Dominion Nuclear Connecticut, Inc.
Millstone Power Station
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Dominion

January 25, 2005

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Serial No. 04-771A
MPS Lic/MAE R0
Docket No. 50-336
License No. DPR-65

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
UPDATED RESPONSE TO A REQUEST FOR ADDITIONAL INFORMATION
RECONCILIATION OF REGULATORY REQUIREMENTS

By a letter dated November 5, 2004, Dominion Nuclear Connecticut, Inc. (DNC) submitted a request for a limited exemption from the requirements of 10 CFR 50.68(b)(1) for loading fuel in a NUHOMS 32PT DSC in the Millstone Unit 2 Spent Fuel Pool.

On December 13, 2004, a request for additional information (RAI) was received from the Nuclear Regulatory Commission (NRC) staff that contained three questions. A second RAI was received on December 14, 2004 that contained four additional questions. DNC provided a response to these RAIs in a letter dated January 6, 2005.

In conference calls with the NRC staff on January 6 and January 11, 2005, the staff questioned whether closure of the 2-RW-350 valve was necessary or whether it could be left open during cask loading to promote mixing in the cask laydown pit. DNC has addressed the staff concern by revising applicable portions of our January 6, 2005 response to change valve 2-RW-350 status from closed to open.

Attachment 1 contains DNC updated responses to the three questions from the December 13, 2004 RAI. Attachment 2 contains a complete updated list of all commitments made by DNC in support of this exemption request. The list of commitments provided in Attachment 2 supersedes all the commitments made by DNC in the letters dated November 5, 2004 and December 13, 2004. Attachment 3 contains a copy of the updated Technical Evaluation M2-EV-04-0025, Revision 2, "Boron Dilution Analysis for the TN32PT Cask in the Millstone 2 Spent Fuel Pool."

If you have any questions concerning the attached additional information, please contact Mr. David W. Dodson at (860) 447-1791, extension 2346.

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

Attachments: (3)

Commitments made in this letter are listed in Attachment 2.

cc: U.S. Nuclear Regulatory Commission
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Millstone Power Station

SN: 04-771A
Docket No.: 50-336
Subject: Response to RAI

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Leslie N. Hartz, who is Vice President - Nuclear Engineering, of Dominion Nuclear Connecticut, Inc. She has affirmed before me that she is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of her knowledge and belief.

Acknowledged before me this 25TH day of January, 2005.

My Commission Expires: May 31, 2006.

Vicki L. Hull
Notary Public

(SEAL)

Attachment 1

<u>Reconciliation of Regulatory Requirements</u>

<u>Updated Response to a Request For Additional Information</u>

Millstone Power Station Unit 2
Dominion Nuclear Connecticut, Inc. (DNC)

Updated Response to the December 13, 2004 Request For Additional Information (3 questions)

NRC Question 1:

Criterion 5b, "Boron Dilution Analysis," specifies that the analysis provided is a summary of the "Boron Dilution Analysis for TN32PT Cask" performed in the MP2 Spent Fuel Pool" (Reference 8 of DNC letter). The staff recognizes the similarity of Reference 3 of DNC's letter to the current dilution analysis. However, because the current analysis prescribes critical boron concentrations higher than the former and includes possible direct dilution sources to the dry storage cask (DSC) we are requesting a copy of that analysis (Reference 8 of DNC's letter).

Response:

A copy of the current revision of Reference 8 of DNC's letter dated November 5, 2004 is provided in Attachment 3 of this letter. That document is Technical Evaluation M2-EV-04-0025, Revision 2, "Boron Dilution Analysis For TN32PT Cask in The Millstone 2 Spent Fuel Pool." Revision 2 of this Technical Evaluation incorporates the change requiring Valve 2-RW-350 be open when a fueled DSC is in the Cask Pit.

NRC Question 2:

In page 11 of DNC's letter, DNC stated that "dilution times are based on a feed and bleed operation with instantaneous complete mixing." DNC also indicated that the Cask Loading Pit volume was conservatively neglected when calculating the volume of the spent fuel pool (SFP), and mentions that the DSC is located at the bottom of the cask handling pit that is connected to the SFP through a gate opening. DNC's analysis does not include the possibility of localized boron dilution and stratification in the cask handling area as described in Reference 10 of DNC's letter. Please, provide a description (and pertinent drawings) of the SFP configuration (including the cask handling area) that adequately represent a justification for DNC's assumptions.

Response:

Attachment 4 to DNC's January 6, 2005 letter (Serial No. 04-771) contains two sketches of the Millstone Unit 2 Spent Fuel Pool and Cask Pit to assist in understanding the physical layout. The sketch labeled "Millstone 2 Spent Fuel Pool" provides a view looking down to orient the main portion of the SFP with respect to the Transfer Canal on the west side of the pool and the Cask Pit in the northeast corner of the pool. The gate openings to the Cask Pit and transfer canal are also shown. A Transfer Cask/DSC is shown in the Cask Pit. The second sketch labeled "Millstone 2 Cask Pit" provides key dimensions related to the Cask Pit and the top elevation of the Transfer Cask/DSC.

To respond to NRC staff concerns about boron stratification in the Cask Pit, DNC has revised its analysis of the SFP and the DSC dilution event. The revised analysis, Technical Evaluation M2-EV-04-0025, Revision 2, is provided in Attachment 3. The key changes in this revised analysis, relative to the previously submitted boron dilution analysis are:

1) The requirement to have forced Spent Fuel Pool cooling flow in the Cask Pit by requiring 2-RW-350 to be open whenever a fueled DSC is present in the Cask Pit.
2) The time to reach the critical boron concentration in the DSC is now calculated using a no-mixing model, as well as an instantaneous perfect-mixing model (feed and bleed). The no-mixing model provides bounding values of the amount of time available to mitigate the dilution event before the boron concentration in the Cask Pit volume reaches the DSC critical boron concentration.

This revised approach directly responds to NRC Question 2 concerning the possibility of boron stratification in the Cask Pit.

A dilution of the boron concentration in the SFP and the DSC, which is located in the bottom of the Cask Pit, may occur through three categories of water entering the SFP and DSC. They are: (1) A dilution through the Spent Fuel Pool Cooling System, (2) A dilution of the SFP by water spilling into the top of the SFP, or (3) A dilution of the Cask Pit by water spilling into the Cask Pit.

The responses for events involving dilutions of the Spent Fuel Pool Cooling System (SFPCS) or water spilling into the top of the SFP are described below. The response for events involving a direct dilution of the Cask Pit by water spilling into the Cask Pit is described in the response to NRC Question 3.

<u>Dilution of the Spent Fuel Pool Cooling System</u>

A dilution through the SFPCS is the limiting dilution event. Up to 200 gpm of unborated water can be introduced via the cooling system, with the limiting source coming from the Primary Make-up Water (PMW) Line, which ties into the SFPCS between the SFPCS pump discharge and the discharge pipe to the SFP. The SFPCS discharges through two lines into the bottom of the SFP and one line into the bottom of the Cask Pit. The SFPCS suction pipe is at the top of the SFP. The results of two boron concentration-mixing models are provided, an instantaneous mixing model and a slug flow (no-mixing) model. The no-mixing model results are bounding and address the potential for boron stratification in the Cask Pit.

The instantaneous mixing model (feed and bleed) predicts that it will take at least 9.5 hours to dilute the DSC water from 2500 ppm (initial TS concentration) to 1700 ppm (critical concentration) of boron.

The slug flow (no-mixing) model shows that at least five hours will be available before the DSC water decreases from 2500 ppm to 1700 ppm of boron. This value of five hours for the slug flow model is based on 200 gpm of unborated water and 850 gpm of 2500 ppm water in the cooling lines producing a mixed volume of 2023 ppm borated water. Thus, 1050 gpm of total flow at 2023 ppm boron starts filling the pool through the three SFPCS discharge pipes at the bottom of the SFP. It will take five hours for the 2023 ppm borated water to fill the SFP, including the DSC, and finally reach the SFPCS suction pipe located at the top of the pool. As the 2023 ppm borated water fills the SFP, the 2500 ppm borated water spills over the top of the pool. Thus, during the entire five hour period, the DSC water boron concentration will be greater than the 1700 ppm critical concentration.

Consequently, direct dilution of the SFPCS in 5 to 9.5 hours is conservatively the range of time to reach 1700 ppm boron in the DSC, depending on the degree of mixing. The first credited means of detection of a dilution event will be the SFP high level alarm in the control room within one hour of the dilution initiation. The second credited means of detection is by the individual who is continuously monitoring the SFP for overflow. Overflow of the SFP is calculated to occur within two hours of dilution initiation. Thus, detection of the dilution in the worst case is two hours. Therefore, at least 3 hours (5 hours – 2 hours) is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached. Since some mixing will occur, this estimate is conservative.

Dilution of the SFP by Water Spilling into the Top of the SFP

Unborated water spilling into the SFP at the operating deck can come from several sources. The maximum unborated water flow rate from these sources is 100 gpm. The results of two boron concentration-mixing models are provided, an instantaneous mixing model and a slug flow (no-mixing) model.

Assuming instantaneous mixing, the 9.5 hour dilution time previously discussed for going from 2500 ppm to 1700 ppm boron concentration in the DSC is bounding, since the maximum dilution flow rate for water spilling into the top of the SFP is 100 gpm, which is less than the 200 gpm dilution rate used in calculating the previous instantaneous mixing 9.5 hour dilution time.

For the slug flow (no-mixing) model, the limiting case is if the 100 gpm of dilution flow spills directly into the SFP cooling suction line. The total minimum SFPCS flow is 850 gpm, so that if 100 gpm of unborated water is entering the suction line, then 750 gpm of 2500 ppm borated water makes up the balance of the flow. If 100 gpm of unborated water is mixed with 750 gpm of borated water, the resulting mixed boron concentration will be 2205 ppm. It will take five hours for the 2205 ppm borated water to fill the entire pool, including the DSC, by entering the SFPCS through the SFPCS discharge pipes at the bottom of the SFP, and eventually reaching the SFPCS suction pipe at the top of the SFP. During this time, as the 2205 ppm borated water is filling the pool, the initial 2500 ppm borated water spills over the top of the pool. As the 2205 ppm borated water reaches the SFPCS suction pipe at the top of the pool, another cycle of slug flow starts. At least two cycles of this slug flow (5 hours per cycle) can be accommodated before the boron concentration goes below 1700 ppm boron in the DSC. Thus, at least 10 hours is available in this case before the boron concentration goes below 1700 ppm in the DSC.

For the initiating boron dilution event of unborated water spilling into the top of the SFP, the above slug-flow model will be limiting, since with valve 2-RW-350 open, SFPCS water flow goes into the Cask Pit through the open SFPCS line at the bottom of the Cask Pit, and water flows upward, leaving the Cask Pit, out the gate opening and into the SFP. Given the flow direction being out of the Cask Pit, the primary means of dilution of the Cask Pit water boron concentration would be due to the water entering from the SFPCS line into the bottom of the Cask Pit.

