TRANSNUCLEAR
AN AREVA COMPANY

August 14, 2009
E-28173

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: Revision 2 to Transnuclear, Inc. (TN) Application for Amendment 11 to the Standardized NUHOMS® System, Response to Second Request for Additional Information (Docket No. 72-1004; TAC NO. L24080)

References: 1. Letter from B. Jennifer Davis (NRC) to Donis Shaw (TN), "SECOND REQUEST FOR ADDITIONAL INFORMATION FOR REVIEW OF AMENDMENT 11 TO THE STANDARDIZED NUHOMS® SYSTEM (TAC NO. L24080)," March 27, 2009

References: 2. Letter from Robert Grubb (TN) to Document Control Desk (NRC), "Revision 1 to Transnuclear, Inc. (TN) Application for Amendment 11 to the Standardized NUHOMS® System (Docket No. 72-1004; TAC NO. L24080)," December 21, 2007

This submittal provides responses to the request for additional information (RAI) forwarded by Reference 1. Enclosure 2 herein provides each of the NRC staff RAI followed by a TN response. Enclosure 3 provides a list of additional changes, not associated with the RAI and Enclosure 4 provides a reference associated with Item No. 5 of Enclosure 3. Enclosure 5 provides a list of changed Certificate of Compliance (CoC), Technical Specifications (TS), and updated final safety analysis report (UFSAR) pages. Enclosure 6 provides the changed pages.

In the TS, changes to reflect Amendment 10 have been made and incorporated. Changes made in response to Amendment 11 RAI No. 1 and new changes based on this second RAI are both indicated by revision bars in the right margin and italics for inserted text. The new changes are shaded, to distinguish them from the RAI No. 1 changes.

The changes shown as Notes 1, 2, and 3 on TS Page 4-2 are incorporated, but shaded for attention, as they are associated with Amendment 10 and a commitment made in the response to Amendment 11 RAI No. 1 (Reference 2).

For the UFSAR, replacement and new Amendment 11 Revision 2 pages are provided, annotated as Revision 2, with changes indicated by italicized text and revision bars. As with the TS, changes made in response to Amendment 11 RAI No. 1 and new changes based on this second RAI are both indicated by revision bars in the right margin and italics for inserted text, with new changes shaded to distinguish them from RAI No. 1 changes. The only exception to this is Chapter W.5; based on extensive changes made, W.5 is provided with no tracked changes. Certain changes on these pages had been made through the 10 CFR 72.48 process. Those changes are indicated by

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double revision bars and "72.48" in the right margin.

Enclosures 6 and 9 of this submittal include proprietary information which may not be used for any purpose other than to support NRC staff review of the application. In accordance with 10 CFR 2.390, I am providing an affidavit (Enclosure 1) specifically requesting that you withhold this proprietary information from public disclosure. A Public version of the proprietary drawing in Enclosure 6 is provided in Enclosure 7. Because the Enclosure 9 computer disk is entirely proprietary, no Public representation is provided.

Also, the three UFSAR drawings included as part of Enclosure 6 contain security-related information. Accordingly, non-security-related (Public) versions of these drawings are provided as Enclosure 7.

Should the NRC staff require additional information to support review of this application, please do not hesitate to contact Mr. Don Shaw at 410-910-6878 or me at 410-910-6930.

Sincerely,

Robert Grubb
Chief Operating Officer

cc: Jennifer Davis (NRC SFST) (11 paper copies of this cover letter and Enclosures 1 through 6, 1 paper copy of Enclosure 8, and 1 copy of the Enclosure 9 compact disk, all provided in a separate mailing)

Enclosures:

1. Affidavit Pursuant to 10 CFR 2.390
2. RAI Responses
3. List of Additional Changes, Not Associated with the RAI
4. Larrabee, C. P. and Coburn, S. K. (1962). "The Atmospheric Corrosion of Steels as Influenced by Changes in Chemical Composition." Proceeding of First International Congress on Metallic Corrosion, Butterworths, London, pages 276-285.
5. List of Changed CoC, Technical Specifications and UFSAR Pages Associated with Amendment 11, Revision 2 for RAI No. 2
6. Amendment 11 Revision 2 Proposed changes to the NUHOMS® CoC 1004 Certificate of Compliance (Amendment 10 Rulemaking version), the associated Technical Specifications, and the UFSAR (Proprietary/Security-Related version)
7. UFSAR Drawings NUH-32PT-1004-SAR, NUH-03-8011-SAR, and NUH-03-8012-SAR (Public versions)
8. Listing of Proprietary Computer Files Enclosed
9. Proprietary Compact Disk Containing the Computer Files Listed on the Enclosure 8

AFFIDAVIT PURSUANT
TO 10 CFR 2.390

Transnuclear, Inc.)
State of Maryland) SS.
County of Howard)

I, Robert Grubb, depose and say that I am Chief Operating Officer of Transnuclear, Inc., duly authorized to execute this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in Enclosures 6 and 9 and is listed below:

1. UFSAR Drawing NUH-32PT-1004-SAR, Revision 4A, Sheet 4 of 4.
2. Compact Disk Containing Certain Computer Files Associated with the Thermal Analysis of the OS197L Transfer Cask

The drawing and the disk have been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by Transnuclear, Inc. in designating information as a trade secret, privileged or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure are a design drawing showing dry shielded canister basket assembly details, and computer input/output files associated with the thermal analysis of the OS197L Transfer Cask, which are owned and have been held in confidence by Transnuclear, Inc.

