff is confusing sources of a design defect, of which there are many, with the methods of triggering that defect, which are few (as defined above). Our methodology assumes a defect exists, regardless of how that defect may have originated. What is important is the trigger of the defect which causes a failure, not the mere presence of the defect.

Slide #18

- Rare possibility of the right combination of internal state histories and/or the right external inputs to trigger a software trajectory with a defect

NEI Comment: This should read "The right external inputs to trigger the same software trajectory with the same defect. Only one defective software block must be considered, per NUREG 6303."

Slide #19

- Staff understands this system was implemented using "Commercial Grade Dedication" processes, and the details of the software design are not fully known. There are many forms of software failure mechanisms besides internal states encountering the right triggers.

NEI Comment: The details are not always known (in many cases they are), but the resulting product is always equivalent to a item developed under Appendix B. So the likelihood of a defect is the same. We address both internal and external triggers and a combination of both. There are many sources of defects, but not many sources of triggers. This is a key concept that must be distinguished.

- Why is only this one mechanism addressed?

NEI Comment: Need clarification on what other failure mechanisms should be but are not covered. Again, we think the staff is confusing sources of defects with sources of triggers.

- What technical basis shows it is sufficient to demonstrate CCF can be eliminated from further consideration?

NEI Comment: The technical basis is that the demonstration of non-concurrent triggers facilitates a conclusion that the likelihood of a CCF is as low as other sources of CCF that are not considered in the plant's deterministic safety analysis. Other sources of CCF that are not considered include an earthquake that exceeds the EQ design basis, an EMI burst that exceeds the EQ design basis, an electrical fault that exceeds the EQ design basis, a maintenance error, or an operator error. If the likelihood of a software CCF due to a digital design defect can be made as low or lower than the other sources of CCF that are already excluded, then the software CCF can be eliminated from further consideration in deterministic safety analysis. A CCF due to a digital design defect or any of the sources that are not considered in deterministic safety analysis is still considered in the PRA.

Slide #20

- Industry representatives agreed that this is an area that requires further investigation

NEI Comment: This was our position at the July 11 meeting. But we have provided the technical basis for our non-concurrent trigger conclusion in the follow up material. We do not intend further investigation on this issue but plan more discussion on this issue during the NEI 16-XX interaction with the staff.

- Industry representatives stated that this example is consistent with current NRC policy (defined in SRM-SECY 93-087), but there are challenges associated with BTP 7-19

NEI Comment: This is consistent with NRC policy because Section 1.9 of BTP 7-19 clarified the policy to allow design attributes that eliminate the need for further consideration of CCF. But

currently, BTP 7-19 does not permit other preventive measures beyond diversity and simplicity (100% testing); so this is a key part of BTP 7-19 that requires revision.

Slide #21

- The staff does not perceive a technical basis exists to support the non-concurrent trigger argument to eliminate software based or software logic based CCF from further consideration.

NEI Comment: That consideration should be in the PRA. The preventive measures resulting in non-concurrent triggers is sufficient to make the likelihood of CCF equivalent or less than other sources of CCF that are not considered in deterministic safety analysis.

- The staff needs more information about the industry's challenges associated with BTP 7-19, and how these challenges might be addressed in NEI 16-XX.

NEI Comment: A key challenge is that BTP 7-19 offers only two methods to reach a conclusion that further consideration of CCF can be eliminated. When that conclusion is not reached, it is practical (although onerous) to demonstrate coping for many digital applications, but it may not practical to demonstrate bounded for 50.59 question 6. NEI plans to provide the industry perspective regarding changes needed to BTP 7-19 and additional details on the contents of NEI-XX in the near future.

- The staff would like to explore the reasons why a D3 analysis for a modification like the Control Room HVAC Chiller example is considered overly burdensome.

NEI Comment: A CCF vulnerability assessment and CCF coping analysis can both be highly burdensome and costly. A CCF coping analysis can be especially burdensome where compliance to SRP 18-A must be demonstrated for credited manual actions. Licensees need the flexibility to decide which is less burdensome for each specific application. Beyond the analysis burdens, the more significant problem is that coping and bounded are different; a demonstration of coping may not be a demonstration of bounding for 50.59 question 6.

NRC TABLETOP EXERCISE: HVAC CHILLERS CONTROLS

Slide #6
Flow chart requires addressing Points 2 and 3 of BTP 7-19.

NEI Comment: Why is Point 1 skipped? Point 1 says "demonstrate that vulnerabilities to common-mode failures have adequately been addressed." Section 1.9 says "there are two design attributes, either of which is sufficient to eliminate consideration of software based or software logic based CCF."

Slide #8
We believe a D3 analysis is required when installing a digital system.

NEI Comment: Two years ago, NRC and Industry reached agreement that there are two parts to a D3 analysis (1) a CCF vulnerability (or susceptibility) analysis and (2) a CCF coping analysis, for the cases where further consideration of a CCF cannot be eliminated. Therefore, a CCF vulnerability assessment is always needed, but a CCF coping analysis is needed only when the CCF vulnerability assessment concludes that there is a CCF vulnerability.

Slide #14
- Identical controllers configuration. So design defect**s** will affect both chillers

NEI Comment: NRC policy requires consideration of only one defective software block, not multiple blocks with different defects. So in the sentence above “defects” should be singular.

Slide #15
- The chiller safety function is not credited in the accident analysis in Chapter 15 of FSAR

NEI Comment: Not directly, but indirectly to maintain environment for other equipment that is credited.
- Per analyzed event, failure of the chillers did not disable the credited safety functions of the Reactor Trip or ESFAS - (Assuming adequate indication of the chiller failure to and response by plant operators)

NEI Comment: This implies that an adverse effect on ESF controls or components, or RG 1.97 indications, would be acceptable. We do not believe that to be the staff's position; industry believes the potential for these additional adverse effects should be considered.