Thus, for water spilling into the top of the SFP, at least 10 hours of time is available before reaching 1700 ppm boron in the DSC. Furthermore, detection of water spilling into the pool should be near immediate by the individual who is assured to continuously monitor the SFP for overflow or any water ingress into the pool. The backup means of detection of a dilution event will be the SFP high level alarm in the control room within two hours of dilution initiation. (Note that it takes two hours for the SFP high level alarm to be reached at a 100 gpm dilution rate, instead of the one hour it would take to reach the SFP high level alarm at a 200 gpm dilution rate.) Thus, detection of the dilution in the worst case is two hours. Therefore, at least eight hours (10 hours – 2 hours) is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm is reached in the DSC.

In summary, for the limiting case of a 200 gpm dilution of unborated water into the SFPCS, at least five hours is available from the start of the dilution until the critical boron concentration is reached in the DSC. This five hour time value is calculated using a conservative slug flow model which credits no mixing of the incoming diluted SFPCS water with the initial 2500 ppm borated water in the SFP that is required by Technical Specifications. Detection of the dilution in the worst case is two hours. Therefore, at least 3 hours (5 hours – 2 hours) is available for mitigation of the dilution event. This is more than sufficient time to terminate the event before 1700 ppm is reached in the DSC. Furthermore, this time estimate is conservative since mixing of the water will occur in the SFP which will result in more time available.

The analysis provided in response to this question assumes that only the spent fuel pool cooling suction at the top of the SFP will be open. The SFPCS also contains one suction pipe that takes suction lower in the SFP ("deep suction") at an elevation near the top of the SFP racks. To assure consistency with this analysis, the SFP cooling "deep suction" Valve 2-RW-2 will be required to be shut. Shutting Valve 2-RW-2 does not alter the ability of the SFPCS to cool the SFP.

<u>NRC Question 3:</u>

One of the proposed commitments associated with this request is to establish "appropriate controls or measures to minimize the possibility of direct dilution of the cask handling area of SFP prior to DSC loading." Please, explain with more details the controls and measures to be used during fuel handling activities. Also, describe any sources of direct dilution that DNC has considered during the analysis (e.g. addition of cold water directly to the cask pit through a fire hose) that could allow localized boron dilution.

<u>Response:</u>

A copy of the current revision of Reference 8 (Technical Evaluation M2-EV-04-0025, Revision 2) of DNC's letter dated November 5, 2004, is provided in Attachment 3. That document specifies what additional controls are necessary to assure that direct dilution to the Cask Pit is prevented or minimized.

The additional controls required by the Technical Evaluation are summarized as:

When a fueled 32PT DSC is in the Millstone Unit 2 SFP, then:

1) An individual will remain on the SFP floor at all times, to ensure that no water is unintentionally spilling into the SFP and that the SFP is not overflowing.

2) Valve 2-RW-350 must remain open.

3) SFP water will be sampled for boron concentration after each intentional addition of a maximum of 500 gallons of unborated water.

A direct inadvertent dilution to the Cask Pit from water spilling into the top of the Cask Pit is credible due to the Primary Makeup Water (PMW) hose station near the Cask Pit. Direct dilution to the Cask Pit from the PMW hose station may occur during normal cask handling operations. However, this is limited to 500 gallons of unborated water before boron sampling is required. Inadvertent flow of unborated water from the PMW hose station to the Cask Pit will be observed by the individual on the SFP floor who is monitoring for water entering the SFP. Should such a flow occur from the PMW hose station, the appropriate valve, 2-PMW-408, 2-PMW-409 or 2-PMW-295 will be shut, or if an un-isolable leak occurs, the PMW pumps will be secured. In any case, minimal unborated water volume will enter the Cask Pit before isolation. The requirement to have a minimum of 850 gpm of SFPCS flow, in combination with the requirement to have 2-RW-350 open, ensures substantial SFPCS flow to the Cask Pit. Therefore, localized boron dilution and stratification will not occur in the Cask Pit during DSC operations. (It is estimated that the Cask Pit volume will be turned over once per hour with 2-RW-350 in the open position and a minimum of 850 gpm of total SFPCS flow.)

During a conference call with the NRC on December 14, 2004 concerning this issue, the NRC raised the possibility of error by a person who was unaware of the importance of preventing unborated water from entering the SFP or Cask Pit, when a fueled DSC is in the Cask Pit. To provide assurance against this type of single personnel error by an "unaware" person, DNC will commit to keep an individual present on the SFP floor who will specifically monitor for water spilling into the SFP (or Cask Pit), or SFP water overflow, whenever a fueled DSC is in the Cask Pit. The individual who is monitoring the SFP would promptly identify any water entering the SFP from the "unaware" person's actions and terminate the dilution event. As a result of this commitment, detection of an inadvertent dilution of the SFP with a fueled DSC in the SFP will be essentially immediate. The prompt detection of any dilution into the Cask Pit will result in prompt termination of the source of flow into the Cask Pit. Therefore, no significant amount of unborated water can inadvertently enter and potentially stratify the boron concentration in the Cask Pit. The requirement to maintain a minimum of 850 gpm of total SFPCS flow, and the requirement for Valve 2-RW-350 to be open, assures significant flow is present in the Cask Pit. Significant SFPCS flow in the Cask Pit assures that any small amount of unborated water added to the Cask Pit will be mixed. This ensures that localized boron dilution and stratification will not occur in the Cask Pit during DSC operations.

Attachment 2

Reconciliation of Regulatory Requirements

List of Regulatory Commitments

Millstone Power Station Unit 2
Dominion Nuclear Connecticut, Inc. (DNC)

The following is a comprehensive list of commitments that have been identified in this submittal, as well as previous submittals associated with this exemption request. The list of commitments provided in this Attachment supersedes the previously stated commitments made by DNC in the letters dated November 5, 2004 and December 13, 2004. These commitments will be incorporated into our commitment management program:

1. DNC will revise ISFSI procedures or calculations to state that poison rod assembly (PRA) use is not authorized by the proposed 10CFR50.68(b)(1) exemption.

2. DNC will revise ISFSI procedures to require that when a fueled 32PT DSC is in the MPS2 SFP, cooling flow must be at least 850 gpm.

3. During the time that a fueled DSC is in the SFP, procedural controls will be implemented to ensure that the transfer canal bulkhead gate will not be used to block the transfer canal opening to the SFP.

4. An additional precaution will be added to the SFP high level alarm response procedure to identify that if there is a fueled DSC in the SFP additional boron concentration limits apply. These limits will be specified in the procedure.

5. Training will be conducted to ensure operators are aware of the 32PT DSC TS SFP boron concentration requirements, and should a boron dilution occur, at what boron concentration criticality in the DSC could occur. The training will emphasize the importance of avoiding any inadvertent additions of unborated water to the SFP, responses to be taken for notification or alarms that may be indicative of a potential boron dilution event during cask loading and fuel movement in the SFP, and identification of the potential for a boron dilution event during decontamination rinsing activities.

6. Appropriate controls or measures to minimize the possibility of direct dilution of the cask handling area of the SFP will be established prior to DSC loading.

   a) DNC will revise ISFSI procedures to require an individual remain on the SFP floor at all times when a fueled 32PT DSC is in the MPS2 SFP to ensure that the SFP is not overflowing and that water is not unintentionally spilling into the SFP.

   b) DNC will revise ISFSI procedures to require Valve 2-RW-350 remain open when a fueled 32PT DSC is in the MPS2 SFP.

   c) DSC procedures will be modified to include a requirement that the SFP will be sampled for boron concentration after each intentional addition of a maximum of 500 gallons of unborated water.

7. DNC will revise ISFSI procedures to require Valve 2-RW-2 will be closed when a fueled 32PT DSC is in the MPS2 SFP.

Attachment 3

Reconciliation of Regulatory Requirements

Technical Evaluation M2-EV-04-0025, Revision 2

Millstone Power Station Unit 2
Dominion Nuclear Connecticut, Inc. (DN

QA ☒ Non-QA ☐

DB or LB document change required? yes ☐ no ☒

TECHNICAL EVALUATION

for

Boron Dilution Analysis for TN32PT Cask in the Millstone 2 Spent Fuel Pool

Millstone Unit 2

M2-EV-04-0025

Revision 2

January 13, 2005

33 pages

Joe Parillo (signature)		1/18/05
Preparer		Date
Tom Guarino (signature)		1/18/05
Independent Reviewer		Date
Cary LaRoe (signature)		1/18/05
Engineering Approver		Date

1.0 PURPOSE

This Technical Evaluation analyzes all the potential boron dilution sources to the Millstone 2 Spent Fuel Pool (SFP), and verifies that sufficient time is available to detect and terminate the boron dilution event, to ensure that criticality is not reached in the fuel within the NUHOMS 32PT Dry Storage Canister (DSC).

2.0 BACKGROUND

Current Situation

Millstone 2 (MP2) currently credits 600 ppm of soluble boron in the MP2 SFP to maintain k_{eff} of the *fuel in the storage racks* of the SFP to less than or equal to 0.95 on a 95/95 basis. The MP2 Operating License Technical Specifications (TS) currently require a minimum of 1720 ppm of soluble boron when fuel is stored in the SFP. This value of 1720 ppm soluble boron concentration ensures that should a boron dilution event occur, sufficient time is available to detect and terminate the boron dilution event prior to reaching 600 ppm of boron, thus ensuring that the fuel in the storage racks of the SFP would have a k_{eff} of less than or equal to 0.95. This analysis was previously reviewed and approved by the NRC (Ref: 7.15). The boron dilution analysis presented in this evaluation does not alter this existing boron dilution analysis for the fuel in the storage racks.

Proposed Situation

Millstone 2 is proposing to load fuel in a NUHOMS 32PT Dry Storage Canister (DSC) because the MP2 SFP is nearly full. The DSC would be located in the Cask Laydown Pit of the SFP. The Technical Specifications associated with the NUHOMS 32PT Dry Storage Canister (DSC) require a certain soluble boron concentration for loading and unloading of fuel within the DSC to ensure that k_{eff} of the fuel in the DSC is maintained below 0.95. This DSC TS boron concentration is extremely conservative since it does not credit fuel burnup. This Technical Evaluation demonstrates that if a boron dilution event were to occur in the Millstone 2 SFP, that the boron dilution event could be detected and terminated before criticality is reached by the fuel in the NUHOMS 32PT DSC. The boron dilution analysis presented here for the *fuel in the DSC*, does not alter the previous boron dilution analysis that was for the *fuel in the storage racks*.

3.0 DISCUSSION

Attachment 1 analyzes the potential sources that could dilute the boron concentration in the MP2 SFP. This analysis demonstrates sufficient time is available to detect and terminate the boron dilution event prior to reaching criticality in the NUHOMS 32PT DSC located in the MP2 SFP.

4.0 SAFETY SIGNIFICANCE

No RAC12 screening or evaluation is required for this Technical Evaluation, since it will support LBDCR LBC-MP2-04-006 that will be submitted to the NRC.

5.0 CONCLUSION

Based on the evaluation of Attachment 1, an unplanned or inadvertent dilution event would be detected and stopped before the boron concentration was reduced to a level that would cause criticality in the fuel contained within the 32PT DSC. The large volume of water required to dilute the SFP, the limited flow rates from potential dilution sources, the TS controls on SFP boron concentration, control room alarms, and regular observation of SFP water level would ensure that detection of the dilution event allowed sufficient time to terminate the dilution.

