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NLS2017096
October 31, 2017

Mr. Jason Kozal
Chief, DRP Branch C
U.S. Nuclear Regulatory Commission, Region IV
1600 East Lamar Boulevard
Arlington, TX 76011-4511

Subject: Additional Risk-Related Information for November 7, 2017, Regulatory Conference
Cooper Nuclear Station, Docket No. 50-298, DPR-46

References:

1. Letter from T. Pruett, U. S. Nuclear Regulatory Commission, to J. Dent, Nebraska Public Power District, dated August 14, 2017, "Cooper Nuclear Station - NRC Baseline Inspection Report 05000298/2017011 and Preliminary White Finding"

2. Letter from J. Dent, Nebraska Public Power District, to J. Kozal, U. S. Nuclear Regulatory Commission, dated August 23, 2017, "Nebraska Public Power District Request for Regulatory Conference"

Dear Sir:

The purpose of this letter is to provide additional information in support of the November 7, 2017, Regulatory Conference with Nebraska Public Power District.

In Reference 1, the U. S. Nuclear Regulatory Commission (NRC) identified a preliminary white finding with two apparent violations associated with inadequate procedures for inspecting and conducting testing on the non-safety related Emergency Station Service Transformer 4160V non-segregated bus (Emergency bus) which is one of the station's standby offsite power sources to the two safety related critical buses. This finding resulted from the NRC's review of a January 17, 2017, fault on the Emergency bus. There were no adverse consequences to plant operation because of the bus fault, except for the loss of the Emergency offsite power source for less than 5.5 days of the Technical Specification 3.8.1 7-day Limiting Condition for Operation, and the inability to align the Supplemental Diesel Generator, if needed, for that same period. On August 23, 2017, Cooper Nuclear Station (CNS) submitted a letter (Reference 2) to the NRC documenting the option to attend a Regulatory Conference. The NRC has scheduled a Regulatory Conference for November 7, 2017.

CNS agrees with the violations as characterized in the NRC's inspection report. CNS has taken actions to improve the inspection and testing to ensure reliability of the non-safety related buses that supply offsite power to the station, in accordance with 10CFR50.65, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." CNS concludes, however, based on

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additional information, that the risk significance of this finding, including both internal and external events, is best estimated as very low risk in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." This best estimate does not include, consistent with NRC Inspection Manual Chapter 0609: Attachment 4, "Initial Characterization of Findings," a hypothetical consequential Startup Station Service Transformer bus (Startup bus) failure. The degraded condition on the Emergency bus that led to the January 17, 2017, fault did not cause a Startup bus fault. In addition, CNS has validated, through both engineering evaluation and mock-up testing, that a similar Emergency bus fault would not result in a consequential failure of the Startup bus. The best estimate does include enhancements based on implementation of FLEX mitigation strategies and new information concerning the proceduralized recovery of offsite power by backfeeding through the Normal Station Service Transformer bus (Normal bus) following a plant transient, if the Emergency bus and Startup bus sources are not available. Information that supports this conclusion, and that will be discussed at the Regulatory Conference, is summarized in the attachment to this letter, and supported by additional documentation provided in the enclosures.

CNS appreciates the opportunity to further discuss the details surrounding this preliminary white finding at the Regulatory Conference. Should you have any questions regarding the information presented in this letter, please contact Jim Shaw, Licensing Manager, at (402) 825-2788.

This letter contains no regulatory commitments.

Sincerely,

John Dent, Jr.
Vice President - Nuclear and
Chief Nuclear Officer

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Attachment: Evaluation Summary

Enclosures:

1. Apparent Cause Evaluation – CR-CNS-2017-00223, Rev. 2 – Phase-to-Phase Fault of ESST Non-Segregated Bus
2. CNS-ER-2017-053, "SSST Bus Inspection Report"
3. Engineering Study – PSA-ES122, Rev. 1, "Additional Information for the January 2017 ESST Fault Significance Determination"
4. CNS-ER-2017-051, "Summary of CNS ESST Bus Fault Analysis and Testing"
5. CNS-ER-2017-048, "SSST Bus Duct Evaluation Considering ESST Bus Arc Fault Event"
6. CNS-ER-2017-050, "Justification for ESST Bus Duct Test Specimen Configuration"
7. CNS-ER-2017-052, "Test Report of ESST Bus Fault Simulation Testing"

cc: Document Control Desk w/attachment and enclosures
USNRC

Regional Administrator w/attachment and enclosures
USNRC - Region IV

Director, Division of Reactor Projects w/attachment and enclosures
USNRC - Region IV

Cooper Project Manager w/attachment and enclosures
USNRC - NRR Plant Licensing Branch IV

Senior Resident Inspector w/attachment and enclosures
USNRC - CNS

NPG Distribution w/attachment and w/o enclosures

CNS Records w/attachment and enclosures

Attachment

Evaluation Summary

Table of Contents:

This attachment provides a detailed summary of evaluations conducted by Cooper Nuclear Station (CNS) that are associated with the January 17, 2017, Emergency Station Service Transformer (ESST) bus (Emergency bus) fault and the additional information to demonstrate that the safety significance is very low vice the preliminary low-to-moderate safety significance discussed in NRC Inspection Report 50000298/2017011.