2) The information is of a type customarily held in confidence by Transnuclear, Inc. and not customarily disclosed to the public. Transnuclear, Inc. has a rational basis for determining the types of information customarily held in confidence by it.

3) The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.390 with the understanding that it is to be received in confidence by the Commission.

4) The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence.

5) Public disclosure of the information is likely to cause substantial harm to the competitive position of Transnuclear, Inc. because:

   a) A similar product is manufactured and sold by competitors of Transnuclear, Inc.

b) Development of this information by Transnuclear, Inc. required expenditure of considerable resources. To the best of my knowledge and belief, a competitor would have to undergo similar expense in generating equivalent information.

c) In order to acquire such information, a competitor would also require considerable time and inconvenience related to the development of a design and analysis of a dry spent fuel storage system.

d) The information required significant effort and expense to obtain the licensing approvals necessary for application of the information. Avoidance of this expense would decrease a competitor's cost in applying the information and marketing the product to which the information is applicable.

e) The information consists of a design drawing showing dry shielded canister basket assembly details, and computer files associated with the design and analysis of dry spent fuel storage and transportation systems, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with Transnuclear, Inc., take marketing or other actions to improve their product's position or impair the position of Transnuclear, Inc.'s product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

f) In pricing Transnuclear, Inc.'s products and services, significant research, development, engineering, analytical, licensing, quality assurance and other costs and expenses must be included. The ability of Transnuclear, Inc.'s competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

Further the deponent sayeth not.

Robert Grubb
Chief Operating Officer, Transnuclear, Inc.

Subscribed and sworn to me before this 13th day of August, 2009.

Notary Public

My Commission Expires 10 / 14 / 2012

CHAPTER 2 Structural Evaluation

2.1 Reconsider the response to RAI 2-9 and tile interpretation provided by TN for the "cask system" and provide the type of information requested that was considered by the NRC staff to be missing for the transfer cask.

The normally short time of use of the transfer cask does not provide a reason for excluding the listing of the design codes and standards alternatives that apply to the design and fabrication of the transfer cask. The following statement is contained in NUREG-1745 relative to the SPENT FUEL STORAGE CASKS (SFSCs): "The [XXXX] SFSC System consists of the OVERPACK and its integral CANISTER." The fact is that the canister cannot be placed into the overpack without the transfer cask, and because of this the transfer cask is considered part of the cask system. The transfer cask is considered within the scope of the definition provided in NUREG-1745.

This information is needed to confirm compliance with 10 CFR 72.236(b).

Response to 2.1

Transnuclear has reviewed the NUREG-1745 and agrees that code alternatives for the Transfer Casks also need to be listed in the Technical Specifications. Technical Specification 4.2.3 is revised to list the applicable code year and edition for the transfer casks used. The ASME code alternatives for the transfer casks are also added to Technical Specification 4.2.4.

2.2 Clarify the response provided to RAI 9-14 to be consistent with a potentially revised proposed technical specification 5.5.

The proposed change to technical specification 5.5 associated with the response to RAI 9-14, does not provide the specificity requested for the frequency of testing and location of the high temperature zones that may reach or exceed 350 degrees F. There appears to be confusion between temperature testing during the construction and fabrication process of the concrete of the HSM-H and the temperatures associated with the thermal operating conditions for the HSM-H storage modules once the loaded DSCs have been inserted. The current proposed technical specification, while addressing temperature testing during fabrication and an inspection for spalling and cracking of the concrete, does not appear to be internally consistent. The 350 degrees F thermal condition should apply to the completed concrete components of the HSM-H, not during the fabrication stage as is stated.

The technical specification should identify the location(s) of the expected high concrete temperatures for the conditions under a minimum of 40 hours of blocked vent condition that are to be monitored. This could, for example, be described as including a zone on the roof section or other appropriate areas based on the predicted temperatures. Prior to the start of the test, the zone of interest should be inspected for surface conditions and the records of the concrete compressive strength for that component verified as meeting the design requirements. The inspection after the 40 hours duration of the blocked vent condition of the loaded storage module would consist of visual observation of the exterior surface for spalling and cracking, and if these conditions are observed data collected to describe the extent of the conditions.

The above testing and observations should be performed at each ISFSI site where the HSM-H is used with the fuel storage conditions that produced the highest predicted concrete temperatures. If the HSM-H units to be used at a specific ISFSI site are constructed with concrete containing significant changes in cement, aggregates or water-cement ratio of the concrete mix than that used in a previously tested HSM-H module, then the first module should undergo testing and observation using the changed concrete mix.

This information is needed by the staff to confirm compliance with 10 CFR 72.236(b) and

Response to 2.2

In addition to Technical Specification 5.5, which is applied during the construction and fabrication process of the HSM-H, existing Technical Specification 5.2.5 "HSM or HSM-H Thermal Monitoring Program" provides the guidance to be used to monitor the thermal performance of each loaded HSM. This technical specification assures that positive means exist to identify conditions which threaten to approach the temperature criteria for proper HSM or HSM-H operation and allow for the correction of the off-normal thermal condition that could be exceeding the concrete and fuel cladding temperature criteria. Therefore, no additional changes are necessary.

Chapter 3 Thermal Evaluation

3.1 Justify that the assumption of a uniform heat flux at the transfer cask outer shell is a conservative representation of DSC/TC system within the supplemental shielding, and demonstrate that it can produce a conservative estimate of the temperature distribution on the transfer cask outer shell.