The acceptability of this conclusion is based on the addition of 5 procedural requirements for the ISFSI procedures when a 32PT DSC is in the MP2 SFP with fuel inside the DSC: (1) The requirement to verify that the transfer canal bulkhead gate is not in place to block the opening to the spent fuel pool. (2) An individual will remain on the SFP floor at all times, to ensure that no water is unintentionally spilling into the SFP, and the SFP is not overflowing. (3) Valve 2-RW-350 must remain open. (4) Spent Fuel Pool Cooling Flow must be at least 850 gpm. (5) Spent Fuel Pool water will be sampled for boron concentration after each interval of 500 gallons of unborated water has been added to the spent fuel pool.

6.0 ATTACHMENTS

Attachment 1 Millstone Unit 2 Spent Fuel Pool Boron Dilution Analysis for the NUHOMS 32PT DSC
Attachment 2 Independent Reviewer's Comment Sheet

Attachment 1

Millstone Unit 2
Spent Fuel Pool Boron Dilution Analysis
Summary for a NUHOMS 32PT DSC

Attachment 1 Table of Contents

1.0 Introduction

The purpose of this evaluation is to ensure that sufficient time is available to detect and terminate a boron dilution event in the Millstone Unit 2 Spent Fuel Pool to maintain sub-criticality in the fuel contained inside a NUHOMS 32PT DSC.

Current Situation

Millstone 2 (MP2) currently credits 600 ppm of soluble boron in the MP2 SFP to maintain k_{eff} of the *fuel in the storage racks* of the SFP to less than or equal to 0.95 on a 95/95 basis. The MP2 Operating License TS currently require a minimum of 1720 ppm of soluble boron when fuel is stored in the SFP. This value of 1720 ppm soluble boron concentration ensures that should a boron dilution event occur, sufficient time is available to detect and terminate the boron dilution event prior to reaching 600 ppm of boron, thus ensuring that the fuel in the storage racks of the SFP would have a k_{eff} of less than or equal to 0.95. This analysis was previously reviewed and approved by the NRC (Ref: 7.15). The boron dilution analysis presented in this evaluation does not alter this existing boron dilution analysis for the fuel in the storage racks.

Proposed Situation

Millstone 2 is proposing to load fuel in a NUHOMS 32PT Dry Storage Canister (DSC) because the MP2 SFP is nearly full. The DSC would be located in the Cask Laydown Pit of the SFP. The Technical Specifications associated with the NUHOMS 32PT Dry Storage Canister (DSC) require a certain soluble boron concentration for loading and unloading of fuel within the DSC to ensure that k_{eff} of the fuel in the DSC is maintained below 0.95. This DSC TS boron concentration is extremely conservative since it does not credit fuel burnup. This Technical Evaluation demonstrates that if a boron dilution event where to occur in the Millstone 2 SFP, that the boron dilution event could be detected and terminated before criticality is reached by the fuel in the NUHOMS 32PT DSC. The boron dilution analysis presented here for the *fuel in the DSC*, does not alter the previous boron dilution analysis that was for the *fuel in the storage racks*.

This Technical Evaluation (TE) includes the following plant specific features and potential events:

- instrumentation
- administrative procedures
- boration sources
- dilution sources
- dilution flow rates
- boron dilution initiating events
- boron dilution times and volumes

2.0 SPENT FUEL POOL AND RELATED SYSTEM FEATURES

This Section provides background information on the SFP and related systems.

2.1 Spent Fuel Pool

The SFP is located in the auxiliary building. The pool is designed for the underwater storage of spent fuel assemblies after removal from the reactor core. The spent fuel storage racks, located in the bottom of the SFP are licensed to accommodate fuel assemblies in both intact and consolidated forms. The SFP is designed to maintain approximately 24 feet of borated water above the stored fuel assemblies (Ref.: 7.5.5). Connected to the spent fuel pool are the transfer canal and the cask laydown pit. The transfer canal and cask laydown pit are normally open to the pool, but may be isolated from the spent fuel pool by use of bulkhead gates. The cask laydown pit is the area where a fuel transfer cask is placed.

2.2 Spent Fuel Pool Storage Racks and Pool Volume

There are 3 Regions for fuel storage, designated Regions A, B and C. The stainless steel storage racks consisting of vertical cells grouped in parallel rows, are designed for a center-to-center distance of 9.8 inches in Regions A and B and 9.0 inches in Region C. Spent fuel decay heat is removed by the SFP cooling system described below. The arrangement also provides for adequate convective cooling of stored fuel assemblies.

The fuel storage racks are designed to maintain a K_{eff} of 0.95 or less during normal conditions and under abnormal conditions. Borated spent fuel pool water at a concentration of 600 ppm is credited to maintain a K_{eff} of 0.95 or less under normal conditions. The Operating License Technical Specifications require 1720 ppm of soluble boron in the spent fuel pool with fuel in the pool (Ref: 7.4.2 and 7.4.5). A boron dilution analysis was submitted to and approved by the NRC (reference 7.8 and 7.15) that demonstrated there is sufficient time to detect and mitigate a potential boron dilution event from reaching 600 ppm, starting from an initial spent fuel pool soluble boron concentration of 1720 ppm.

The volume of water in the SFP with the SFP at the low level setpoint, is 29,318 ft^3 or 219,314 gallons (Ref.: 7.1.1) of water. This value of 219,314 gallons has been adjusted to remove the fuel storage rack volume and fuel volume. The fuel storage racks displace approximately 600 ft^3, and the fuel assembly volume displaced is 5,384 ft^3 (Ref.: 7.1.1) assuming fuel in all storage locations.

The transfer canal is connected to the spent fuel pool, and is normally open to the spent fuel pool. The transfer canal has a capacity of 76,387 gallons (Ref.: 7.2.5) and the gate area has a capacity of 1,615 gallons (Ref: 7.2.5).

Thus the minimum total water volume of the spent fuel pool and transfer canal with the spent fuel pool water level at the low level setpoint is: 219,314 + 76,387 + 1,615 = 297,316 gallons, which is conservatively rounded down to 297,000 gallons. This value does not include the cask pit volume.

The volume of free water in the cask pit is calculated next. Per reference 7.2.5, the volume of the cask laydown pit is 23,326 gallons. This will be conservatively rounded down to 23,050 gallons. Next we will substract the volume of the DSC in the cask pit. Per reference 7.3.7, the DSC is a cylinder of radius 3.5625 feet and a length of 16.9167 feet. We will conservatively assume the DSC is a solid cylinder with no water in it. Therefore the volume of water displaced by the DSC is:
Volume = Pi x (3.5625 feet)**2 x 16.9167 feet = 674.49 ft**3
Converting to gallons, 674.49 cuft x 7.48 gallons/cuft = 5045 gallons. This will be conservatively rounded up to 5050 gallons of water displaced. Thus the net amount of water in the cask pit is 23050 gallons – 5050 gallons = 18000 gallons of water.

Since the volume of free water in the cask pit is 18,000 gallons, the total volume of water in the SFP with the cask pit free volume is 315,000 gallons (297,000+18,000).

One additional volume needed later in this evaluation is the free volume of water from the spent fuel pool floor to the top of the cask. This is calculated next. Per reference 7.2.5, the volume change per inch in the SFP + transfer canal + cask pit is 787 gallons/inch. Note that the value of 787 gallons/inch conservatively does not include the gate area. Since the cask is 16.9167 feet tall the total volume from the floor of the SFP to the top of the cask is:
787 gallons/inch * 16.9167 feet x 12 in/ft = 159,761 gallons.
However, this volume must be reduced by the fuel volume, rack volume and cask volume to determine the free volume of water. As discussed above, the fuel volume displaces 5384 ft**3, the rack volume displaces 600ft**3 and the DSC displaces 5050 gallons. Therefore the free net water volume from the SFP floor to the top of the DSC is:
159761 gallons – 5050 gallons – (5984 ft**3 * 7.48 gall/ft**3) = 120,050 gallons. This is conservatively rounded down to 120,000 gallons of free water. Therefore 120,000 gallons is the free volume of water from the spent fuel pool floor to the top of the cask.

2.3 Spent Fuel Pool Cooling

The function of the SFP cooling system is to remove aecay heat generated by spent fuel assemblies stored in the pool by limiting the temperature of the borated pool water to an acceptable level, thereby ensuring the cladding integrity of stored spent fuel assemblies. The SFP cooling system consists of 2 trains of SFP cooling, which can be augmented by the shutdown cooling system during refueling outages. The SFP cooling system and shutdown cooling system are cooled by the Reactor Building Component Cooling Water (RBCCW) System.

2.4 Spent Fuel Pool Instrumentation

The SFP is provided with level and temperature instruments that provide annunciation in the main control room (Ref.: 7.5.6). The high level alarm of the SFP (Ref 7.2.1) will initiate the operators response to a potential boron dilution event in the SFP. The SFP low level alarm is set for a water depth of 38 feet. The setpoint of this alarm will ensure the TS minimum level is maintained (Ref.: 7.4.4). The high level alarm is set for a water depth of 39'-2" (Ref.: 7.2.1). Thus there is about 14 inches between the low level alarm and the high level alarm. The high level alarm is about 16 inches below the SFP operating deck.

If the pool level were to be raised from the low level alarm point to the high level alarm point, a dilution of approximately 11,074 gallons could occur before the alarm is received in the control room. This is calculated by 14 inches between the low and high level alarm setpoint and the value of 791 gallons/inch (Ref 7.2.5) needed to change SFP level, thus:
14 inches * 791 gallons/inch = 11,074 gallons.

If the pool level were to be raised from the high level alarm point to the point of overflowing the SFP at the operating deck, a dilution of approximately 12,656 gallons would be required. This is calculated by 16 inches between the high level alarm setpoint and the overflow level, and the value of 791 gallons/inch (Ref 7.2.5) needed to change SFP level, thus:
16 inches * 791 gallons/inch = 12,656 gallons.

SFP temperature instrumentation provides continuous monitoring (high temperature alarm) and recording of pool water temperatures by main control room personnel. A low-flow alarm will alert operating personnel that one or both SFP cooling water pumps has failed to operate. SFP cooling water flow instrumentation annunciates a low SFP cooling water flow alarm in the main control room. SFP heat exchanger outlet instrumentation annunciates a high-temperature alarm in the main control room.

2.5 Spent Fuel Pool Administrative Procedures

Currently, Operating License Technical Specifications (TS) requires the soluble boron concentration in the SFP to be greater than or equal to 1720 ppm (Ref.: 7.4.2) whenever a fuel assembly or consolidated fuel storage box is stored in the spent fuel pool.

The cask to be used for dry storage at Millstone Unit 2 is the NUHOMS 32PT Dry Storage Canister (DSC). The current Technical Specification requirements for the 32PT DSC are Amendment 7 to CofC 1004 (Ref: 7.13). TS 1.2.15a of Amendment 7 requires 2500 ppm of soluble boron when loading or unloading fuel from the 32PT DSC. There is also a proposed Amendment 9 to CofC 1004 (Ref 7.14). In the proposed Amendment 9, TS 1.2.15a requires from 1800 ppm to 2500 ppm of soluble boron, depending on the fuel enrichment, when loading or unloading fuel from the 32PT DSC. The required 32PT DSC TS surveillance interval for verifying adequate boron concentration is within 4 hours of loading the 1st fuel assembly or within 4 hours of flooding the DSC for fuel removal. Subsequent verification is every 48 hours.