A. Discussion of Offsite Power Sources

At CNS the AC Electrical Distribution System consists of the 22kV Main Generator, Main Power Transformers, and the 345 kV and 161 kV switchyards, to supply power to the main grid system. Station 4160V power is supplied by the Normal Station Service Transformer (NSST) (Normal bus) or the Startup Station Service Transformer (SSST) (Startup bus), depending on the plant operating status. The station has emergency power supplied from either the non-safety-related ESST (Emergency bus) or the safety-related Emergency Diesel Generators (EDGs). Additionally, a single Supplemental Diesel Generator (SDG) is available to provide power for a single 4160VAC Critical Bus during a Station Blackout (SBO) or Loss of Offsite Power (LOOP) with an EDG unavailable. The Normal, Startup, and Emergency buses transmit power using metal enclosed non-segregated bus ducts. It was in a section of the Emergency bus duct that the fault occurred on January 17, 2017.

The NSST steps down the 22 kV Main Generator output to provide station house loads, when the generator is online. The NSST is energized from the Main Generator isolated phase bus which feeds the Main Power Transformers. The Normal bus provides the normal source of AC power to the 4160V distribution system when the generator has been synchronized to the grid and is operating above 20% electrical power. It provides power to the non-safety related buses 1A, 1B, 1C and 1D. Buses 1A and 1B are normally aligned to the NSST during Main Generator operation and supply power to safety-related critical buses 1F and 1G. Each of the 1C and 1D buses supply power to one of the Reactor Recirculation Motor-Generator Sets. Normally one of these buses is supplied from the NSST and the other from the SSST. This alignment prevents a Scram if the Startup bus is lost during operation and ensures forced reactor circulation following a Scram. When the generator is not online, the Normal bus can be back-fed from the 345 kV Switchyard by way of the Main Power Transformers after Main Generator flexible links are removed to prevent the generator from being energized. This configuration is controlled per Procedure 2.2.18, "4160V Auxiliary Power Distribution System," and requires a pre-assembled protective relay panel, located in the West Warehouse, to be installed in the Control Room.

The SSST steps down power from the 161 kV switchyard, with two low-side windings, X-Winding and Y-Winding, to provide power to two separate 4160V buses. The Startup bus is the preferred source of offsite AC power to the station whenever the Main Generator is off-line. The transformer is normally energized to provide for quick automatic transfer of non-safety related buses 1A and 1B to the SSST if the NSST fails or the Main Generator trips off-line. Buses 1A and 1B normally supply power to safety-related critical buses 1F and 1G.

The ESST steps down power from the 69 kV switchyard and is the preferred emergency AC power source. The Emergency bus is energized and unloaded during normal conditions and is fed by the 69 kV bay located in the 161 kV switchyard. This transformer is used to supply the plant's critical 4160V loads in case both the NSST and the SSST are not available for service. In the event both the normal and startup power sources are lost, the Emergency bus will supply the critical 4160V buses 1F and 1G.

The safety-related Emergency Diesel Generators (DG-1 and DG-2) provide the necessary power to safely shut down the reactor with a LOOP, which is normally supplied from the non-safety-related but preferred Startup bus and Emergency bus sources. A plant transient which causes a generator trip results in loss of power from the NSST and an automatic fast transfer to the SSST. The loss of both the Startup bus and Normal bus to either critical bus results in the automatic connection to the Emergency bus and automatic starting of the respective EDG. If the ESST also fails or is unavailable, the EDG output breaker will close when the EDG has reached rated speed and voltage, restoring power to the affected critical bus.

The SDG is an additional source of power to recover a single critical 4160 VAC bus during a SBO. It is designed to provide power to selected loads on plant buses 1F or 1G in order to maintain the reactor in a hot standby condition or to transition and maintain the reactor to cold shutdown conditions by manual Operator action only. The SDG can also provide an additional source of power to CNS in the event of a LOOP concurrent with one EDG being unavailable. The SDG shares the Emergency bus with the ESST. Either supply can be isolated by motor operated disconnect switches (MODS). If the SDG is aligned to one of the critical buses, the ESST is not available to supply bus load due to the ESST and SDG MODS being interlocked.

B. Offsite Power Maintenance Rule Status

Prior to the event on January 17, 2017, the Maintenance Rule Function EE-PF10, which monitors the ESST function, was in (a)(2) status and was moved to (a)(1) status due to the January 17, 2017, failure. Up to that point the function had 0.51% unavailability accrued against it with a criterion limit of 3.0% during a rolling 36 month period. After the January 2017 event the unavailability raised to 1.04%.