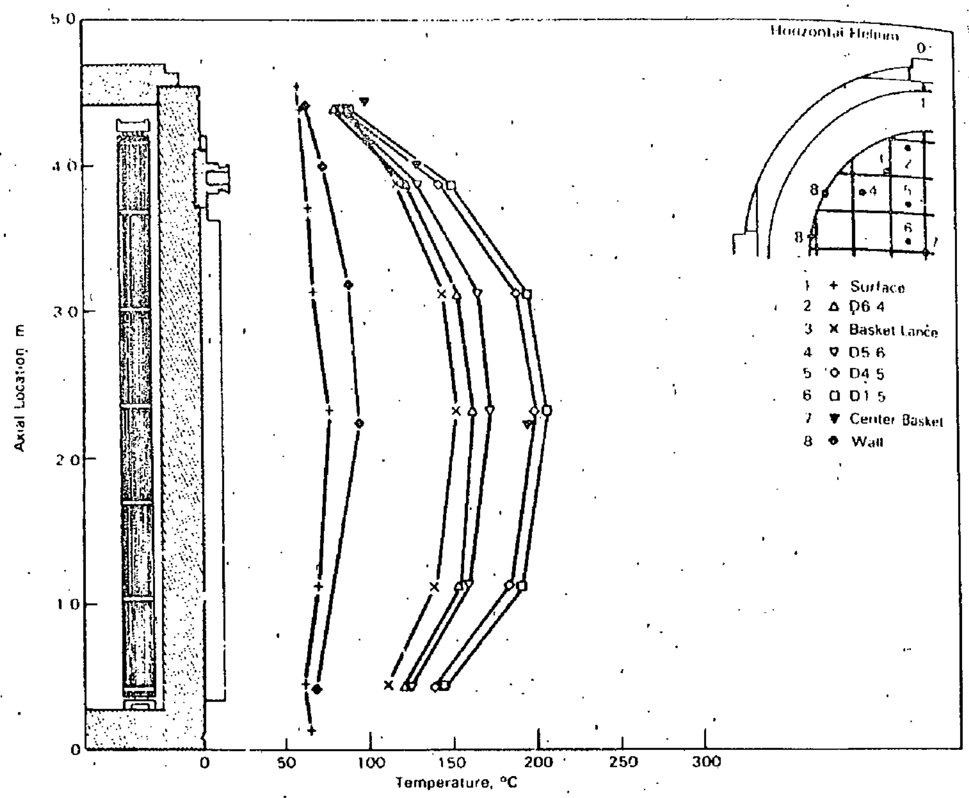
In the FLUENT model of the OS197L on the transfer skid enclosed with the supplemental shielding, the assumption of a uniform heat flux at the transfer cask outer shell is a significant simplification in the boundary conditions. It does not account for the variation in heat transfer on the transfer cask shell, due to variation in the surface heat transfer coefficient around the circumference of a horizontal cylinder. It also assumes that the heat flux is uniform along the entire 183.85-inch axial length of the neutron shield, as well as around the circumference of the 40.18-inch diameter neutron shield. (Note that this temperature distribution provides boundary conditions for the next step in the analysis, using a 2D ANSYS model of the OS197L transfer cask.)

This information is needed to satisfy the provisions of 10 CFR 72.236(f).

Response to 3.1

The justification for using a uniform heat flux at the transfer cask outer shell for determining the temperature distribution on the transfer cask's outer shell within the auxiliary shielding is based on a combination of prior safety analyses and the result of physical testing. The following paragraphs describe the relevancy of each of these justifications.

<u>Physical Testing:</u> The use of a uniform decay heat flux is validated by physical test data. For example, Figure 4-14 in the report, "The TN-24P PWR Spent-Fuel Storage Cask: Testing and Analyses," EPRI, EPRI-NP—5128, (PNL-6054), 1987, illustrates the measured temperatures on a horizontal TN-24P cask with a helium backfill. As seen, while the axial variation in the measured fuel cladding temperature clearly shows the effect of the decay heat peaking factor, the axial variation in temperature is largely not present for the temperature distribution at the edge of the basket (i.e., T/C #8) and is barely noticeable for the temperature distribution along the outer edge of the cask body (i.e., T/C #1). These results clearly demonstrate that the use of a uniform decay heat flux along the outer wall of the cask, especially if combined with end effects, would yield the same nearly uniform cask surface temperatures with a slight fall off at the ends as seen in the actual testing. Thus, the validity of using a uniform heat flux to support the calculation of the temperature distribution on the cask is supported by test data.



Physical testing on a full scale mockup of the storage module and the DSC canister shell was also conducted in support of the NUHOMS® HD System (Docket No. 72-1030) for NUHOMS® model - 32PTH to validate the analysis approach, including the use of a uniform heat flux applied to the canister shell. The testing demonstrated that the analytical model based on a methodology of using a uniform heat flux applied to the canister shell overestimated the actual DSC surface temperatures observed in the physical testing.

<u>Confirmatory Modeling by the NRC:</u> The use a uniform heat flux for determining the temperature distribution on the transfer cask's outer shell was validated by the staff performing confirmatory analysis in Amendment 10 to the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (Docket No. 72-1004). The Amendment 10 safety analyses for the DSC assumed a uniform heat flux on the canister shell to determine the temperature distribution on the DSC shell surface within the storage modular and a uniform volumetric heat load within the fuel basket to determine the temperature distribution on the DSC shell surface within the transfer cask. Then, based on the computed DSC shell temperature distributions, a detail thermal model of the fuel basket, which included the decay heat peaking factor variation along the fuel rod length, was used to determine the peak fuel cladding temperature within the fuel basket.