Millstone proposes to add the following 5 requirements to the ISFSI procedures.
When a 32PT DSC is in the SFP with fuel inside the DSC:

(1) The requirement to verify that the transfer canal bulkhead gate is not in place to block the opening to the spent fuel pool.
(2) An individual will remain on the SFP floor at all times, to ensure that no water is unintentionally spilling into the SFP, and the SFP is not overflowing.
(3) Valve 2-RW-350 must remain open.
(4) Spent Fuel Pool Cooling Flow must be at least 850 gpm.
(5) Spent Fuel Pool water will be sampled for boron concentration after each interval of 500 gallons of unborated water has been added to the spent fuel pool.

2.6 Boration Sources

The normal source of borated water to the SFP is from the refueling water storage tank (RWST). The boron concentration in the RWST is maintained above 1720 ppm in accordance with Operating License TS Surveillance Requirement (Ref.: 7.4.1 and 7.4.3).

3.0 SPENT FUEL POOL DILUTION EVENT

3.1 Calculation of Boron Dilution Times and Volumes

3.1.1 Criticality Analysis

Millstone 2 Operating License Technical Specifications require the spent fuel pool boron concentration to be maintained ≥ 1720 ppm of soluble boron, with fuel in the SFP.

During loading of the 32PT DSC in the cask laydown pit of the spent fuel pool, the boron concentration in the SFP and DSC will be required to be maintained greater than or equal to the CofC 1004 Amendment 7 TS 1.2.15a limit of 2500 ppm of soluble boron. The allowable fuel enrichment and Poison Rod Assembly (PRA) requirements corresponding to the 2500 ppm minimum boron concentration are specified in CofC 1004 Amendment 7 TS Table 1-1g. Transnuclear (TN) performed a criticality analysis (reference 7.6) that showed that even if the soluble boron concentration was reduced below 2500 ppm, a soluble boron concentration of 1700 ppm would maintain sub-criticality in the 32PT DSC. A bounding fuel enrichment and PRA combination was used in the analysis. This analysis is extremely conservative in that no credit is taken for fuel burnup. Further, this analysis is highly conservative since optimum moderation is used in the calculations. Boron dilution with full moderation (DSC being fully flooded at all times during the event) is more realistic and results in a reduction in the boron concentration requirement to maintain sub-criticality.

TN performed a second criticality calculation to address pending Amendment 9 to CofC 1004, which modifies TS 1.2.15a to allow a sliding scale of required soluble boron concentration from 1800 ppm to 2500 ppm, depending on fuel enrichment. TN performed a criticality analysis (reference 7.6) that showed that even if the soluble boron concentration was reduced below 1800 ppm, a soluble boron concentration of 1200 ppm would maintain sub-criticality in the 32PT DSC. This analysis is extremely conservative in that no credit is taken for fuel burnup. Further, this analysis is highly conservative since optimum moderation is used in the calculations. Boron dilution with full moderation (DSC being fully flooded at all times during the event) is more realistic and results in a reduction in the boron concentration requirement to maintain sub-criticality.

Thus the criticality analysis performed by Transnuclear covers the range of required boron concentrations of 1800 ppm to 2500 ppm, that are allowed by the existing approved Amendment 7 and the proposed Amendment 9 to CofC1004. This range of boron concentrations from 1800 to 2500 ppm correspondingly covers a range of initial fuel enrichments/PRA's.

Based on the criticality analysis performed by Transnuclear (reference 7.6), for fuel with a required soluble boron concentration of 2500 ppm to meet $k_{eff} \leq 0.95$ on a 95/95 basis, a soluble boron concentration of 1700 ppm will maintain the $k_{eff} < 1.00$ with a 95% probability at a 95% confidence level.

Based on the criticality analysis performed by Transnuclear (reference 7.6), for fuel with a required soluble boron concentration of 1800 ppm to meet $k_{eff} \leq 0.95$ on a 95/95 basis, a soluble boron concentration of 1200 ppm will maintain the $k_{eff} < 1.00$ with a 95% probability at a 95% confidence level.

As will be shown later in this evaluation, the boron dilution event starting from 2500 ppm produces the shortest dilution time interval that requires the operators to detect and terminate the dilution event.

3.1.2 Boration Dilution Times and Volumes

The dilution times and volumes calculated here are based on a starting SFP soluble boron concentration of 2500 ppm and maintaining a final concentration of 1700 ppm of soluble boron in the DSC. It will be shown that this initial condition for fuel requiring 2500 ppm of SFP soluble boron results in the shortest (conservative) possible dilution times.

There is no automatic SFP level control system in the SFP, so that any dilution to the SFP will add water to the SFP. Therefore, the addition of unborated water to the SFP will lead to increased SFP water level, and if not controlled, an overflow of the SFP.

Multiple methods of analysis will be used to determine the boron concentration in the SFP/DSC during the dilution. One method will be the continuous dilution method (feed and bleed), which is an instantaneous mixing model. Slug flow (no mixing model) will also be considered. Ultimately the slug flow model will be used as a bounding value for the time to reach criticality in the DSC, however the instantaneous mixing models should provide more realistic estimates due to the forced flow in the SFP and cask laydown pit.

3.1.2.1 Instantaneous mixing model (feed and bleed)

The continuous dilution method assumes unborated water is added at a constant rate with a constant rate of removal. This physically corresponds to unborated water being added to the SFP, and borated water at the current concentration being lost by overflow of the SFP. This feed and bleed method will give accurate results in a well-mixed system. In this model, the location of where the dilution flow is added is not important since perfect mixing is assumed. Since perfect mixing is assumed the boron concentration in the SFP and DSC are the same. For conservative results, it is assumed that the initial SFP water volume will be at the low alarm level.

By conservatively only crediting the SFP water level is at the SFP level low alarm setpoint, and not crediting the cask pit volume, the calculated SFP volume is 297,000 gallons, as stated earlier in Section 2.2.

A continuous "feed and bleed" dilution of the SFP will be calculated by the equation for change in boron mass per unit of time.

$$dm/dt = m_{in}^{o} - m_{out}^{o} \text{ (Ref: 7.1.1)}$$

where m_{in}^{o} , m_{out}^{o} are the mass flow rates of boron in and out, respectively.

Ignoring the minimal temperature effects, the mass flow rate of boron in each instance is equal to the product of the volumetric flow rate of diluted water, Q, and the concentration of boron, C, within the diluted water.

$$m^{o} = Q * C \text{ (Ref: 7.1.1)}$$

If the concentration of water volume added is zero and the flow rate out is equal to the flow rate in, the equation can be rewritten as:

$$dm/dt = -Q_{out} * C_{out} = V_{SFP\ Total} * dC/dt \text{ (Ref: 7.1.1)}$$

where:

$V_{SFP\ Total}$ = volume of the SFP, at the low level alarm
dC/dt = change in concentration of the SFP with respect to time

Therefore, if the equation above is rearranged and integrated from zero to time (t), the following would be the result:

$$-Q_{out} * t = V_{SFP\ Total} * (\ln C_t - \ln C_o) \text{ (Ref: 7.1.1)}$$

Realizing that Q is equal to the volume divided by time and that the volume out is equal to the volume in, the left side of the equation reduces to the negative of the volume in V_{in}. Then, by moving the negative on the left to the right and realizing that C_t is equal to our final concentration and C_o is our initial concentration, the above equation can be rewritten in its final form.

$$V_{in} = V_{SFP\ Total} * \ln (C_t / C_o) \text{ (Ref: 7.1.1)}$$

The SFP volume at the low level alarm, less the volume displaced by the racks and fuel, is 297,000 gallons. Using this volume, we can determine the total dilution volume needed to dilute the SFP from the initial 2500 ppm boron concentration to 1700 ppm, by solving the above equation for V_{in}.

Inserting the following values:
$V_{SFP\ Total}$ = 297,000 gallons
C_t = 2500 ppm
C_o = 1700 ppm

$$\mathbf{V_{in} = 297{,}000\ gals * \ln (2500\ ppm / 1700\ ppm)}$$
$$\mathbf{V_{in} = 114{,}541\ gallons}$$

The result is 114,000 gallons, conservatively rounding down. Thus for the feed and bleed instantaneous mixing model, 114,000 gallons of water would be needed to dilute the boron concentration from 2500 ppm to 1700 ppm in the SFP/DSC.

As discussed in Section 3.1.1, the Transnuclear (TN) criticality analysis (Ref 7.6) also performed calculations for the NUHOMS 32PT DSC for fuel with a starting soluble boron concentration requirement of 1800 ppm. TN performed a criticality analysis that showed that even if the soluble boron concentration was reduced below 1800 ppm, a soluble boron concentration of 1200 ppm would maintain sub-criticality in the 32PT DSC. For a dilution from 1800 to 1200 ppm, the following volume of water would be required.

Inserting the following values:

$V_{SFP\ Total}$ = 297,000 gallons
C_t = 1800 ppm
C_o = 1200 ppm

V_{in} = 297,000 gals * ln (1800 ppm / 1200 ppm)
V_{in} = 120,423 gallons

Thus the volume for a dilution from 1800 to 1200 ppm is more than the volume of water required for a dilution from 2500 to 1700 ppm. Therefore, the dilution from 2500 ppm to 1700 ppm is more restrictive (gives shorter dilution times) and will be analyzed as the limiting case.

For dilution sources with automatic make-up, the capacity for dilution is essentially infinite. Should one of these sources begin adding unborated water to the pool, the pool level would rise to the high level alarm setpoint, alerting the control room operators. Should the high level alarm fail, and no operator actions were taken, the pool will eventually fill to the curb and begin overflowing.

As stated earlier in Section 2.4, the volume of water from the SFP low level setpoint to high level setpoint is approximately 11,074 gallons, with an additional approximately 12,656 gallons from the high level setpoint to pool overflow. Thus a total of approximately 23,730 gallons of water must be added to the SFP to overflow the SFP. Later in this evaluation, it is shown that a 200 gallon per minute (gpm) dilution flow is the limiting dilution flowrate. At a 200 gpm dilution flow rate into the spent fuel pool, the pool will overflow in 2 hours if level was initially at the low level setpoint. This is calculated by: 23,730 gallons/ 200 gpm = 118.65 minutes, which is about 2 hours.

ISFSI administrative procedures will require that if a DSC is in the SFP with fuel inside the DSC, an individual will remain on the SFP floor at all times, to ensure that no water is unintentionally spilling into the SFP, and the SFP is not overflowing. As will be justified later in this Technical Evaluation, for a bounding dilution flow rate of 200 gpm of unborated water, and using this instantaneous mixing model, 9.5 hours are needed for the SFP/DSC soluble boron concentration to change from 2500 ppm to 1700 ppm. This is simply calculated as follows, using the 114,000 gallons of water previously determined as the volume needed to dilute the pool from 2500 to 1700 ppm, and the worst case dilution flowrate of 200 gpm:

114,000 gallons / 200 gpm = 570 minutes = 9.5 hours

Thus using the instantaneous mixing model, with 200 gpm of unborated water entering the SFP, it will take 9.5 hours to dilute the SFP/DSC from 2500 ppm to 1700 ppm. The operators would receive a high spent fuel pool water level alarm in the control room in about 1 hour. It will take about 2 hours to overflow the pool. When a fueled DSC is in the SFP, an individual will be continuously monitoring the SFP for indications of overflow or water spilling into the pool. Thus a maximum of 2 hours will occur before detection of the dilution event. This allows 7.5 hours to terminate the dilution event, which is a more than adequate time interval to terminate the event.