C. Apparent Cause Evaluation – CR-CNS-1017-00223, Rev. 2 (Enclosure 1)

On January 17, 2017, CNS experienced a phase-to-phase electrical fault on the non-segregated bus that supplies the critical buses from the ESST, one of the two credited offsite AC power sources. Per Technical Specifications, a 7-day shutdown action was entered at 1644 CST. Immediate actions included repair of the bus, inspection of the entire ESST non-segregated bus, and testing of the ESST transformer. Operability of the ESST was restored on January 23, 2017, at 0138 CST. The SSST bus (the other credited offsite AC power source) immediately below the faulted area was not damaged. The direct cause of the fault was degraded bus bar insulation due to electrical corona, together with electrical tracking across the surface of the adjacent bus support. The apparent cause was a lack of organizational understanding of possible failure mechanisms of this equipment, with a contributing cause of electrical testing of the bus that was inconsistent with industry guidance and which in turn reduced the probability of detecting a degraded condition. The potential extent of condition was the SSST non-segregated bus that supplies plant distribution switchgear. That bus was subsequently inspected and found to be in good overall condition, and although there were indications of corona on the SSST bus, those indications were much fewer and less severe, and there were no signs of bus support tracking. The procedure governing periodic bus inspections was revised to ensure that electrical testing of the bus will be performed as recommended by industry guidance, and that a more thorough periodic inspection will be performed considering this event. The ESST and SSST buses were subsequently satisfactorily tested under the revised guidance. The ESST non-segregated bus insulation will be replaced, and measures will be taken to reduce or eliminate the conditions that can cause electrical corona to be present, for both the ESST and SSST buses. Additionally, training related to bus inspections and this event will be re-evaluated and revised as appropriate.

D. CNS-ER-2017-053, "SSST Bus Inspection Report" (Enclosure 2)

During the week of September 25, 2017, CNS performed an inspection of the two 4160V non-segregated buses that deliver power from the SSST to the four non-safety-related switchgears; A, B, C, and D. The inspection was performed per Preventative Maintenance work order 5069489 which is performed on a ten year frequency. The inspection includes a visual inspection of the buses' insulation, bus connections, and structures. The inspection also performs Hi-Pot testing and Low-Resistance testing to further validate that the bus is isolated from ground and that all the bolted connections are in an acceptable condition. Based on the inspection results, it is concluded that the SSST buses are in an acceptable condition with only minor issues identified, none of which threatened the buses' ability to perform their function. Any defect found that was deemed to be more than superficial was repaired per work order 5203744.

E. Engineering Study – PSA-ES122, Rev. 1, "Additional Information for the January 2017 ESST Fault Significance Determination" (Enclosure 3)

This study provides new additional information and concludes that the best estimate increase in core damage frequency, including both internal and external events, is in the order of 3.8 E-7 over the 151-hour exposure period. This is based on:

1. The hypothetical consequential failure of the SSST bus because of an ESST bus fault should not be included in the final Significance Determination Process (SDP). The ESST bus failure on January 17, 2017, did not cause a consequential failure of the Startup bus. The preliminary SDP assumed, hypothetically, that the Startup bus would be damaged and lost 25% of the time that an Emergency bus fault would have occurred. This should be excluded because it appears to be inconsistent with IMC 0609, Attachment 4, Section 04.c, which states as an entry screening condition into the SDP, "*State the facts pertaining to the degraded condition or programmatic weakness without any hypothetical situations, failures, or occurrences.*"

   Further, CNS performed extensive, bounding laboratory testing and analysis (as discussed below) which confirmed that damage from other postulated Emergency bus faults would be limited to the Emergency bus without a consequential Startup bus failure. Testing and analysis also concluded that an Emergency bus fault would not have resulted in the failure of the Startup bus if the Emergency bus fault had occurred at more susceptible locations that included the areas between external bus duct supports, and areas of the flexible expansion boots.

2. Inclusion for FLEX mitigation strategies and modeling changes are based on FLEX implementation procedures and thermohydraulic analysis documentation. As partially reflected in the preliminary SDP, CNS FLEX strategies provide very effective capabilities to mitigate the significance of a SBO event. CNS has completed additional Human Reliability Analysis to develop failure probabilities for FLEX mitigation actions including alignment of the FLEX portable diesel generators for charging of the safety related DC power supplies. Further analysis of FLEX strategies and associated thermohydraulic analyses demonstrated that FLEX early containment venting through the hardened vent path to maintain the containment pressure between 5 and 15 psig would allow for additional time to recover AC power in the situation where either Reactor Core Isolation Cooling or High Pressure Coolant Injection were operating in the long-term, because action to power the DC battery chargers was successful.