In contrast, the confirmatory analyses conducted by the NRC for its review of Amendment 10 used a single, combined CFD model of the DSC within the storage module and a single, combined COBRA-SFS model of the DSC within the transfer cask. Each confirmatory model applied the decay heat along the active fuel length and with an axial peaking factor adjustment. Both confirmatory thermal models showed that the two-step process described above for the safety analyses yielded peak fuel cladding temperatures that were conservatively higher or essentially the same as that determined via the confirmatory models (see Tables 4.22, 4.23, and 4.24 of the Safety Evaluation Report (SER) for CoC 1004 Amendment 10 [ML090400180]). Similar comparative results were obtained between the two methodologies for the bounding accident conditions for the DSC in the transfer cask as seen via Table 4.10 of the SER.

As such, the two-step process of assuming either a uniform heat flux on the surface of the DSC or a uniform volumetric decay heat within the fuel basket is shown to accurately reflect the heat spreading within the canister and cask structures and to yield conservative predictions of the peak fuel cladding temperature.

<u>Past Safety Analyses:</u> The methodology of using a uniform heat flux for the evaluation of the heat transfer mechanisms outside of the DSC shell and the determination of the canister shell temperature distribution has been used for numerous past safety analyses. These safety analyses include the following recent applications:

1) ***Standardized Advanced NUHOMS® Horizontal Storage System (Docket No. 72-1029) for NUHOMS® models -24PT1 and -24PT4***
2) ***NUHOMS® HD System (Docket No. 72-1030) for NUHOMS® model -32PTH***
3) ***Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (Docket No. 72-1004) for NUHOMS® models -24P, -24PHB, -32PT, and -24PTH***

In each of these safety analyses, the canister shell temperature distribution was determined using a uniform heat flux boundary condition on the canister shell. Further, for the NUHOMS® HD System (Docket No. 72-1030) thermal evaluation, the effective thermal conductivity within the neutron shield of the OS187H transfer cask (i.e., a water filled annular region that surrounds the cask's structural shell) is based on the use of a uniform heat flux boundary condition applied to the cask's structural shell. In each case, the resulting peak fuel cladding and system temperatures predicted using this methodology were validated by confirmatory analyses by the NRC using a combination of CFD and COBRA-SFS models that included the effects of non-uniform heat fluxes.

3.2 Justify that a uniform heat flux at the inner surface of the DSC outer shell is a conservative representation of the heat flux from the OSC, and show that it can produce a conservative estimate of the temperature distribution on the DSC outer shell,

In the 2D ANSYS model of the OS197L on the transfer skid enclosed within the supplemental shielding, the assumption of a uniform heat flux at the inner surface of the DSC outer shell is a significant simplification in the boundary conditions. It is physically unrealistic, in that it ignores the effect of the non-uniform gap between the OSC outer shell and the TC inner shell and variation in heat transfer on the DSC inner shell (which is due to variation in the thickness of the R90 and R45 basket support rails around the circumference of the DSC and the non-uniform decay heat loading configuration within the basket.) It is also physically unrealistic in the assumption that the heat flux is uniform along the entire 186.2-inch axial length[1] of the DSC, since the active fuel extends only over 144 inches within the OSC inner cavity, which is only 169.6 inches long. (Note that this temperature distribution provides boundary conditions for the final step in the analysis, using a 3D ANSYS model of the 32PT DSC. This model is used to calculate the peak component temperatures, including the peak cladding temperature.)

This information is needed to satisfy the provisions of 10 CFR 72.236(f).

Response to 3.2

The justification for the use of a uniform heat flux on the inner shell of the DSC for predicting the temperature distribution on the outside of the DSC shell is based on the same discussion provided for RAI 3.1 above. The effects of the non-uniform gap between the DSC and the TC inner shell is addressed by 2D ANSYS OS197L TC model and is reflected in the predicted DSC surface temperature distribution. The effects of the support rails (and other fuel basket details) plus the positioning of the active fuel region and the fuel peaking factor are addressed by the 3D ANSYS model of the DSC.

The conservatism provided by this modeling approach is validated by the detailed COBRA-SFS model of the DSC within the transfer cask used by the NRC in its confirmatory analysis of CoC 1004 Amendment 10. The detailed COBRA-SFS model included a detail representation of the DSC (including the non-uniform decay heat loading over the active fuel length and the variation in the R90 and R45 support rails) and the non-uniform air gap between the DSC outer shell and the TC inner liner. With the inclusion of these details, the COBRA-SFS confirmatory results (see Table 4.24 of the safety evaluation report (SER) for CoC 1004 Amendment 10 [ML090400180]) produced a predicted peak fuel cladding temperature that is 4°F below that predicted by the safety evaluation of the DSC within the OS200 cask that used a uniform decay heat loading over the 186.2-inch axial length of the DSC.

Additional justification that a uniform heat flux at the inner surface of the DSC outer shell produces a conservative estimate of the DSC outer shell temperature is shown in Figure 4.12 of the SER. The figure presents a comparison of SAR ANSYS model results with the heat load modeled as a uniform heat flux on DSC shell with the confirmatory results obtained using a fully coupled CFD DSC detailed model in HSM-H. As seen in Figure 4.12, the axial temperature along the length of the DSC outer shell at selected radial location (i.e., the top of the DSC, 45° from the top, at 90° on the side, at 135°, and at the bottom of the DSC) as predicted with ANSYS model are higher and considerably flattened, in comparison to the distributions obtained with the fully coupled StarCD CFD model. These results demonstrate that the modeling approach used in the SAR is conservative in that it over-estimates the peak DSC shell temperatures and yields a greater DSC surface area at the higher temperatures.