3.1.2.2 Slug Flow (no mixing) Model

To provide a bounding evaluation of the time to reach criticality in the DSC, should an inadvertent dilution of the SFP occur, a slug flow model will be used. Multiple cases are evaluated since it is important in this no mixing model, where the dilution occurs.

Dilution Case of 200 gpm of unborated water into the SFP Cooling System with no mixing

A dilution of the spent fuel pool cooling system (SFPCS) is the limiting dilution event. Up to 200 gpm of unborated water can dilute the SFP cooling system, with the limiting source coming from the Primary Make-up Water (PMW) Line. The SFP cooling system discharges through 2 lines into the bottom of the SFP and 1 line into the bottom of the cask pit, where the DSC is located. The slug flow (no mixing) model for this event shows that at least 5 hours will be available before the DSC water boron concentration decreases from 2500 ppm to 1700 ppm of boron. This value of 5 hours for the slug flow model is calculated as follows:

Initially, the entire SFP, including the water in the DSC is at 2500 ppm boron concentration. Initially SFP cooling flow is at 850 gpm, which is the minimum allowed with a fueled DSC in the SFP. A 200 gpm inadvertent unborated water addition then occurs in the PMW make-up line, adding an additional 200 gpm of unborated water to the SFP cooling system (SFPCS) recirculation flow of 850 gpm, which contains 2500 ppm borated water. This produces a total flow of 1050 gpm, at a mixed boron concentration of 2023 ppm (2500*850/1050). Thus 1050 gpm of total flow at 2023 ppm boron starts filling the pool. This 2023 ppm water is added at the bottom of the SFP through 2 SFPCS discharge lines, and to the bottom of the cask pit through 1 SFPCS discharge line. If no mixing where to occur, the SFP would fill with 2023 ppm water, displacing the 2500 ppm water to spill out the top of the pool. Eventually, the 2023 ppm water would fill the SFP and start entering the SFPCS suction line, which is at the top of the pool. The time it takes to fill the SFP, and therefore DSC, with 2023 ppm water is a conservative measure of time to reach 1700 ppm boron concentration in the DSC. It will take 5 hours for the 2023 ppm borated water to fill the entire pool, including the DSC, in this manner. The 5 hours is calculated as follows:

Total volume of SFP water = 315,000 gallons (from section 2.2)
Time to displace 315,000 gallons at 1050 gpm =
315,000 gallons / 1050 gpm = 300 minutes = 5 hours

Thus during this 5 hour period, the DSC water boron concentration will be greater than the 1700 ppm critical concentration. This is the limiting case for producing the shortest time to criticality due to an inadvertent dilution event. The 1st credited means of detection of the dilution will be the spent fuel pool high level alarm in the control room within 1 hour of the dilution start. The 2nd credited means of detection is by the individual who is continuously monitoring the spent fuel pool for overflow. Overflow of the spent fuel pool will be within 2 hours of the dilution start. Thus detection of the dilution in the worst case is 2 hours. Therefore, at least 3 hours (5 hours – 2 hours) is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached.

Dilution Cases of 100 gpm of unborated water Spilling into the SFP with no SFP mixing

This situation involves 100 gpm of unborated water spilling into the top of the spent fuel pool or transfer canal. This does not include water spilling into the cask pit, which is addressed separately. Unborated water spilling into the spent fuel pool at the operating deck can come from several sources. The maximum unborated water flow rate from these sources is <100 gpm. Two separate cases are provided below, with case 1 being limiting. The 1st case involves 100 gpm of unborated water spilling into the top of the SFP near the SFPCS suction line, no SFP mixing occurs, and all of the unborated water enters the SFPCS suction line. The 2nd case involves the 100 gpm of unborated water spilling into the top of the SFP far away from the SFPCS suction line, and the cold unborated water sinks to the bottom of the SFP and does not mix, displacing 2500 ppm borated water.

Case 1

The limiting case is if 100 gpm of dilution flow spills into the pool near the SFP cooling suction line, which is at the top of the pool. This case is limiting since with valve 2-RW-350 open, water flow goes into the cask pit from the open SFP cooling discharge line, and water flow leaves the cask pit out the gate opening and into the main SFP. Given the flow direction being out the cask pit, the primary means of dilution of the cask pit water boron concentration would be due to the water entering from the SFPCS discharge line into the bottom of the cask pit. Thus direct dilution of the SFPCS suction line at the top of the SFP will result in a reduced boron concentration of the SFPCS water entering the SFPCS discharge line at the bottom of the cask pit.

Initially, the entire SFP, including the water in the DSC is at 2500 ppm boron concentration. Initially SFP cooling flow is at 850 gpm, which is the minimum allowed with a fueled DSC in the SFP. A 100 gpm inadvertent unborated water addition then occurs, spilling into the top of the SFP. If all of the unborated water enters the SFPCS suction line at the top of the SFP, then 100 gpm of unborated water and 750 gpm of 2500 ppm water will provide the SFPCS recirculation total flow of 850 gpm. This produces a total flow of 850 gpm, at a mixed boron concentration of 2205 ppm (2500*750/850). Thus 850 gpm of total flow at 2205 ppm boron starts filling the pool. This 2205 ppm water is added at the bottom of the SFP through 2 SFPCS discharge lines, and to the bottom of the cask pit through 1 SFPCS discharge line. If no mixing where to occur, the SFP would fill with 2205 ppm water, displacing the 2500 ppm water to spill out the top of the pool. Eventually, the 2205 ppm water would fill the SFP and start entering the SFPCS suction line, which is at the top of the pool. The time it takes to fill the SFP, and therefore DSC, with 2205 ppm borated water, and displace all the 2500 ppm borated water is calculated as:

Total volume of SFP water = 315,000 gallons (section 2.2)
Time to displace 315,000 gallons at 850 gpm =
315,000 gallons / 850 gpm = 370 minutes = more than 6 hours
For conservatism, this is rounded down to 5 hours.

Thus it will take 5 hours for the 2205 ppm borated water to fill the entire pool, including the DSC, with 2500 ppm borated water spilling over the top of the pool. In fact, an additional cycle

of this slug flow can be accommodated. The 2nd cycle of slug flow through the SFPCS suction line would produce a total flow of 850 gpm, at a mixed boron concentration of 1945 ppm (2205*750/850).
Thus at least 2 cycles of this slug flow (5 hours per cycle) can be accommodated before the boron concentration approaches or goes below 1700 ppm boron in the DSC. Thus at least 10 hours is available in this case before the boron concentration goes below 1700 ppm in the DSC.

In summary, for water spilling into top of the spent fuel pool at up to 100 gpm of unborated water, at least 10 hours of time is available before reaching 1700 ppm boron in the DSC. Detection of the leak into the pool will be immediate by the individual who is continuously monitoring the spent fuel pool for overflow, or for any water leaking into the pool. Another means of detection of the dilution will be the spent fuel pool high level alarm in the control room within 2 hours of the dilution start. Note that it takes 2 hours for the SFP high level alarm to be reached at a 100 gpm dilution rate, instead of the 1 hour it would take to reach the SFP high level alarm at a 200 gpm dilution rate. Thus detection of the dilution in the worst case is 2 hours. Therefore for this case, at least 8 hours (10 hours – 2 hours) is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached.

Case 2

This no-mixing case is if 100 gpm of unborated water spills into the pool far away from the SFP cooling suction line, which is at the top of the pool. This case evaluates how long it would take for the DSC boron concentration to fall below 1700 ppm if cold unborated water spills into the top of the SFP and sinks to the bottom with no mixing, displacing 2500 ppm borated water.

As previously stated in section 2.2, there is 120,000 gallons of water between the floor of the SFP and the top of the DSC, when the DSC is seated in the cask pit. Thus it would take 20 hours for the unborated water at 100 gpm flowrate to sink to the bottom of the SFP with no mixing, and rise to the top of the cask, displacing all 2500 ppm water. This is calculated as:

Time to reach top of DSC = 120,000 gallons / 100 gpm = 1200 minutes = 20 hours

Thus after 20 hours, the unborated water would start to spill into the DSC. This case is not as limiting as case 1 discussed above.

In conclusion, for the limiting case (case 1), with 100 gpm of unborated water spilling into the top of the SFP, it will take at least 10 hours for the boron concentration in the DSC to reach 1700 ppm. Detection of the leak into the pool will be immediate by the individual who is continuously monitoring the spent fuel pool for overflow or for any water leaking into the pool. Another means of detection of the dilution will be the spent fuel pool high level alarm in the control room within 2 hours of the dilution start. Thus detection of the dilution in the worst case is 2 hours. Therefore for this case, at least 8 hours (10 hours – 2 hours) is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached.

3.1.2.3 Direct Dilution into the Cask Laydown Pit

Since the cask pit contains the fueled DSC, direct dilution to the cask pit is considered separately. The possible means of direct dilution to the cask pit are discussed next.

Dilution of the cask pit through the SFP cooling return line

Spent Fuel Pool Cooling has a outlet pipe that goes directly to the cask laydown pit, through valve 2-RW-350, and discharging to the bottom of cask pit. Valve 2-RW-350 will be required to be open whenever a fueled DSC is present in the cask pit. The possibility of dilution to the cask pit through this line is addressed in section 3.1.2.2.

Dilution of the cask pit by water spilling into the cask pit at the SFP operating deck

The other potential path for direct dilution of the cask laydown pit is for water leakage into the cask pit spilling into the cask pit from the operating deck, due to a leak of water from another system. A walkdown of the spent fuel pool operating deck shows that there is only 1 credible source of water that could dilute the cask pit directly by water spilling into the cask pit from the spent fuel pool operating deck. This potential dilution source is the PMW hose station (section 5.2) located near the cask laydown pit. All other potential leakage sources (sections 5.3 through 5.7) are eliminated as not being credible sources of direct dilution to the cask pit as explained next.

Dilution of the cask pit from dilution sources described in sections 5.3 through 5.7

The potential sources of dilution described in sections 5.3 through 5.7 are not credible sources of dilution directly spilling into the cask laydown pit since these potential dilution sources are far away from the cask laydown pit and would leak into the spent fuel pool or transfer canal, since the SFP or transfer canal are between the potential leak source locations and the cask laydown pit. The one exception to this is the North roof drain pipe described in section 5.7, which is addressed separately next. Further, ISFSI procedures will require that an individual will be continuously present on the SFP floor who will identify any water leaking into the SFP or a SFP overflow. Therefore, prompt identification of any water spilling into the SFP will occur.