3. CNS has the additional information required to adequately include the NSST backfeed offsite power source into the significance determination. CNS has completed actual field demonstrations and table-top discussions to provide a backfeed implementation timeline that conservatively reflects backfeed feasibility within 17 hours. CNS awareness of the importance of the NSST backfeed capability is seen in its implementing procedures, training, and prestaging of materials necessary for backfeed implementation. Attachment 3 of this study provides a detailed timeline review of the NSST backfeed actions.

This study also discusses several issues that make the best estimate increase in core damage frequency conservatively high. These include:

- Review of the preliminary significance determination found that, absent the hypothetical 25% likelihood of a consequential SSST bus failure, the SSST bus common cause failure probability is the dominant contributor to significance. The offsite power ESST and SSST buses are non-safety related passive standby components meaning that they do not need to change state to perform their safety function. The active components in the offsite power system are the in-plant circuit breakers that have a non-safety related function to close in order to provide power to the safety buses as well as a safety-related function to open to isolate and allow the EDGs to provide power to the safety buses, in the event of a LOOP.

Specifically, assumptions made to assess the susceptibility of the SSST to failures similar to the ESST fault (common cause) are uncharacteristic of the CNS current configuration. Also, due to the fact that there is no industry data available to statistically develop common cause likelihood of a passive bus, the NRC preliminary significance numerical approach used to apply common cause is correspondingly high in uncertainty.

The preliminary SDP application of active component generic common cause failure data for passive components such as the ESST and SSST could be conservative. CNS has found that the environmental condition, one of the coupling factors for determining a common cause group, of the SSST bus bears little similarity to the susceptible ESST bus. Documentation detailing the satisfactory condition of the SSST bus is available that provides results of visual inspections of the entire bus. Insulation integrity testing results are available for the SSST bus to further eliminate the need to assume a high likelihood of common cause failure.

- Inclusion of more realistic Stuck Open Relief Valve failure probability. CNS data analysis indicates that a value of 8.1 E-3 per Safety Relief Valve operations is more appropriate than the 1 out of every 10 events used in the preliminary SDP.

- Cutset review shows situations where one of the EDGs is probalistically assumed to be in a test and maintenance condition while the Emergency bus is failed. This condition would require Operations to enter a 36-hour Technical Specification hot shutdown Limiting Condition for Operation. So application of the 151 hour exposure time to these cutsets produces a conservative total result.

F. Evaluation and Testing of ESST Bus Fault Impact on SSST Bus

CNS completed an engineering evaluation and mockup testing which demonstrated that the Startup bus was not susceptible to damage which would cause a Startup bus fault given a fault on the Emergency bus. These evaluations and testing were summarized in CNS Engineering Report (ER) 2017-051, "Summary of CNS ESST Bus Fault Analysis and Testing" (Enclosure 4) which concludes:

> *The 'SSST Evaluation' assessment performed a conservative evaluation considering an ESST arc fault induced pressure wave to escape from a breach in the ESST duct, and impact the SSST duct below. The results of the evaluation demonstrated that the SSST duct cover would not breach under the pressure loading and would not melt from heating, thus protecting the SSST bus bars from debris and molten material from the ESST bus above. The resulting pressure wave impacting the SSST duct resulted in*

limited duct cover deformation, which would maintain significant margin above the required electrical breakdown strength in air. This result indicates an SSST fault under this condition would be unlikely. The evaluation approach is considered conservative, since the evaluation indicates the pressure wave will peak and clear before the ESST duct melts and breaches (see Figure 2-3 and [4a]). As a result the SSST duct would not be subjected to an arc induced pressure wave. This was confirmed based on the 'Mockup Testing' results (refer to Section 2.2.4 A, 2.2.4 C and [4d]]).

The 'Mockup Testing' effort performed arc fault testing of two representative configurations of the CNS ESST/SSST bus duct system, one at the center of a typical ESST/SSST bus duct span, the other at the expansion joint location. For both configurations, the fault energy exceeded the calculated value during the ESST arc fault of 1/17/2017 (refer to Sections 2.2.4 A and 2.2.4 C). Post-test inspections of the SSST duct identified no visible degradation of the SSST bus conductors, bus bar insulation, or bus bar insulating supports (refer to Sections 2.2.4 B and D). Continuous monitoring of the applied voltage on the SSST bus determined that no electrical faults occurred during the 'CONT1' and 'FLEX1' tests [4d].

Comparison of the 1/17/2017 in situ post-event images (Figure 1-1, Figure 1-2, Figure 1-3) to that of the 'Mockup Testing' post-test images for sample 'CONT1' (Figure 2-14) and sample 'FLEX1' (Figure 2-19 and Figure 2-20) indicates very similar magnitude and pattern of damage as a result of the actual and induced arc faults. This provides further confidence the result is repeatable and not an anomaly.

