May 9, 2002

Mr. J. A. Price
Vice President - Nuclear Technical Services - Millstone
Dominion Nuclear Connecticut, Inc.
c/o Mr. David A. Smith
Rope Ferry Road
Waterford, CT 06385

SUBJECT: MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2 - COMPLETION OF STAFF REVIEW RELATED TO AMPACITY DERATING ISSUES ASSOCIATED WITH GENERIC LETTER 92-08 (TAC NO. MA3392)

Dear Mr. Price:

Generic Letter (GL) 92-08, "Thermo-Lag 330-1 Fire Barriers," dated December 17, 1992, and subsequent U.S. Nuclear Regulatory Commission (NRC) staff requests for additional information dated September 19, 1994, August 12, 1996, and May 13, 1997, requested that you submit plans and schedules for resolving the Thermo-Lag issue. You responded to these requests by letters dated November 3, 1995, December 13 and 27, 1996, July 11, 1997, and February 17, 1999. In addition, you provided the staff with additional information on March 17, 1998, and May 25, 1999. The NRC staff docketed this information in a letter dated February 9, 2001.

With assistance from our contractor, Sandia National Laboratories (SNL), we have completed our review of the analytical approach for ampacity derating determinations for Millstone Nuclear Power Station, Unit No. 2 as provided in your submittals. The results of the review are documented in the safety evaluation (Enclosure 1) and the SNL technical evaluation report (Enclosure 2), "A Review of the Revised Millstone Nuclear Power Station Fire Barrier Ampacity Derating Analyses," dated September 30, 1999. During our review, we discussed three specific issues with your staff that required further action by Dominion Nuclear Connecticut, Inc. On February 22, 2002, you submitted a letter stating that you addressed these three issues in your corrective action program and that there are no operability or reportability concerns associated with these specific issues.

On the basis of its review, the staff has determined that you have provided all the information required to adequately address the ampacity derating issues identified in GL 92-08. You should

retain all documentation of the ampacity issue for future NRC audits or inspections. This documentation should include your evaluation of the open issues and your corrective actions.

Sincerely,

/RA/

Richard B. Ennis, Sr. Project Manager, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-336

Enclosures: As stated

cc w/encls: See next page

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Richard B. Ennis, Sr. Project Manager, Section 2
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING AMPACITY DERATING ISSUES

DOMINION NUCLEAR CONNECTICUT, INC.

MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2

DOCKET NO. 50-336

1.0 INTRODUCTION

Generic Letter (GL) 92-08, "Thermo-Lag 330-1 Fire Barriers," dated December 17, 1992, and subsequent U.S. Nuclear Regulatory Commission (NRC) staff requests for additional information (RAIs), dated September 19, 1994, August 12, 1996, and May 13, 1997, requested that Northeast Nuclear Energy Company (NNECO/the licensee) submit plans and schedules for resolving the Thermo-Lag 330-01 Fire Barriers issue for Millstone Nuclear Power Station, Unit No. 2 (MP2). NNECO responded to these requests by letters dated November 3, 1995, December 13 and 27, 1996, July 11, 1997, and February 17, 1999. In addition, NNECO provided the NRC staff with additional information on March 17, 1998, and May 25, 1999. The staff docketed this information in a letter dated February 9, 2001. On March 31, 2001, the MP2 license was transferred to Dominion Nuclear Connecticut, Inc. (DNC/the licensee). By letter dated February 22, 2002, DNC provided additional information.

2.0 BACKGROUND

On December 17, 1992, the NRC issued GL 92-08, "Thermo-Lag 330-1 Fire Barriers" (Thermo-Lag). This GL was issued to obtain information from licensees to verify that the use of Thermo-Lag complied with NRC fire protection requirements for safe shutdown capability. The GL had three principal areas of concern: the fire endurance capability of Thermo-Lag, the ampacity derating of cables enclosed in Thermo-Lag, and the evaluation and application of the results of tests conducted to determine the fire endurance ratings and the ampacity derating factors of Thermo-Lag.

On December 18, 1998, the NRC issued a letter to NNECO that essentially closed out a significant portion of the issues raised by the GL. However, this letter also stated that there were remaining open issues involving ampacity derating that would be separately tracked. The purpose of this safety evaluation (SE) is to address the ampacity derating issues associated with the GL.

The following is a list of significant correspondence associated with this issue:

12/17/92: NRC issued GL 92-08 re: Thermo-Lag 330-1 fire barrier systems.