3.3 Justify by means of mesh sensitivity studies, or other relevant evaluations, that the fluid mesh in the FLUENT model of the OS197L transfer cask within the supplemental shielding provides adequate distance for a transition to true ambient to occur.

The size of the exterior fluid mesh in the FLUENT model of the OS197L transfer cask within the supplemental shielding may not be sufficient to extend to true ambient temperature. The mesh extends only about 1.5 to 2 IJD beyond the outer surface of the supplemental shielding into the surrounding air. Typically, the transition length is on the order of 5 to 10 L/D for thermal and velocity gradients in an infinite medium. The effect of truncating the distance to ambient would be non-conservative; it would overstate the steepness of the temperature gradient to ambient, resulting in a higher heat transfer rate than can actually be obtained.

This information is needed to satisfy the provisions of 10 CFR 72.236(f).

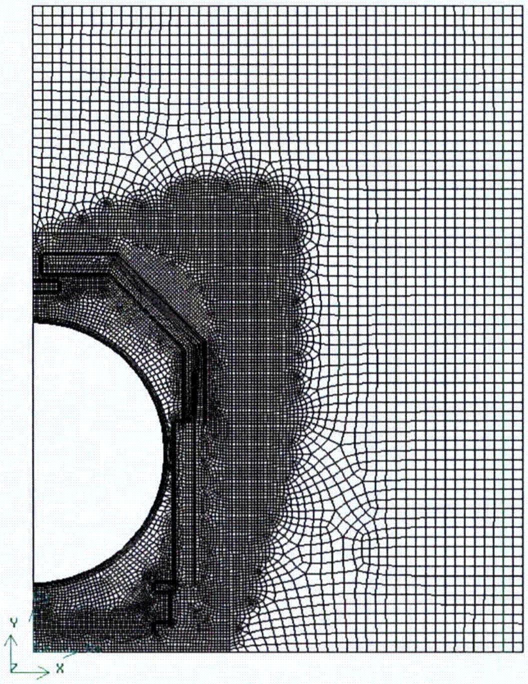
Response to 3.3

By definition, the thickness of a thermal boundary layer is measured by the distance from the surface to the point at which the flow temperature is within 99% of the free stream temperature. Since the boundary layer thickness on the auxiliary shielding will not be more than a few inches thick at most (based on logic, hand calcs, etc), the 'steepness' of the temperature gradient is not over stated by the positioning of the ambient boundaries 75 to 100 inches away, as used in the CFD modeling. What can be affected by the proximity of the ambient boundary are the velocity and pressure profiles, which in turn have an impact on the boundary layer calculation. However, given the relatively low flow velocities and delta pressures associated with this case, the effect on the computed surface temperature was expected to be only minor and it was expected that these effects would diminish in proportion to the separation distance between the ambient boundary and the auxiliary shield wall. As such, no significant impact was expected by the selection of the ambient boundary positioning used in the modeling. To verify this conclusion, a sensitivity analysis was conducted using an extended computational mesh which extends the ambient boundaries from 150 to 660 inches in the x-direction and from 200 to 1,000 inches in the y-direction (see figures below). This increase in dimensions provides a transition length of 5 to 10

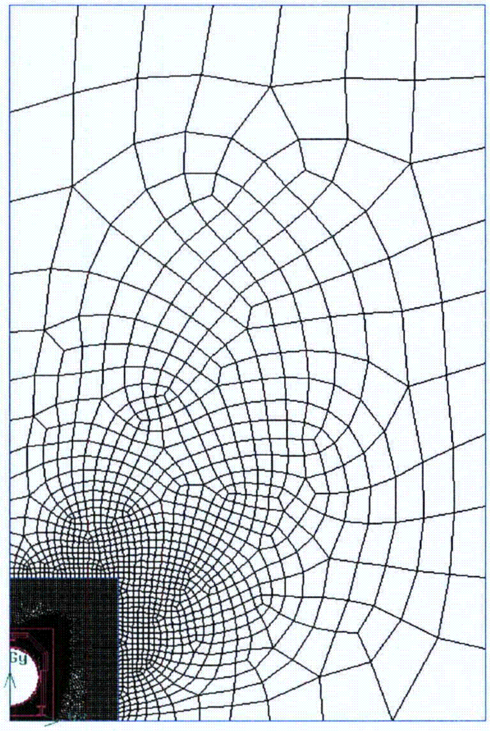
L/D between the exterior surfaces of the auxiliary shielding and the ambient boundary. Note that even though the OS197L cask now is limited to 13 kW/DSC, this sensitivity analysis is carried out with 24 kW/DSC heat load.

As evidenced by the cask shell temperature distributions presented in the figures below, the results for the extended computational mesh produced a similar temperature profile as that obtained with the original mesh. Specifically, not only are the maximum and minimum temperatures similar, but the area-weighted average temperature for the simulated cask shell segment of 284°F obtained for the extended mesh model is virtually the same as the 285°F average temperature obtained using the original computational mesh. Therefore, the positioning of the ambient boundary did not have an adverse effect on the solution results.