The other analyses that support this conclusion include:

- CNS-ER-2017-048, "SSST Bus Duct Evaluation Considering ESST Bus Arc Fault Event" (Enclosure 5)
- CNS-ER-2017-050, "Justification for ESST Bus Duct Test Specimen Configuration" (Enclosure 6)
- CNS-ER-2017-052, "Test Report on ESST Bus Fault Simulation Testing" (Enclosure 7)

G. Evaluation of NRC Questions

Following issuance of the NRC's preliminary SDP, CNS has had numerous discussions with the NRC Resident Inspectors and Regional staff. Below is a compilation of those questions with the associated CNS responses.

NRC Questions and Responses

Question	Response
1. How do the bus duct mock-ups provide adequate representation of in-field expected response to fault? Specifically, how do open ends and horizontal mock-ups adequately account for bends, vertical runs, and length of bus duct of installed plant equipment?	The horizontal configuration tested in the mock-up would envelope a vertical/corner span relative to support spacing and response to pressure loads. Additionally the ESST duct on the vertical run consists of four steel panels (as opposed to the aluminum bottom panel for the horizontal run, where the fault occurred in situ). The steel strength and melting point exceeds that of aluminum, thus the 'Mock-up Testing' configuration with the aluminum panel is considered as bounding. Pressure loading within the ESST duct is primarily due to the shock generated from the expansion of the gas and vaporization of aluminum from the arc energy. Traveling shock waves through a long duct system, on the order of several hundred feet, will continue along the duct until reaching a closed end. Given a wave travel at or slightly greater than sonic velocity (approximately at 1150 ft/sec), the wave will not reach the end and reflect back to the arc location until approximately 0.2 seconds - i.e., the arc location will not see the effects of the end condition within this time. Therefore, the long duct behaves like an infinite volume or open end. There are minor pressure wave reflections from each intermediate Glastic bus support at approximately 3 foot spacing and also as a result of changes in direction (horizontal to vertical, for instance). However, study of orifice reflection coefficients show that the reflected pressure is insignificant until the open area ratio is less than approximately 20%. The bus bar supports provide approximately 44% open area, thus they are not expected to contribute to reflective effects. In the 'Mock-up Testing' configurations, the end conditions were further restricted to limit the open area at the source end to 31% open and 14% open at the free end. Therefore, the end condition of the ESST duct used in the 'Mock-up Testing' samples was more restricted than that found in situ; thus the mock-up test is more conservative in that any pressure wave magnitude

	generated would be expected to be larger than would occur in situ. See ER 2017-051, Sections 2.2.2.B and 2.2.2.E (Enclosure 4).
2. What are the specific alloys and material properties associated with the mock-ups and why are they representative of plant installed materials?	The 'Mock-up Testing' samples utilized bus bar fabricated from Alloy 6101. The material specification for the bus bars in situ is unknown. In the absence of verification, it is most likely that the ESST bus bar material is either Aluminum 1350 or Aluminum Alloy 6101. These are common bus bar materials; both have ASTM specification numbers for use as "bus bar," and both were available at the time of construction of CNS. Both materials have similar aluminum content, melting point ranges and electrical properties. Alloy 6101 has higher yield and tensile strengths than those of Alloy 1350. However, based on the configuration of the bus bar supports, strength of the bus bars is not an attribute that will change the arc fault response. Therefore, use of either material for the testing, would not have significantly changed the obtained results. The resulting bus bar damage observed in situ and the test are similar. The aluminum alloy AL 3003-H14 was used to fabricate the SSST duct and the lower panel of the ESST duct for the mock-up samples. This aluminum grade was confirmed to be the same as the in situ based on use of a material analyzer examination performed by CNS personnel. See ER 2017-051, Sections 2.2.2.F and 2.2.2.G (Enclosure 4).
3. What alloy is being used for the bus bars?	Aluminum Alloy 6101. See Question 2. See ER 2017-051, Section 2.2.2.F (Enclosure 4).
4. What construction standards or processes were followed for verifying mock-ups represent plant installed configuration?	Typical construction standards were used. A switchgear/bus vendor, knowledgeable of the CNS installation, was utilized to construct the bus ducts for the mock-ups. Plant drawings, pictures and walkdowns were utilized to make the mock-up represent installed configuration to the extent possible. Mock-up similarities are evaluated in ER 2017-051, Section 2.2.2 (Enclosure 4).
5. Was statistical analysis applied for the number of tests to be conducted to ensure an adequate	An experiment which can be analyzed statistically requires that a treatment is imposed on a group of objects so that a response can be observed. An observational study involves collecting and analyzing data without changing existing