9/19/94: NRC issued RAI re: licensee's ampacity derating assessment methodology.

11/3/95: NNECO provided initial response (without calculations).

5/16/96: SNL provided a report to NRC documenting findings and recommendations based on review of 11/95 response.

8/12/96: NRC issued RAI re: technical concerns associated with the licensee's analyses. (moot - see 9/30/99).

12/13/96: NNECO submitted 8/96 RAI response which included the supporting calculations not provided in the 11/95 submittal.

3/27/97: SNL provided a report to NRC documenting unresolved technical issues.

5/13/97: NRC issued RAI requesting resolution of the remaining technical issues. (moot - see 9/30/99)

7/11/97: NNECO provided a preliminary response to the 5/97 RAI. NNECO committed to revise its ampacity derating calculations for both Unit 1 and Unit 2 and identified the intended approach for resolution of the technical concerns without providing specific details.

3/17/98: NNECO provided the NRC with a draft RAI response providing more specific proposed answers to the identified technical concerns. Docketed 2/9/01.

3/19/98: SNL provided a letter to NRC documenting unresolved technical issues.

12/18/98 NRC issued a letter to NNECO that closed out a significant portion of the issues raised by the GL and tracks ampacity issues separately under TAC No. MA3392.

2/17/99: NNECO provided official response to 5/97 RAI. The submittal cited that all issues have been resolved, but did not provide updated calculations for review.

2/26/99: SNL requested calculations to confirm resolution.

5/25/99: NNECO completed updating calculations and provided the NRC with a copy of their revised engineering calculation for ampacity derating due to Thermo-Lag. Docketed 2/9/01.

9/30/99: SNL provided a report to NRC that states that 8/12/96 and 5/13/97 RAIs are moot based on revised methodology of new calculations and identifies issues requiring further evaluation.

2/22/02: DNC provided letter to NRC stating that open issues were added to their Corrective Action Program via Condition Report CR-02-00125.

3.0 EVALUATION

The NRC staff performed an independent review of the licensee's submittals and Sandia National Laboratory's (SNL) Technical Evaluation Report (TER) dated September 30, 1999 (see Enclosure 2). As described by the TER, revised calculation 96-ENG-01528-E2 dated May 25, 1999, provided an entirely new set of ampacity derating calculations which differed significantly from those documented in prior licensee submittals. Further, the revised calculation was based on a new technical approach compared with those approaches used by the licensee in prior calculations. Therefore, all of the previous technical issues raised in the RAIs of August 1996 and May 1997 have been either resolved or rendered moot. The new technical issues raised by the most recent TER were independently reviewed and addressed by the NRC staff. The staff's evaluation follows the same format as the TER in that it addresses the cable tray calculations followed by the conduit calculations and the unique configuration calculations. Each significant issue raised by the TER was independently reviewed by the staff as described in the following evaluation.

Cable Tray Calculations

The licensee's overall approach for analyzing the ampacity derating of cable trays is based on thermal modeling. The analysis is performed in two parts: an analysis of the baseline case and an analysis of the clad case. The ampacity limits for each case are compared to determine the fire barrier derating factor. The overall analysis process involves: 1) estimation of the baseline ampacity limit for each cable in a given tray; 2) estimation of the fire barrier ampacity derating factor for the tray; 3) calculation of the adjusted allowable ampacity limit for each cable; and 4) comparison of the actual installed raceway ampacity load to the allowable ampacity limit. It should also be noted that the MP2 thermal model is inherently limited to single-layer fire barrier configurations with no air gaps between successive layers of fire wrap.

The staff reviewed the TER concern regarding the ampacity limit and concludes that the 80% open air ampacity limit does not apply to each case. The 80% limit, which the TER attributes to Stolpe, is not contained in the referenced paper by Stolpe. The Insulated Cable Engineers Association (ICEA) standards do, however, state that they use the equations by Stolpe with an added maximum limitation of 80% of the free air ampacity. According to NUREG/CR-6681, the 80% limit is used to address specific applications such as "where the diameter of any individual cable exceeds the depth of fill for the tray overall." Therefore, applying this 80% limit to all configurations is overly conservative. In addition, it should also be noted that Stolpe's method already includes various sources of conservatism depending on the actual configuration. For example, both Stolpe and ICEA calculate ampacities based on a 100% load factor with all cables in the raceway fully loaded and without any spaces between any cables to dissipate heat. Though this assumption would certainly envelope all cases, the degree to which a particular configuration has less loading or more spacing would result in a commensurate increase in ampacity for which neither Stolpe nor ICEA include in their tables or equations. Furthermore, the licensee used actual test data to validate their analytical methods and the actual test data shows that there is already a significant amount of conservatism in their analytical methods.