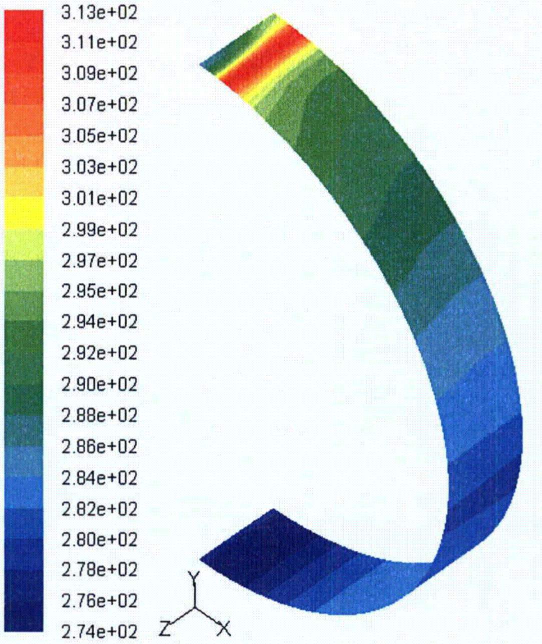
It was noted that the extended mesh setup has more difficulty in achieving a steady-state solution at the top of the cask shell in terms of a symmetric temperature distribution pattern along the z-axis. After numerous runs with variations in the under relaxation factors, pressure-velocity coupling method, and extended consultation with FLUENT technical support, it was concluded that the turbulent nature of the heat transfer at this portion of the cask shell was the root cause of the non-symmetry. This conclusion is supported by the fact that extending the number of iterations yielded a cyclic repetition in the temperature distribution pattern, but with little change in the resultant peak, minimum, and average cask shell temperature between iterations. While exercising the model in a transient mode and averaging the temperature results could be used to yield a time-averaged solution, the added effort was deemed not necessary for the purpose of addressing the sensitivity of the solution to the placement of the ambient boundary condition.



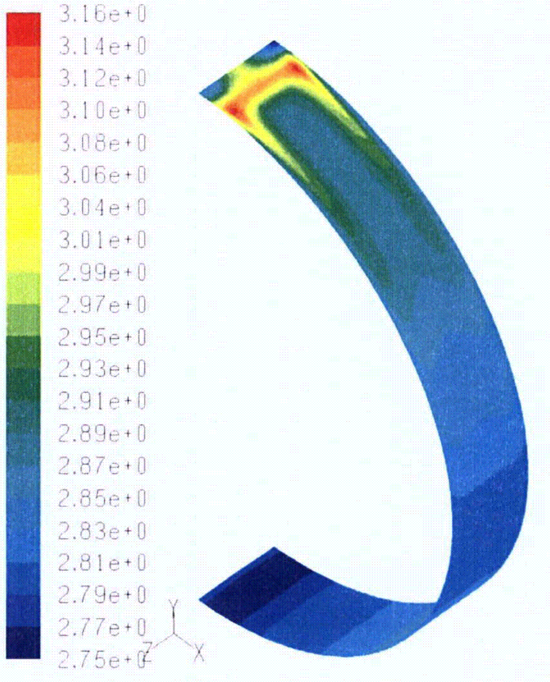
Original Computational Mesh



Extended Computational Mesh



Cask Shell Temperature Distribution (°F)
Original Analysis for 24 kW & 117°F Ambient



Cask Shell Temperature Distribution (°F)
Extended Mesh Analysis for 24 kW & 117°F Ambient

3.4 Justify that the analysis results presented in Figures W.4-5 and W.4-9 result from a conservative representation of DSC/TC system within the supplemental shielding, and demonstrate that this is a conservative estimate of the temperature distribution on the transfer cask outer shell.

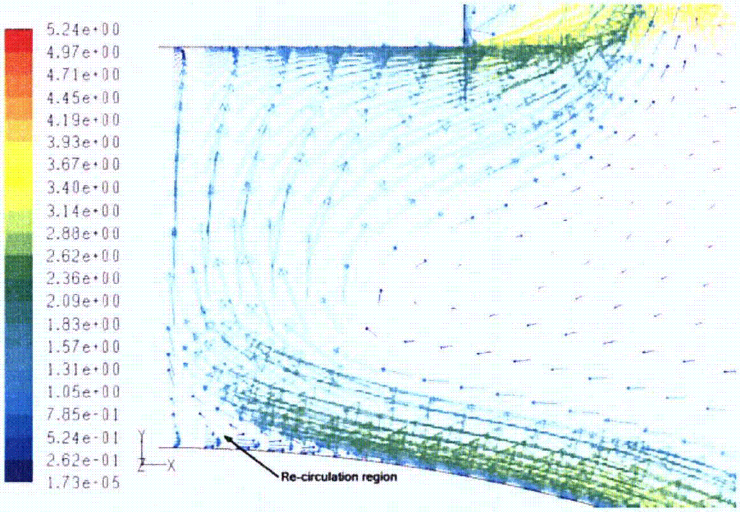
The temperature graphics in Figures W.4-5 and W.4-9 show an off-set peak temperature location on the TC outer shell that does not appear to be consistent with natural convective heat transfer or with the flow field velocity vectors shown in Figures W.4-7 and W.4-8. (Note that this temperature distribution provides boundary conditions for the next step in the analysis, using a 2D ANSYS model of the OS197L transfer cask.)

This information is needed to determine compliance with 10 CFR 72.236(f).