representative sample?	conditions. Data from either an experiment or an observational study can be analyzed using statistics; however, the current test scenario does not align with either an experiment (because no treatment is imposed) or an observational study (as the test is clearly designed and not conducted in situ). Given that this experiment is not a statistical experiment; no statistical analysis was applied to determine the number of tests to be conducted. As this experiment is closer to an engineering prototype experiment, there are no variables accounted for in the experimental design which would benefit from random sampling. Taken with the on-site data (where an arc caused damage in the presence of a bus support beam), this test (showing the damage resulting from an arc without a support beam) provides sufficient data to answer the question of whether the presence of the bus support meaningfully impacted the path of the blast wave and subsequent equipment damage resulting from the arc flash. [Information Provided by Dr. Susan VanderPlas, Statistical Analyst, Nebraska Public Power District]
6. How are the mock-up open ends representative of actual field conditions?	The ends of the mock-ups are conservative when compared to the in situ design. See Question 1. See ER 2017-051, Section 2.2.2.E (Enclosure 4).
7. What if any material differences were there in the test mock-up vs. the onsite configuration?	Negligible material differences. See Question 2. Also see discussion (Question 12) on the weather boot below. See ER 2017-051, Section 2.2.2.F and 2.2.2.G (Enclosure 4).
8. What are the effects of any differences in support spans of the test mock-up vs. the onsite configuration?	Continuous bus mock-up: The support spans of the upper specimen fault initiating duct are not exactly the same as that in the field. This is evident by comparing the outer support spans of about 15.5" of the test specimen to the in situ spans of 4 ft. The support locations of the specimen are chosen to produce an unshielded load on the target duct while not resulting in unrealistically high displacement at its ends. The stiffness of the upper ESST duct configuration is analytically evaluated in ER 2017-050 (Enclosure 6) to show that it represents the field condition. The 8 ft. support span of the target SSST duct test configuration is the same as in the field. However, the test specimen is only a single span representation of a

	continuous simply supported duct. This is considered conservative since the vertical beam response to the pressure load will be overestimated compared to the continuous in situ duct. Expansion bus mock-up: For the ESST duct, the majority of the support spans replicate the field dimensions. However, certain spans differ from that of the in situ busway. This is acceptable since the ESST duct is supported at two other points prior to this span. This difference in dimension will not significantly affect the response of the beam at the point of the induced fault. This is because any moment induced in the duct, acting as a beam, from the pressure reaction will be resisted by the supports and not affected by the stiffness of the span in question. Furthermore, it is noted that the expansion joint is not likely to transfer any vertical load or moment from the fault across it due to the lack of connection between the two duct ends at the expansion joint. For the SSST duct, the majority of the spans replicate the field dimensions. The in situ busway turns down vertically and is supported by a channel attached to the side of the Turbine Building at two locations. The in situ SSST bus duct test configuration is not supported at the South support for the ESST duct. Therefore, to approximate the influence of the vertical run on the duct response, two 5/8" diameter threaded rods are used to support the lower SSST duct specimen at its southern end. This test specimen configuration is justified, through the analysis presented in ER 2017-050 (Enclosure 6), by comparing the vertical stiffness of the test SSST specimen at the load application location to that of the geometry found in the field while including the vertical run. The span between supports north of the expansion boot of the SSST duct test configuration is less than that of the in situ configuration. This is acceptable since loading of the SSST duct from a fault along the ESST duct in this region would be bounded by the continuous duct test configuration and the cantilever duct south of the expansion joint. See ER 2017-051, Section 2.2.2.B (Enclosure 4) and ER 2017-050 (Enclosure 6).
9. How do the Glastic end piece supports represent	Conservative representation of total length of ducting. See Question 1.

the total length of ducting?	See ER 2017-051, Section 2.2.2.E (Enclosure 4).
10. What are the impacts of the corona damage and insulation aging observed in the recent SSST inspection?	During the bus inspection the requirement for the bus condition is that the bus be free from unacceptable indications of surface anomalies, which suggests that conductor insulation degradation exists. In addition, no unacceptable indication of corrosion, cracks, foreign debris, excessive dust buildup, or evidence of moisture intrusion will exist. An unacceptable indication is defined as a noted condition or situation that, if left unmanaged, could lead to a loss of intended function. None of the indications identified were deemed as detrimental to the bus or would have caused short-term failure. With that said, any indication with any appreciable depth into the insulation was repaired using shrink tape. See ER 2017-053 for additional details (Enclosure 2).
11. Is there any impact to fault testing or analysis from the SSST internal duct materials that are flaking off?	The internal coat of paint on the bus duct had flaked off somewhat. This had no impact to the Startup bus.
12. Is there any impact of boot material differences in test setup vs onsite?	When the weather protective boot materials are compared, the material used for the in situ bus ducts has higher mechanical strength and has flame retardant behavior that is absent from the material used for the mock-ups. The mock-ups represent a weaker configuration when compared to the installed bus duct. See ER 2017-051, Section 2.2.2.C (Enclosure 4).
13. What are the tolerance of the 604 breakers and relays (percent of error)?	The time-overcurrent pick-up accuracy is +/- 0.05 A and +/- 3% of setting. The curve timing accuracy is +/- 1.50 cycles and +/- 4% of curve time. This information has been previously provided in Certrec Request "8/8 Request" in Cooper Inspection - Supplemental Information for ESST Busbar Fault.
14. Could the fault current magnitude have been higher than observed in January fault?	The January 17, 2017, fault is considered representative of any fault from the same initiating cause (namely, corona damage and tracking). The current is driven by available fault current and arc impedance which would not significantly change. The arc impedance would not noticeably change from one fault to another since the arc impedance is based on environment and bus material, which is consistent throughout the bus. Therefore, the testing performed at 2.5% to 5.4%