The TER concern related to the ampacity limit is a general comment on the licensee's methodology and does not specifically address a safety issue related to any particular component at MP2 within the scope of Thermo-Lag-induced ampacity deratings. Later in this

SE, all cables that the TER identified as appearing to exceed their ampacity ratings, as a result of the 80% limit, are individually addressed below.

The TER states that the derating factor (DF) for the clad case analyses appears to be derived in an overly conservative manner given other related fire barrier raceway configurations tested in the industry. The licensee estimated that the DF impact ranged from 0.36 to 0.38. This would correspond to an ampacity derating factor (ADF) of 62%-64%. The MP2 fire barriers being analyzed are 1.5" thick (per the calculations). One industry test involved a thicker fire barrier system, a 24" wide tray with a 1.25" base barrier system, and two 3/8" upgrade layers for a total barrier thickness of about 2". In this test, the ADF value of 48% corresponded to a DF (or ampacity correction factor (ACF)) of 0.52. A second similar test involving a similar tray configuration with a 3-hour single layer 1.125" thick barrier system identified a 41.4% ADF (or a 0.586 DF). In comparison to these tests, the MP2 results appear conservative.

The staff reviewed the TER concern regarding the derating factor and agrees that the derating factor determined by the licensee is very conservative compared to industry data. However, the staff finds that any additional safety margin resulting from the licensee's conservative tests also does not pose a safety concern.

The staff reviewed the TER concern regarding nominally overloaded cables. On page 8 of 81 of the licensee's calculation 96-ENG-01528E2, Revision 2, two of the four cables are for non-safety related equipment that operate only when the plant is shut down and even then only operate infrequently during shutdown. Therefore, with regard to safe shutdown capability, these two cables do not pose a safety concern. For the other two cables, only one is energized at a time and the calculated heat generation was substantially below the ICEA/Stolpe calculated value. If a 44% derating factor were to be applied to these cables, all four cables would be in an acceptable range. A derating factor of 44% is a mid-range derating factor for a nominally anticipated condition (41.4% to 48%). Additionally, the note at the bottom of the table on page 8 of the calculation says that the Thermo-Lag for these four cables was removed and, therefore, the Thermo-lag derating factor is not applicable. Consequently, all four cables are operating at less than 50% of the cable's ampacity rating. Based on the preceding evaluation, the staff finds that there are no safety concerns associated with these cables.

The TER identifies three additional trays that the TER states contains cables that are potentially overloaded. They are:

- Cable Z1B5105/A in Tray Z14FM20;

- Cables Z2B0606/A, Z2B0606/B, Z2B0610/A, and Z2B0610/B, in Tray Z23GE10; and

- Cables Z2B0610/A and Z2B0610/B, in Tray Z23HB10.

The staff reviewed the TER concern regarding the three cable trays containing potentially overloaded cables and finds that sufficient conservatism exists to conclude that these cables are not overloaded. For the first tray (Z14FM20), page D1 of the licensee's calculation states that the Thermo-Lag was removed from the tray. This cable's load is less than 1/3 of the cable's base ampacity and is, therefore, well within acceptable limits. For the second and third trays (Z23GE10 and Z23HB10), the numbers are marginal. The licensee is potentially over-penalizing themselves with their ampacity deratings and under-penalizing themselves by not taking the 80% Stolpe open air ampacity limit. Without the 80% limit, the cables operate within

an acceptable range. With the 80% limit coupled with the range of ampacity derating values considered more realistic (41.4 to 48%), these cables would, again, be within an acceptable range. The staff finds that this, coupled with the other inherent conservatisms of the model previously described, indicates that the cables in these trays are not overloaded, and therefore, do not pose a safety concern.

Conduit Calculations

The licensee's approach to the analysis of fire barrier clad conduits was similar to that taken for cable trays. The licensee first calculated the baseline ampacity, then estimated an ACF, and then estimated the clad case ampacity as the product of the ACF and baseline ampacity. The licensee compared this estimate to the actual load ampacity to determine case acceptability.