Dilution of the cask pit from the North Roof Drainpipe

The overhead roof drainpipe on the north side of the spent fuel pool is a seismically supported drain line, as described in section 5.7. This overhead roof drain does not go directly over the cask pit, but if it were to leak vertically, it would leak only a few feet north of the cask pit. Since it is a roof drain, the water draining inside the pipe is not under pressure, which will limit the leak rate and the area that leaking water would spray laterally. Because of the physical layout surrounding the cask laydown pit, it is very unlikely that leaking water from the roof drain would enter the cask pit, but rather would enter the spent fuel pool or the floor drain system. This is because the spent fuel pool has a rail well on the north side of the pool that has its own drain. Further, the cask pit has additional protection on the north side due to a surface mounted rail, which will direct leaking water north of the rail, into the rail well or into the spent fuel pool. Further, the simultaneous events that would have to take place for any leakage to enter the cask pit is not credible. For the failure of the roof drain to allow water to enter the cask pit, the following must occur at the same time: (1) A DSC with fuel must be in the cask pit, (2) it must be raining, (3) the crack of the pipe must occur at the time the DSC is in the cask pit and it is raining, and (4) the leaking water must find its way to the cask laydown pit, even though the barriers described above should prevent water from entering the cask pit. For these reasons, this is not a credible dilution path for water to enter the cask pit.

It is important to emphasize that the leak in the roof drain pipe would have to occur at the time the DSC was in the cask pit, since, if the leak in the pipe had occurred earlier, the leakage from the pipe would have been noticed the last time it rained, by operators during routine shift rounds. The simultaneous events described above are not credible, and therefore this dilution path is not credible.

As additional protection against this event, ISFSI procedures will require that an individual will be continuously present on the SFP floor who will identify any water leaking into the SFP or a SFP overflow. Therefore, prompt identification of any water spilling into the SFP will occur, and any water leaking into the cask pit can be terminated or re-directed.

Dilution of the cask pit from the PMW hose station near the cask pit

As described in section 5.2, there is a PMW hose station located near the cask pit. This is a credible source of dilution to the cask pit. As stated in section 5.2, this system is designed to seismic Class 2 requirements. This hose station terminates in 2 available pipe connections. One of the 2 connections commonly has a hose attached for use in SFP activities. Each pipe connection has its own isolation valve, 2-PMW-408 and 2-PMW-409. Upstream of these 2 valves is a common isolation valve, 2-PMW-295. There is a short run of pipe upstream of the isolation valve 2-PMW-295 that runs to, and then through the north wall of the SFP. Should any type of a PMW leak or inadvertent discharge of PMW occur from this hose station, and with personnel present in the area, the appropriate isolation valve can be used to terminate the leak or inadvertent discharge. Should a pipe leak occur in the short section of pipe upstream of isolation valve 2-PMW-295, the PMW pump(s) can be turned off, which would terminate the discharge.

ISFSI procedures will require that an individual will be continuously present on the SFP floor to identify any water leaking into the SFP or a SFP overflow. Therefore, prompt identification of any water spilling into the SFP or cask pit will occur.

The PMW hose station will be used for normal cask operations, so it is not possible to permanently isolate this dilution source. ISFSI procedures will allow up to 500 gallons of PMW to be added to the cask pit or SFP before boron sampling is required. Thus up to 500 gallons of unborated water could be added to the cask pit for normal operations. This will have a limited but acceptable effect on boron concentration in the cask pit, and boron sampling will confirm the minimum 2500 ppm soluble boron concentration requirement before additional PMW addition is possible.

If a leak were to occur for whatever reason from the PMW hose station, the possibility exists that this water could reach the cask laydown pit. ISFSI procedures will require that an individual will be continuously present on the SFP floor to identify any water leaking into the SFP or a SFP overflow. Therefore, prompt identification of any water spilling into the SFP or cask pit will occur.

Specific consideration was given to the potential of a pipe leak in the PMW pipe that runs through the north wall of the SFP to valve 2-PMW-295. This short run of pipe to the hose station normally has no flow. Therefore it is unlikely for a leak in this pipe. To quantify the potential leak size from this pipe, calculations were performed (reference 7.1.1) specific to this pipe. The leak methodology used is consistent with that described in section 5.1. Per reference 7.1.1, a leak in this section of PMW pipe would be < 7 gpm. If such a leak were to occur, it is unlikely that much, if any of this leakage would make it to the cask laydown pit, because of the physical layout surrounding the cask laydown pit. Such leakage would enter the spent fuel pool or the floor drain system. This is because the spent fuel pool has a rail well on the north side of the pool that has its own drain. Further, the cask pit has additional protection on the north side due to a surface mounted rail, which will direct leaking water north of the rail, into the rail well or into the spent fuel pool. However, even if all 7 gpm of the PMW leakage goes to the cask pit for 1 hour, this is only 420 gallons (7 gpm x 60 minutes). Within 1 hour shutting down the PMW pumps can terminate this leakage, or the leakage can be redirected away from the SFP or cask pit. Therefore the 500 gallons of PMW that may be added for normal ISFSI operations bound this potential leakage into the cask pit.

Thus, potential dilution of the cask laydown pit from the PMW hose station is prevented by:
(1) ISFSI procedures will require that an individual will be continuously present on the SFP floor to identify any water leaking into the SFP or a SFP overflow.
(2) ISFSI procedures will require that the SFP will be sampled for boron concentration after each interval of 500 gallons of unborated water has been added to the spent fuel pool.

Summary of measures to minimize the possibility of direct dilution of the cask handling pit

In order to minimize the possibility of a direct dilution of the cask handling pit, with a DSC with fuel in the cask handling pit, the following measures will be administratively implemented:

(1) ISFSI procedures will require that an individual will be continuously present on the SFP floor to identify any water leaking into the SFP or a SFP overflow.
(2) ISFSI procedures will require that the SFP will be sampled for boron concentration after each interval of 500 gallons of unborated water has been added to the spent fuel pool.
(3) Valve 2-RW-350 will be required to be open to ensure that adequate mixing occurs in the cask pit should inadvertent dilution occur.

3.1.2.4 Conclusions

In the limiting case of a dilution of 200 gpm of unborated water into the SFPCS, it would take at least 5 hours for the boron concentration in the DSC to go from 2500 ppm to 1700 ppm. Thus a total of 60,000 gallons (200 gpm x 60 min/hr x 5 hours) of water would have to be added to the SFPCS for this to occur. In this case, with 2 hours allowed for detection, at least 3 hours is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached.

For the less limiting case of a dilution of 100 gpm of unborated water spilling into the SFP, it would take at least 10 hours for the boron concentration in the DSC to go from 2500 ppm to 1700 ppm. Thus a total of 60,000 gallons (100 gpm x 60 min/hr x 10 hours) of water would have to spill into the SFP for this to occur. In this case, with 2 hours allowed for detection, at least 8 hours is available for mitigation of the dilution. This is more than sufficient time to terminate the event before 1700 ppm in the DSC is reached.

3.1.3 Mixing During the Dilution Event

ISFSI procedures will require at least 850 gpm of SFP cooling flow during the time period when a DSC with fuel is in the cask laydown pit. This corresponds to 51000 gallons per hour (850 gpm x 60 minutes). As previously discussed, the volume of the spent fuel pool, including the cask pit is 315,000 gallons, thus at 850 gpm SFPCS flow, the spent fuel pool volume is being turned over about every 6 hours (315000/51000). The cask pit volume, which contains the DSC will be turned over more frequently. About 1/3 of the SFPCS discharge flow will go through the cask pit. This corresponds to about 850 gpm * 1/3 = 283 gpm, or about 300 gpm of flow through the cask pit. In an hour, 300 gpm x 60 minutes = 18,000 gallons. The volume of the cask pit is about 18,000 gallons (section 2.2) with the DSC present. Thus the cask pit volume will be turned over about once per hour.

As previously described, the limiting time to dilute the DSC boron concentration from 2500 ppm to 1700 ppm at a 200 gpm dilution rate into the SFPCS is 5 hours, without crediting mixing. However, as described above, there is substantial SFPCS flow, so that with mixing, more time is available before the boron concentration in the DSC reaches 1700 ppm. In the instantaneous mixing model 9.5 hours is available before the DSC boron concentration goes from 2500 ppm to 1700 ppm at a 200 gpm dilution rate into the SFPCS. For the purpose of this Technical Evaluation, the time of 5 hours from the slug flow model is used as the fastest time to reach 1700 ppm in the DSC.

4.0 DILUTION SOURCE PATH EVALUATION

This Section evaluates the potential for dilution of the SFP/DSC both from the SFP Cooling System as well as from external sources within the SFP building.

4.1 Spent Fuel Pool Cooling

There is limited potential for addition of water from systems that cross-connect into the SFP Cooling system. Potential water addition can be supplied from the Low Pressure Safety Injection (LPSI) system through the Shutdown Cooling Heat Exchangers. The borated water source being the Refueling Water Storage Tank (RWST) which is maintain at or above 1720 ppm boron (Ref.: 7.4.1 and 7.4.3). The RWST is also the source of water for the Refueling Pool Purification system at a transfer rate of 125 gpm. Both sources are isolated by a multiple of normally closed valves, 2-SI-458, 2-RW-15 and 2-RW-27 and either 2-RW-25 or 2-RW-28B depending which RW Purification Pump is in operation, and controlled procedurally by Operations (Ref.: 7.2.4 and 7.2.5). These systems are not a threat to dilute the DSC boron concentration to 1700 ppm since the injected water is from a borated water source with a concentration ≥ 1720 ppm.

4.2 Auxiliary Feedwater

The Auxiliary Feedwater (AFW) system takes suction from the Condensate Storage Tank (CST) and is a backup supply of makeup water with a flow rate of 100 gpm to the SFP. It is isolated by a normally locked closed valve, 2-FW-54, and controlled procedurally by Operations (Ref.: 7.2.3). The CST is a non-borated water source with a useable volume of 250,000 gallons (Ref.: 7.5.2). Makeup to the CST is a manual evolution that is performed by Operations and controlled by procedure (Ref.:7.2.3). Auxiliary Feedwater is not considered a dilution that will threaten reaching a DSC soluble boron concentration of 1700 ppm, since the flow rate of 100 gpm is less than the 200 gpm dilution flow rate limit of unborated water entering the SFPCS needed to dilute the DSC from 2500 ppm to 1700 ppm in 5 hours. Operators would be alerted to this event by a high SFP water level alarm, and administrative procedures will require continuous coverage that the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the pool overflow, leaving 3 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, an inadvertent addition of unborated water from the Auxiliary Feedwater system to the SFP is not considered a threat to dilute the DSC below 1700 ppm.

4.3 Primary Makeup Water

The Primary Makeup Water system is the normal makeup water supply to the SFP from the Primary Water Storage Tank (PWST). This is being supplied at a minimum rate of 50 gpm (Ref.: 7.5.1) which is adequate for the water loss due to evaporation and any system leakage that may occur. The Primary Makeup Water (PMW) System has a 150,000 gallon tank capacity (Ref.: 7.5.3). The maximum makeup capability of this permanently installed system is 200 gpm (Ref.: 7.5.1). This manipulation is a manual evolution that is performed by Operations and controlled by procedure (Ref.: 7.2.5). Per this procedure, two valves provide isolation of this normal makeup supply, unless makeup is in progress. Should a failure occur where makeup from this source at the maximum flowrate is allowed to dilute the SFPCS, this is the limiting case in reducing the boron concentration of the water in the DSC. This is not considered a dilution that will threaten reaching a DSC boron concentration of 1700 ppm since the dilution flow rate of 200 gpm of unborated water into the SFPCS would require 5 hours to dilute the DSC from 2500 ppm to 1700 ppm. Operators would be alerted to this event by a high SFP water level alarm, and administrative procedures will require continuous coverage that the pool is not overflowing whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the pool overflow, leaving 3 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, an in advertent addition of unborated water from the PMW system to the SFP is not considered a threat to dilute the DSC below 1700 ppm.