	greater than the actual fault current from the January 17, 2017, event is representative of any expected arc fault currents on the Emergency bus. Additionally, the protective relay would be expected to act in a shorter time with increasing fault current. See ER 2017-051, Section 2.2.B (Enclosure 4).
15. Is there any impact of tack welding of angle brackets in the test setup versus plug welded onsite?	These minor differences do not affect the performance of the test or its conclusions. Plug welds perform similarly to fillet welds under internal pressure. Furthermore, since the plug welds and tapped screws are normally weaker than fillet welds and bolted connections, respectively, and since they did not exhibit any gross structural failure of the initiating ESST bus duct or the target SSST bus duct in situ, their adequacy is demonstrated and these differences will not affect the conclusion of the tests. The only in situ failure was melting of the bottom aluminum panel of the ESST bus duct. See ER 2017-051 (Enclosure 4) and ER 2017-050 (Enclosure 6).
16. Top covers were bowed, impact to pressure relief path?	Negligible impact to pressure relief path. See Question 1. See ER 2017-051, Section 2.2.2.D (Enclosure 4).
17. Is there any impact of the bolts not being tapped in the test mock-up as they are onsite?	Negligible difference in the ESST top cover only. See Question 4. See ER 2017-051, Section 2.2.2.D (Enclosure 4) and ER 2017-050 (Enclosure 6).
18. What walkdowns were done to support the scaffold build? How are these included in our timeline?	The walkdowns were performed by individuals not involved in scaffold building in order to time the difference in travel to the mock-up scaffold build locations. The travel to the location of the mock-up build took approximately 7.5 minutes and the travel to the location where the scaffold would be built to backfeed took approximately 6.5 minutes.
19. What information was given at the pre-job briefings?	Requirements of 0-EN-HU-102, "Human Performance Traps & Tools," Attachment 9.5, were covered in a Pre-Job Brief at 0700. This is the standard form used for Pre-Job Briefings. An additional scope of work briefing was conducted at 0915 and provided information that a scaffold needed to be built at the Low Level Radwaste Building and included the following information: specified scaffold dimensions, this was to be treated as an emergency drill situation, the involved individuals were to take the time to be safe and do the job right, the builders were to gather their personal protective equipment and leave the maintenance building at

	0925.
20. Which aspect of the timeline did this apply to and what is the final time?	"Build scaffold to generator flex links." Actual building of scaffold was less than 1 hour. This includes travel time and pre-job briefing. Total time is less than 2 hours.
21. How do we decide the size of the scaffold needed and how is this scoped into the timeline?	The size of scaffold needed to reach the flex links is well understood by both the maintenance and outage support groups as the scaffold required is a portion of scaffolding that is built every outage for inspections. The sizing information was required for the mock-up build but would not be required in an actual event as it would be evident to the builders what would be required. Actual size of built scaffolding was 12'x5' with a 15' deck height.
22. Where would we get fall protection in an actual event and how is this scoped into the timeline?	Fall protection is available in the Hot Tool Crib, which is in-route to the build location. This aspect would add less than 5 minutes.
23. Is a scaffolding inspection required? How is this scoped into the timeline?	No, the inspection can be waived per Emergency Procedure 5.7.7, Attachment 4, Step 2. The Technical Support Center Director with concurrence from the Shift Manager can authorize deviation from normal processes when in a site area emergency or general emergency. Additionally, individuals qualified to build scaffolding are qualified to inspect scaffolding and could do so on the spot. No substantive impact to build time is expected.
24. What would the expectation be in an actual event for applying additional scaffold stabilization or cross supports? How was this simulated or included in the timeline?	Per the requirements for building scaffolding for the sizing of scaffold built, no additional stabilization is required. Per the scaffold build that was filmed, additional supports were added. This question is bounded by the scaffold builders exceeding the requirements during the filmed build. Alternate configurations of additional scaffold support would not materially impact the total build time.
25. What is the impact of not using portable lighting in the scaffold build mock up and how is this included in the timeline?	The filmed build was completed without the use of portable lighting to ensure the build was completed in the safest manner. The portable lighting is available on the way to the work location. Setup of portable lighting would add less than 10 minutes to the total build time. (Lighting has been tested to last >24 hours on a single charge). Additionally, in the case of the loss of the ESST concurrent with a common cause failure of the SSST, there would be no need for additional lighting as the non-critical buses would be powered by the NSST. Only following an additional failure or plant trip would portable lighting be required.
26. Is the site conducting any other simulations of the	No, not at this time.