Response to 3.4

The temperature graphics in UFSAR Figures W.4-5 and W.4-9 are consistent with the flow field velocity vectors depicted in Figures W.4-7 and W.4-8. The temperature graphics are not consistent with the natural convective heat transfer profile expected for an isolated cylinder because the transfer cask is not situated in an isolated environment, but is housed within the auxiliary shielding. As described on page W.4-6, the peak temperature on the cask shell is predicted to occur back from the centerline of the cask at the point where the flow separates from the cask and heads towards the exit. The fact that the cask shell temperature reaches a peak and then decreases slightly at the very top of the cask is attributed to the presence of a flow recirculation in this region caused by the presence of the steel plate positioned above the cask shell and below the vent slot in the trailer shielding. The plate's positioning is set to prevent direct line-of-sight between the cask and the ambient while allowing the ventilation air to exit the trailer shielding. However, the plate's positioning also alters the pressure field near the top of the transfer cask from that which would occur for an isolated cylinder and this altered pressure field causes the boundary layer flow around the transfer cask to stagnate and separate earlier than it would for an isolated cylinder. Because of this, a recirculation zone is created between this offset

point of flow stagnation and the centerline of the cask. A close examination of Figure W.4-8 will show the presence of this recirculation zone, although the scale of the figure makes it difficult. An enlarged view of the velocity field in this region of the model presented below clearly demonstrates the presence of the recirculation flow at the top of the cask. Since it is the stagnation zone that experiences the highest surface temperature, the temperature distribution illustrated in Figures W.4-5 and W.4-9 correctly depicts the location of elevated shell temperature at the region of the cask shell where the circumferential flow stagnates and detaches.



Flow Velocity Distribution (ft/sec) Between Top of Cask Shell and Below Auxiliary Shield Top Plate

Although the figure above is for OS197L with a 24 kW heat load, a similar flow re-circulation zone exists for the OS197L transfer cask with a heat load of 13 kW and the justification provided in this response applies for the 13 kW heat load as well. See the revised text and the figure added in Chapter W.4 of updated SAR to address this RAI.

3.5 Describe in detail the representation of the thermal conductivity of the steel basket, aluminum liner plates, neutron poison plates, and aluminum poison plate covers in the detailed ANSYS model of the 32PT DSC.

Because heat transfer through the basket is the primary means of heat removal from the fuel assemblies within the basket, it is necessary for the staff to have a complete understanding of the thermal properties of the basket in order to properly determine, for comparison to staff confirmatory analyses, peak component temperatures, including peak cladding temperature.

This information is needed to satisfy the provisions Of 10 CFR 72.236(f).

Response to 3.5

The thermal conductivity values used for 32PT DSC thermal analyses are presented in UFSAR Appendix M, Section M.4.2 and M.4.3. Section M.4.4.1 provides a detailed 32PT DSC thermal model description. All the basket components (stainless steel, poison plates, aluminum plates, and aluminum transition rails) are modeled individually. The gaps between adjacent basket components are represented with helium or air conductivity, as appropriate. Generally, good surface contact is expected between adjacent components within the basket structure. However, to bound the heat conductance uncertainty between adjacent components owing to imperfect contact between the neutron poison material, aluminum, and the basket grid structure, uniform gaps along the entire surfaces are assumed. The gaps between basket components used in the thermal analysis of the 32PT DSC are summarized in tables and figures in Section M.4.4.1.1.

CHAPTER 5 Shielding Evaluation, and
CHAPTER 8 Radiation Protection Evaluation

The requested addition of the light-weight OS197L transfer cask to the Standardized NUHOMS system presents some unique shielding and radiation protection considerations, given that this transfer cask must be used in conjunction with supplemental shielding and remote operations in order to conduct transfer operations in a safe manner. This is a new, first-of-a-kind review given the operational challenges associated with use of this very high-dose-rate transfer cask.

Normally, transfer casks provide sufficient biological radiation shielding such that workers may safely be in the vicinity of the transfer cask. This is not the case with the light-weight OS197L design. The staff is not only concerned about occupational doses during normal, off-normal, and accident conditions, but also public doses. Given that the amendment to the CoC is not limited to a specific site, the staff must ensure that enough warnings and controls are in place to provide reasonable assurance that both the public and occupational dose limits in 10 CFR Parts 72 and 20 are not exceeded, regardless of where the high-dose rate transfer cask is used.

The following RAIs are geared towards obtaining enough information so that the staff may make a determination regarding whether there is reasonable assurance that the OS197L may be used safely and in accordance with the regulations. The staff is particularly concerned about a potential off-normal event involving either the hangup of the crane or a malfunction of the remote handling equipment. Crane hangups are not uncommon, especially when cranes are loaded with weights approaching their capacity limits. Additionally, the staff is asking for clarification and/or additional information to ensure that the CoC, TS, and SAR each contain the appropriate level of information needed to control the design basis for this unique transfer cask.

During its review of the TN Standardized NUHOMS® Amendment No. 11, the staff, in addition to the technical issues identified in the attached RAIs, identified numerous quality-related problems which reflected inattention to detail on the part of the preparers and reviewers of the SAR. These quality-related problems are documented In RAI 5-35 through RAI 5-49. TN is requested to document these quality-related problems in their corrective action system, identify the cause of these conditions, and identify the corrective action(s) taken to prevent repetition.

5.1 Provide suggested text to revise the description of the OS197L TC in the CoC.

Provide suggested text to revise the CoC to include the material of construction and the corresponding thickness of the OS197L TC. The staff's technical position is that for high dose rate transfer casks, such as the OS197L, the CoC must specify the materials of construction, along with their minimum thicknesses, considering manufacturing tolerances. The CoC should state, at a minimum, that the nominal loaded weight of the OS197L transfer cask is approximately 75 tons, and should specify the minimum thicknesses of the steel shell, the two-piece neutron shield, and the thickness of water inside the neutron shield. Given the high dose rates from the bare transfer cask, this level of detail is warranted in the CoC.

Further, include the description of the OS197L TC system as written in section W.8 in the CoC. Page W.8-4 states "... the OS197L TC system consists of the bare cask and the upper and lower cask shielding utilized in the decontamination area and the additional shielding provided on the cask support skid." Add this description to section 3.b in the Certificate of Compliance. Due to the very high dose rates from the loaded, bare OS197L TC, the TC may not be used without the supplemental shielding in the decontamination area and on the transfer trailer. Furthermore, this level of detail is consistent with the guidance in NUREG-1745.