4.4 RBCCW

The Reactor Building Closed Cooling Water (RBCCW) system provides coolant to the shell side of the SFP heat exchangers. The heat exchanger tubes form a physical barrier between the RBCCW and the SFP cooling systems. The pressures on the tube side and the shell side are nearly equal, with the RBCCW pressure slightly higher. If a tube leak/rupture were to occur, the RBCCW would enter the SFP cooling system, diluting the pool. The volume of the RBCCW is approximately 42,000 gallons (Ref.: 7.2.10), however, makeup to the RBCCW system surge tank is from the Primary Water System. The Primary Makeup Water (PMW) System has a 150,000 gallon tank capacity (Ref.: 7.5.3) and the PMW makeup pumps are capable of providing 200 gpm (Ref.: 7.5.1 and 7.12). Calculations (Ref: 7.2.1) show that the maximum dilution flow from a tube rupture in the SFP heat exchanger would be less than 142 gpm. This is not considered a dilution that will threaten reaching a DSC boron concentration of 1700 ppm since tube rupture flow rate of 142 gpm is less than the limiting dilution flow rate of 200 gpm of unborated water into the SFPCS, which would require 5 hours to dilute the DSC from 2500 ppm to 1700 ppm. Operators would be alerted to this event by a high SFP water level alarm, and administrative procedures will require continuous coverage that the pool is not overflowing, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the pool overflow, leaving 3 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, an in advertent addition of unborated water from the RBCCW system to the SFP is not considered a threat to dilute the DSC below 1700 ppm.

4.5 Filling the Transfer Canal

The transfer canal is normally full of borated water and open to the SFP. The gate that connects the SFP to the transfer canal will be procedurally required to be open when a DSC is in the spent fuel pool cask laydown area. By having the transfer canal open to the pool, this conservatively increases the water volume in the spent fuel pool to minimize the effects of any dilution.

Requiring the gate between the pool and the transfer canal to be open precludes the possibility of a drained transfer canal being filled with unborated water and then opened to the pool.

4.6 Filling the Cask Laydown Pit

The cask laydown pit is adjacent to the SFP and is isolated by a bulkhead gate. A spent fuel shipping cask can be placed in the SFP cask laydown pit for loading of fuel. The gate that connects the SFP to the cask laydown pit will be procedurally required to be open when a DSC is in the spent fuel pool cask laydown pit. Since the gate is procedurally required to be open, the pit can not be drained and re-filled with unborated water, ensuring it does not become a potential dilution source

5.0 PIPE BREAKS AND LEAKS

5.1 Pipe Break/Leak Methodology

Pipe break and leak methodology for boron dilution events in the Millstone 2 spent fuel pool was previously stated in reference 7.12 and provided to the NRC in reference 7.8.

5.2 Primary Water

The Primary Water Storage Tank supplies demineralized water to the SFP area (Ref.: 7.3.6). There is a primary water hose station, line 1 ½"-HCD-43, on the 38'-6" elevation north of the cask laydown area (Ref.: 7.3.6). The PWST, which supplies PMW, has a capacity of 150,000 gallons (Ref.: 7.5.3). Makeup to the PWST is a manual evolution and performed by Operations and controlled by procedure. This system is designed to seismic Class 2 requirements, but considered a moderate energy line and not postulated to crack under a seismic event (Ref.: 7.9). Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is calculated to be less than 7 gpm (Ref.: 7.1.1). This leak flow could go into either the spent fuel pool or cask pit, and each is discussed next.

If this leak flow goes to the SFP, this maximum leak flow rate of 7 gpm is less than the limit of 100 gpm dilution flow rate established previously in this Technical Evaluation. The 100 gpm limit of unborated water spilling into the SFP assures that at least 10 hours is available to dilute the DSC from 2500 ppm to 1700 ppm in 10 hours. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event.

If this leak flow goes directly into the cask pit, detection will be immediate from the continuous coverage on the SFP floor monitoring for leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. This leakage flow can be terminated either by shutting a PMW isolation valve located on the SFP floor, or shutting off the PMW pumps.

Therefore, a leak in the Primary Water system is not considered a threat to dilute the DSC below 1700 ppm.

5.3 Auxiliary Steam and Condensate Return

The location of the Auxiliary Steam and Condensate Return piping on the 38'-6" elevation northwest and southwest areas of the SFP floor allows for the potential of diluting the SFP. The Auxiliary Steam system is a low pressure steam supply system with a normal operating pressure of 25 psig at 267 °F (Ref.: 7.1.1). The Auxiliary Steam and Condensate Return system meets the high energy line classification (piping systems with normal operating temperature equal to or greater than 200 °F, or normal operating pressure equal to or greater than 275 psig) (Ref.: 7.9). The worst case scenario would be a break in the 6x4 reducer at the southwest end of the SFP (Ref.: 7.3.1). After the break, steam would emit at sonic velocity as saturated steam, condense, then collect on piping, supports and other structures above the SFP floor. The water volume emitting as a result of this break calculates to 75.4 gpm (Ref.: 7.1.1). This maximum leak flow rate of 75.4 gpm is less than the 100 gpm dilution flow rate established previously in this Technical Evaluation. The 100 gpm limit of unborated water spilling into the SFP assures that at least 10 hours is available to dilute the DSC from 2500 ppm to 1700 ppm in 10 hours. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, a leak in the Auxiliary Steam and Condensate system is not considered a threat to dilute the DSC below 1700 ppm.

5.4 Fire Protection

Fire Protection (FP) System operation is such that a 50 gpm electric jockey pump (M7-11) maintains system pressure by automatically starting when line pressure drops to 105 psig and will run until pressure reaches 120 psig. An electric driven fire pump (P-82) is activated by a single pressure switch set at 85 psig. In the event this switch or pump fails to operate and line pressure continues to drop, the diesel-driven fire pump is activated by an additional pressure switch set at 75 psig. Both the electric and diesel-driven fire pumps deliver 2000 gpm at 100 psi discharge pressure and remain in operation until they are manually shut down. The fire pumps are supplied from two 245,000-gallon ground level suction tanks. The tanks are automatically filled through a water line fed from city water, so there is essentially an unlimited supply of water (Ref.: 7.5.4).

There are two hose stations (HS) on the 38'-6" elevation of the SFP floor that could potentially be a boron dilution path to the SFP, they are HS 230 and HS 226 (Ref.: 7.3.2).

The FP system is considered a Moderate Energy Line (MEL) because the system operating conditions are less than 200°F and less than 275 psig (Ref.: 7.9). Therefore, piping that meet these operating temperature and pressure limits, requires no postulation of breaks or cracks, based on the original MP2 licensing basis. The FP system HS's on the SFP floor area are being supplied from a 4 inch piping header. To quantify a volume and flow rate from the FP system, the MP2 Hazards Program makes reference to the Standard Review Plan (SRP) NUREG-0800 for guidance in assessing postulated pipe breaks and cracks. In Branch Technical Position ASB 3-1 (Ref.: 7.10), design breaks or cracks are calculated as ½ the pipe diameter in length and ½ the wall thickness in width. The FP system has been calculated to have a flow rate from a crack to be 93 gpm (Ref.: 7.1.1).

This maximum leak flow rate of 93 gpm is less than the limit of 100 gpm dilution flow rate established previously in this Technical Evaluation. The 100 gpm limit of unborated water spilling into the SFP assures that at least 10 hours is available to dilute the DSC from 2500 ppm to 1700 ppm in 10 hours. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, a leak in the Fire Protection system is not considered a threat to dilute the DSC below 1700 ppm.

5.5 Domestic Water

The Domestic Water system is supplied from the city water supply that has several branch connections in the SFP area. This line, 2"-JDD-10 (Ref.: 7.3.3), is considered a moderate energy pipe and therefore, susceptible to the applicable rules for evaluating moderate energy piping for pipe breaks (Ref.:7.9). The Domestic Water system piping and operating parameters are less than the FP system. Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is bounded by the leak rate for the fire protection system, which is 93 gpm.

This maximum leak flow rate of 93 gpm is less than the limit of 100 gpm dilution flow rate established previously in this Technical Evaluation. The 100 gpm limit of unborated water spilling into the SFP assures that at least 10 hours is available to dilute the DSC from 2500 ppm to 1700 ppm in 10 hours. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, a leak in the Domestic Water system is not considered a threat to dilute the DSC below 1700 ppm.

5.6 Turbine Building Closed Cooling Water

The TBCCW system supplies water to the SFP Cooling Supplemental Cooling Heat Exchanger. The worst case scenario would be a break at the 3"-HBD-434 (Ref: 7.3.4) pipe tee as it enters through the south wall into the SFP area. TBCCW is considered a moderate energy system and therefore, susceptible to the applicable rules for evaluating moderate energy piping for breaks (Ref.:7.9). The TBCCW is a closed loop system with a volume of less than 13,000 gallons (Ref.: 7.2.2). Makeup to the TBCCW system is a manual evolution and performed by Operations and controlled by procedure. The TBCCW system piping and operating parameters are less than the FP system. Even if this piping does develop a through wall crack of the size consistent with moderate energy line breaks, the leak flow rate is bounded by the leak rate for the fire protection system, which is 93 gpm.

This maximum leak flow rate of 93 gpm is less than the limit of 100 gpm dilution flow rate established previously in this Technical Evaluation. The 100 gpm limit of unborated water spilling into the SFP assures that at least 10 hours is available to dilute the DSC from 2500 ppm to 1700 ppm in 10 hours. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, a leak in the TBCCW system is not considered a threat to dilute the DSC below 1700 ppm.

5.7 Roof Drains

The roof drain piping around the SFP is such that the roof drains route from the roof to two separate drain headers.

The 10" roof drain line travels along the south wall of the 38'-6" elevation. This 10" drain line is not seismically supported and any leakage from this line would drain onto the SFP floor. This line interconnects 6 roof drains from the south portion of the auxiliary building roof. As documented in reference 7.1.1, the maximum leak flow from roof drain would be less than 100 gpm. As discussed earlier, for the circumstance where 100 gpm of unborated water is spilling into the SFP, at least 10 hours is available before the DSC boron concentration drops from 2500 ppm to 1700 ppm. As discussed earlier, therefore at least 60,000 gallons of unborated water would be required for this dilution.

Reference 7.1.1 showed that if the entire roof surface area of water drains into the pool, 51 inches of rainfall would be required to add 230,971 gallons to the pool. By proportion, a rainfall of 13 inches over 10 hours would be required to add 60,000 gallons to the pool. Thus, both a pipe leak and 13 inches of rain over 10 hours would be necessary to reduce the DSC soluble boron concentration from 2500 ppm to 1700 ppm.

The piping above the SFP is seismically supported (Ref.: 7.3.5) and therefore should not be a potential dilution source of water into the SFP. However, should there be a leak in this piping, the roof area supplying this drain piping is less than the non-seismic header. Therefore the required rainfall would be 13 inches or larger. Thus, both a pipe leak and 13 inches of rain over 10 hours would be necessary to reduce the DSC soluble boron concentration from 2500 ppm to 1700 ppm.