timeline events?	
27. What is the minimum Emergency Response Organization (ERO)/Operations Support Center (OSC) staffing requirement and how does this account for the four people required to build the scaffolding?	Four Fire Brigade personnel were used to build the scaffolding. Two Utility/Fire Brigade individuals are part of the normal operating organization (Control Room) and are on site at all times. Six individuals from Maintenance are required to support ERO minimum staffing for the OSC and would be available to build the scaffold. Additional ERO responders could also assist in this evolution once on site.
28. On the timeline to initiate backfeed, how are the staffing resource requirements accounted for? This question for each block on the timeline.	This information has been scoped into the timeline.
29. How does this align with the ERO drill records for the last 5 drills conducted that were associated with an SBO or a LOOP where the site was on DGs? Provide these if relevant.	CNS has no recent drill records for this specific scenario or a closely related equivalent scenario. Furthermore, the success criteria of making backfeed a priority in a drill scenario would not achieve the goal of fully testing the decision making and execution capabilities of the ERO.
30. Has there been any case at CNS where backfeed was a priority? How does it align with the timeline?	No. However, making backfeed a priority is required by shutdown procedures following the loss of the ESST and SSST (Procedures 2.1.4 and 2.1.4.1). Furthermore, Operations crews have demonstrated in the plant simulator that this would be a priority.
31. Why is the site staying with 10kV for the Hi-Pot testing?	AC Hi-pot testing (also known as dielectric strength testing) is a potentially destructive test. A test failure is identified by a test equipment overcurrent trip, which occurs following an insulation failure and resulting insulation damage. Therefore, if bus insulation breaks down during the test, relatively high values of test current would likely result in more significant bus damage. IEEE Standard C37.23 describes three different types of testing: design, production, and field tests. Those tests are applicable to design and manufacture of metal-enclosed buses, or following installation or modification. IEEE C37.23 is not applicable to periodic testing of metal-enclosed buses.

	A relevant standard is NFPA 70B-2016, "Recommended Practice for Electrical Equipment Maintenance." The standard's recommendations are to perform meggering of the bus, and if desired, a Hi-pot test of the bus in addition. The normal Hi-pot test voltages should be 2 X V + 1000 (in this case, 10KV). As noted in this standard, frequent Hi-pot testing at 75% of the rated insulation withstand levels (in this case, about 14KV) in accordance with IEEE C37.23, is undesirable, "...because this might be above the corona starting voltage of some busways." AC Hi-pot testing of the non-segregated buses at 10KV is consistent with relevant industry guidance, and is appropriate because of the competing concerns of providing adequate assurance that the bus has been adequately maintained and can be returned to service, while reducing the potential for degrading or significantly damaging the bus as a result of the test.
32. What is the impact of the fault being initiated downstream of the power source on the test conducted at KEMA for the booted connection?	If this question is intended to ask why the test wasn't performed on the other side of the expansion boot, then the answer is: The Glastic box is connected directly to a busbar support and the box separates the phases. Since we know that the fault travels away from the source (i.e., into the box) the arc would have to either stay in that location or it would extinguish as there is no ability to sustain a phase to phase fault with insulating Glastic material between phases. Additionally, the side of the boot tested has no supports under the fault location which is conservative with respect to potential damage on the SSST duct/expansion boot. The pressure impact on the boot would be the same from either direction as indicated by the data from the test showing similar pressures on both sides of the expansion boot.
33. The fault in the KEMA testing was initiated by use of a tin/copper wire; was there any impact of using this material instead of pure copper wiring?	This does not have any impact on the fault testing. Tinned copper wire has a coating of tin applied to the outside of the copper wire and is still considered a copper wire. The purpose of the wire is to provide a conductive path to start the arc and will vaporize within microseconds. Additionally, the results of the testing showed that an arc was developed and sustained.
34. How is the fault timing of the KEMA testing representative of the onsite breaker timing installed at CNS?	The fault during testing was held in for 1.02 to 1.03 seconds, which is the same duration but at a 2.5% to 5.4% larger value of current than the fault in January 2017. Had the same levels of current existed at the plant as that of testing, the fault would be a shorter duration.
35. The bolting on the bottom	The bottom panels of the in situ configuration and the bottom

of the bus duct mock-ups for the bottom panel did not appear to be correlated to the actual CNS bottom duct panels; what is the impact of this?	panels in the mock-ups were both drilled and tapped with same size bolts.
36. During the mock-up scaffold construction for a short duration an individual's fall protection anchor point was below their knee. What was done to address this? Was a Condition Report (CR) written to document this?	This individual was coached on the proper use of fall protection. A CR detailing the issue was not required to document or correct this issue.