The underlying thermal model used by the licensee is nominally that recommended by Neher and McGrath for the estimation of conduit ampacity limits. This same model has also been used in the development of the currently accepted industry ampacity standards. However, during implementation of this methodology, the licensee appears to have made the following errors:

1. The licensee has misinterpreted the definition of the conductor count term (n') in the implementation of Neher/McGrath equation 41, the thermal resistance between the surface of the cables and the inner surface of the conduit. The licensee used the maximum conductor count for any single cable in the bundle. This error may result in non-conservative ampacity results. The staff considers that the correct value for the entire cable bundle is the total conductor count.

2. The licensee implemented an incomplete and/or erroneous expression in the calculation of heat transfer within an individual cable. The staff considers that this error taken alone would result in conservative estimates of the ampacity limit. However, the annular region heat transfer model that was presumably intended is not appropriate for the analysis of multi-conductor cables. Use of the annular region model for multi-conductor applications may result in non-conservative ampacity results.

3. The licensee's practice of partitioning the total heat load to individual cables based only on the cable cross-sectional area has not been justified and appears to have led to anomalous results. This modeling assumption is inconsistent with the Neher/McGrath approach.

The staff concludes that the general approach taken by the licensee in the analysis of conduit and single cable wrap applications is appropriate. Though the net effect of the implementation errors noted above have not been fully assessed, none of the cables are subject to a significant ampacity load (i.e., ampacity loads are less than 5 amperes per Attachment E of calculation 96-ENG-1528-E2, Rev. 2). Therefore, the staff finds that for the conduit fire barriers identified, the available information is sufficient to conclude that the subject cables are operating within acceptable ampacity limits.

Unique Configuration Calculations

The licensee has four applications that could not be categorized as either cable tray or conduit calculations. These are referred to by the licensee as "unique Thermo-Lag configurations." The four applications involve: 1) a two-tiered wire-way; 2) a cable tray with one individual cable

wrapped with conduit sections of Thermo-Lag fire barrier material; 3) a cable tray that has one individual wrapped cable plus a fire barrier installed over the tray as a whole; and 4) a tray with two triplex power cables that are wrapped together in a common conduit section envelope. For the subject configurations, the licensee has applied a unique set of modeling tools to estimate the clad case ampacity limits.

The staff finds that the licensee's approach to the analysis of its unique configurations is generally acceptable. However, for each of the four cases, one or more errors were identified in the analysis by SNL. For three of the four cases, the staff finds that despite the errors, the licensee has provided a sufficient basis for concluding that the cables are operating within acceptable ampacity limits. The exception is raceway Z23HA10. Specifically:

1. The licensee has misinterpreted the n′ factor in Stolpe Equation 41. In this case, the licensee assumes a value of 3 when the actual value should be 6 as the total conductor count inside the "conduit." (See Conduit Calculation Section above - Item 1)

2. The analysis of temperature drop from the cable surface to the conductor is incomplete or incorrect. (See Conduit Calculation Section above - Item 2)

3. The model for a single conductor cable is apparently assumed when the cables are actually three conductor cables.

In the case of raceway Z23HA10, the acceptability of the ampacity loads has not been adequately demonstrated because the analysis contains at least three errors, and because the licensee's analysis has shown only a very minimal remaining ampacity margin. The staff brought these errors to the attention of the licensee for further analysis. By letter dated February 22, 2002, the licensee stated that these issues were added to their Corrective Action Program and the licensee confirmed that there are no operability or reportability concerns associated with these specific issues.

The staff finds that the evaluation provided by the licensee coupled with the licensee's corrective actions has provided acceptable resolution of these issues. Therefore, the staff finds that for the unique configurations identified, the information provided by the licensee is sufficient to conclude that the subject cables are operating within acceptable ampacity limits.

4.0 CONCLUSION

The NRC staff has reviewed the responses to GL 92-08 and finds that all of the requested information has been provided and that the responses are an acceptable resolution for the ampacity derating issues associated with Thermo-Lag. The staff finds reasonable assurance that the ampacity of the cables in the cable trays, conduits, and unique configurations at MP2, identified as being affected by Thermo-lag, are all operating within acceptable ampacity ranges. Therefore, the NRC considers GL 92-08 to be closed for MP2.

Principal Contributor: J. Harrison

Date: May 9, 2002

TECHNICAL EVALUATION REPORT
BY
SANDIA NATIONAL LABORATORIES

RELATED TO REVIEW OF AMPACITY DERATING ISSUES ASSOCIATED WITH GENERIC LETTER 92-08
FOR
MILLSTONE NUCLEAR POWER STATION, UNIT NO. 2

Enclosure 2