Since the flowrate of a roof drain leak is less than 100 gpm, than at least 10 hours is available before the boron concentration in the DSC will decrease below 1700 ppm. Operators would be alerted to this event by either a high SFP water level alarm, or the continuous coverage on the SFP floor monitoring for an overflow or leakage spilling into the pool, whenever a DSC is in the SFP with fuel in the DSC. In the worst case, detection would take 2 hours for the high level alarm, leaving 8 hours for mitigation of the event, which is more than sufficient time for operators to mitigate the event. Therefore, a leak in the roof drain system is not considered a threat to dilute the DSC below 1700 ppm.

6.0 CONCLUSIONS

Criticality analysis (Ref.: 7.6) has shown that for limiting fuel enrichments/conditions in a 32PT DSC, which requires an initial soluble boron concentration of 2500 ppm to assure $k_{eff} < 0.95$ on a 95/95 basis, 1700 ppm of soluble boron is needed in the DSC to assure subcriticality on a 95/95 basis. This engineering analysis of scenarios which could dilute the boron concentration below 2500 ppm in the SFP/DSC demonstrates that sufficient time is available to detect and terminate a boron dilution prior to reaching 1700 ppm, thus ensuring sub-criticality in the 32PT DSC is maintained.

The systems that could dilute the spent fuel pool, either by direct connection to the spent fuel pool, or by a potential pipe crack/break have been analyzed. There is no automatic spent fuel pool level control system in the spent fuel pool, so that any dilution to the spent fuel pool will add water to the spent fuel pool. Therefore, the addition of unborated water to the SFP will lead to increased SFP water level, and if not controlled, an overflow of the SFP.

The ability to prevent the DSC soluble boron concentration from being diluted from the NUHOMS CofC 1004 TS minimum value of 2500 ppm to a value of 1700 ppm has been demonstrated by showing that each potential dilution source (with 1 exception described below) meets one of the following two criteria:

- If the dilution flow rate of unborated water is ≤ 200 gpm into the SFP Cooling System, then at least 5 hours will be needed for the DSC soluble boron concentration to be reduced from 2500 ppm to 1700 ppm. For this conclusion to be valid, at least 850 gpm of SFPCS flow is required and 2-RW-350 must be open. All dilution scenarios evaluated in this category will eventually cause a SFP high water level alarm in the control room within 1 hour, or the individual performing continuous monitoring in the SFP, whenever a fueled DSC is in the SFP, will identify an overflow condition. The longest time for an overflow condition to occur with a 200 gpm dilution rate would be 2 hours, therefore the conservatively longest time to detect the dilution event is 2 hours. Since 5 hours are needed at 200 gpm to dilute the DSC soluble boron concentration to 1700 ppm, there is ample time, at least 3 hours, to terminate the dilution event.
- If the dilution flow rate of unborated water is ≤ 100 gpm, and spilling into the SFP or transfer canal, then at least 10 hours will be needed for the DSC soluble boron concentration to be reduced from 2500 ppm to 1700 ppm. For this conclusion to be valid, at least 850 gpm of SFPCS flow is required and 2-RW-350 must be open. All dilution scenarios evaluated in this category will eventually cause a SFP high water level alarm in the control room within 2 hours, or the individual performing continuous monitoring in the SFP, whenever a fueled DSC is in the SFP, will immediately identify water spilling into the pool. The longest time for detection of the dilution event in this situation would be 2 hours. Since 10 hours are needed at 100 gpm to dilute the DSC soluble boron concentration to 1700 ppm, there is ample time, at least 8 hours, to terminate the dilution event.

The one exception to the above discussion concerns unborated water directly spilling into the cask pit. A direct inadvertent dilution to the cask pit from water spilling into the top of the cask pit is credible due to the Primary Makeup Water (PMW) hose station near the cask pit. Direct dilution to the cask pit from the PMW hose station may occur during normal cask handling operations, however this is limited to 500 gallons of unborated water before boron sampling is required. Inadvertent flow of unborated water from the PMW hose station to the cask pit will be observed by the individual on the SFP floor who is monitoring for water entering the SFP. Should such a PMW flow occur, the appropriate valve, 2-PMW-408, 2-PMW-409 or 2-PMW-295 will be shut, if not already shut, or if an un-isolable leak occurs in the PMW pipe, the PMW pumps can be secured. In any case, minimal unborated water volume will enter the pit before isolation. The requirement to have open 2-RW-350 to allow SFP cooling flow to the cask pit will allow substantial flow to the cask pit, ensuring that significant boron stratification will not occur. It is estimated that that the cask pit volume will be turned over once per hour with 2-RW-350 in the open position.

The event with the shortest time to reach 1700 ppm boron in the DSC is a 200 gpm dilution of Primary Makeup Water from the PWST delivered directly to the SFP Cooling System as a manual makeup source to the SFP. Assuming 200 gpm of unborated Primary Makeup Water is emitted into the SFP, and using a conservative slug flow model, it would take 5 hours and 60,000 gallons of PMW to reduce the SFP boron concentration from 2500 ppm to 1700 ppm.

In order to ensure that proper mixing is available during potential dilution events, a minimum of 850 gpm of SFP cooling flow will be required when there is a DSC with fuel in the cask laydown pit. In order to ensure that the possibility of direct cask pit dilutions or effects of dilution are minimized the following 3 requirements will be implemented: (1) Valve 2-RW-350 will be required to be open to ensure that adequate mixing occurs in the cask pit should inadvertent dilution occur, (2) ISFSI procedures will require that an individual will be continuously present on the SFP floor to identify any water leaking into the SFP or a SFP overflow, (3) ISFSI procedures will require that the SFP will be sampled for boron concentration after each interval of 500 gallons of unborated water has been added to the spent fuel pool.

An additional check was performed if the required boron concentration was 1800 ppm for the 32PT DSC. Criticality analysis (Ref.: 7.6) has shown that for limiting fuel enrichments/conditions in a 32PT DSC, which requires an initial soluble boron concentration of 1800 ppm to assure $k_{eff} < 0.95$ on a 95/95 basis, 1200 ppm of soluble boron is needed in the DSC to assure subcriticality on a 95/95 basis. The volume of unborated water for a dilution from 1800 to 1200 ppm is more than the volume of water required for a dilution from 2500 to 1700 ppm. Therefore, the dilution from 2500 ppm to 1700 ppm is more restrictive (gives shorter dilution times) and is the limiting case.

In summary, this engineering analysis of scenarios that could dilute the boron concentration below 2500 ppm in the DSC demonstrates that sufficient time is available to detect and terminate a boron dilution prior to reaching 1700 ppm, thus ensuring sub-criticality in the 32PT DSC is maintained.

7.0 REFERENCES

7.1 Calculations

7.1.1 MP2SFP-03034, Unit 2 SFP Potential Dilution Sources, Rev. 0, approved 10/16/01, and CCN 1, approved 12/8/04, and CCN 2, approved 1/18/05.

7.2.1 S-0409252, MP2 Spent Fuel Pool Heat Exchanger Tube Rupture Analysis, Rev. 0, approved 9/13/04.

7.2 Procedures

7.2.1 ARP 2590E-071, revision 0, Alarm Response for SFP Level HI

7.2.2 Chem Form, 2802E-6, Hydrazine Addition to TBCCW and Chill Water, Rev. 1, issued 2/21/98

7.2.3 OP 2322, Auxiliary Feedwater System, Rev. 25, Ch. 2

7.2.4 OP 2307, Low Pressure Safety Injection, Rev. 12, Ch. 8

7.2.5 OP 2305, Spent Fuel Pool Cooling and Purification System, Rev. 19, Ch. 12.

7.2.6 Not used

7.2.7 Not Used

7.2.8 Not Used

7.2.9 Not Used

7.2.10 Chem Form, 2802E-5, Hydrazine Addition to RBCCW, Rev. 1

7.3 Drawings

7.3.1 25203-26026 Sh. 2 of 4, P&ID Auxiliary Steam and Condensate, Rev. 19, issued 4/12/01

7.3.2 25203-26011 Sh. 1, P&ID Fire Protection System, Rev. 35, issued 4/23/01

7.3.3 25203-26011 Sh. 2, P&ID Domestic Water, Rev. 36, issued 8/14/01

7.3.4 25203-26007 Sh. 1, P&ID TBCCW, Rev. 16, issued 6/19/01

7.3.5 25203-24023, Roof Drain Auxiliary Building Plan, Rev. 2, issued 4/6/97

7.3.6 25203-26030 Sh.1, P&ID Water Treatment System, Rev. 40, issued 8/10/01

7.3.7 NUHOMS FSAR NUH-003, Appendix E-3, Drawing NUH-03-8002-SAR sheet 1 of 3 Rev 7

7.4 Unit 2 Technical Specifications

7.4.1 LCO 3.1.2.7

7.4.2 LCO 3.9.17

7.4.3 LCO 3.1.2.8

7.4.4 LCO 3.9.12

7.4.5 Design Feature 5.6.1

7.5 Unit 2 Final Safety Analysis Report

7.5.1 9.5.2, Spent Fuel Pool Cooling, System Description

7.5.2 10.4.5.3, Condensate and Feedwater System Description

7.5.3 9.12.2, Water Treatment System Description

7.5.4 9.10.2, Fire Protection System Description

7.5.5 9.8.2.1.2, Spent Fuel Storage
7.5.6 Table 9.5-1

7.6 Transnuclear Calculation 10499-01, revision 0, Boron Dilution Criticality Analysis for NUHOMS-32PT

7.7 Not Used

7.8 Letter from Millstone to US NRC, 11/6/2001, B18501, Technical Specification Change Request (TSCR) 2-10-01, Fuel Pool Requirements.

7.9 Specification SP-M2-ME-003, Pipe Rupture Analysis Criteria Outside the Reactor Building - Millstone Unit 2, Rev. 1, dated 4/28/98

7.10 SRP NUREG-0800 Section 3.6.1, Plant Design for Protection Against Postulated Piping Failures in Fluid Systems Outside Containment, Rev. 1, dated 7/1981

7.11 SRP NUREG-0800 Section 3.6.2, Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping, Rev. 1, dated 7/1981

7.12 Technical Evaluation M2-EV-01-0018, revision 0, 10/17/01, Spent Fuel Pool Dilution Analysis Summary.

7.13 Amendment 7 to Certificate of Compliance Number 1004 for the Transnuclear Standardized NUHOMS System.

7.14 Amendment 9 to Certificate of Compliance Number 1004 for the Transnuclear Standardized NUHOMS System.

7.15 Amendment 274 to Millstone 2 Operating License, 4/1/2003, TAC NO. MB3386, A15859

Approved 8/27/02 Effective 8/30/02

ATTACHMENT 2

Independent Reviewer Comment and Resolution Sheet(s)

(ER/EV) No. M2-EV-04-0025 Rev 2

Independent Reviewer: T.M. GUARINO [signature] Date 1/18/05

Comment No.	ER/EV Section	Comment
1	General	The discussion in this TE states that personnel, by procedure, are '... continuously monitoring SFP for overflow, or for any water leaking into the SFP,' what will be the response by the individual should the SFP level rise?
1	Response	The individual monitoring the SFP level should report to the Control Room any suspicious change in SFP level. However, since SFP level rise could be confusing, this Technical Evaluation only credits the time it takes for a SFP water level overflow. Joe Parillo