In sections 3.c and 3.d of the CoC. add Appendix W to the list of referenced FSAR sections.

Additionally, provide suggested text to revise either the CoC or the TS to limit use of the OS197L TC to DSCs with a heat load less than or equal to 24 kW, and to specify that the OS197L TC may only be used with the 52B, 24P, 61BT, 32PT, and 24PHB DSCs. Specification of both the 24 kW heat load limit and the allowed DSCs ensures that dose rates in the OS197L TC are limited to those that were reviewed as part of this amendment.

With respect to the OS197 TC, provide suggested text to revise the CoC to include the materials of construction and the basic structure of the OS197 TC in the TC description. The CoC should state, at a minimum, that the nominal loaded weight of the OS197 transfer cask is approximately 100 tons, and the vertical walls have a steel-lead-steel composition.

This information is requested to satisfy the requirements of 10 CFR 72.236(d).

Response to 5.1

In this RAI, staff requested to add certain parameters associated with the OS197L TC. As noted by the staff in this RAI that "Given the high dose rate from the bare cask this level of details is warranted in the CoC". The allowed contents in the OS197L Transfer Cask is modified such that the maximum decay heat load is limited to 13.0 kW per DSC. Further, only the 32PT and the 61BT DSC are considered as authorized DSCs for transfer with the OS197L TC. The neutron shield in the transfer cask is present during loading and transfer operations and use of the interim cask cover is removed. The shielding and thermal evaluations documented in Chapter W.4 and W.5 are modified to include this change. Changes are also made to the Technical Specifications to include the allowable heat load zoning configurations and fuel qualification tables associated with this modification. Therefore, the dose rates from the bare OS197L transfer cask are reduced by almost an order of magnitude when compared with Revision 1 of the Amendment 11 Application as documented in Response to RAI 5-15. These bare cask dose rates are in the same order of magnitude as other transfer cask designs previously approved by the staff. Therefore, no additional information is necessary to be added to the CoC.

However, the proposed CoC is revised to include the following for the TC:

The TC is a multi-walled cylindrical vessel comprised of gamma shield and neutron shield layers. The nominal loaded total weight of the TC is in the range of 80 to 125 tons

The proposed CoC is also revised to include the following for the OS197L TC:

"The OS197L TC system consists of the bare cask and the upper and lower cask shielding utilized in the decontamination area and the additional shielding provided on the cask support skid. The nominal loaded total weight of the OS197L TC is in the range of 80 to 125 tons."

CoC Sections 3c and 3d have been revised as suggested to add a cross-reference to Appendix W.

TS Section 4.4, TC Design Features, has been revised to state that the OS197L TC shall only be used with DSC models 61BT and 32PT with a heat load of 13 kW or less.

The proposed CoC is also revised to add the following for the OS197series TCs also:

The nominal loaded total weight of the OS197 series TC is in the range of 95 to 125 tons."

5.2 Provide suggested text to revise Insert A of the CoC.

*Provide suggested text to revise Insert A of the CoC to include use of the remote crane operations and optical targeting system in the Loading Operations section during the dry run when the OS197L TC is used.

*Provide suggested text to revise Insert A of the CoC to direct the user to practice the manual crane operations, similar to those that would be used in the event of a crane hangup or other off-normal event, during the dry run when the TC is not loaded with fuel. Inclusion of this in the dry run will assure that the licensee can effectively operate the crane manually in a high dose rate environment. Additionally, inclusion of manual crane operations in the dry run will inform the licensee's predictions of potential worker dose in the event of a crane hangup or other off-normal condition.

These revisions are necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.2

Use of remote operations is the only important aspect for the operation of the bare OS197L TC. The user may choose to use optical or other appropriate systems for targeting in the loading operation. Insert A item 8 to the CoC is revised to include the use of remote crane operations and optical or other appropriate targeting system if the OS197L TC is to be used for loading.

5.3 Provide suggested text to revise the definitions in TS 1.1:

*Specify whether placement of the supplemental trailer shielding is considered part of the Loading Operations or the Transfer Operations.

*Remove the words "governed by the 10 CFR 50 regulations" from the definition of the Fuel Building. While it is true that the regulations in 10 CFR Part 50 apply in the fuel building, the regulations of 10 CFR Part 72 also apply in the fuel handling building. This statement must be removed so as to prevent the implication that Part 72 does not apply within the fuel building.

*Define the "Cask handling area." This term is referred to in TS 4.4.4, but is not defined anywhere in the TS.

These revisions are necessary to ensure compliance with 72.236.

Response to 5.3

The definition of LOADING OPERATIONS provided in TS 1.1 is revised to include the placement of the supplemental trailer shielding.

The definition of FUEL BUILDING provided in TS 1.1 is revised to delete the words "governed by the 10 CFR 50 regulations".

The previous Technical Specification 4.4.4 is deleted because the use of the interim cask cover is removed from the OS197L TC design. Therefore, the definition of CASK HANDLING AREA is no longer needed.

5.4 Provide suggested text to revise TS 2.1 as follows:

*Add a table showing which DSCs may be loaded into each HSM design.

*Add a table showing which DSCs may be loaded into each TC design.

This information is necessary due to the complexity of the Standardized NUHOMS® system, and to ensure compliance with 10 CFR 72.236(a-b).

Response to 5.4

TS 2.1 is revised to add Section 2.1.1 which states that "Each of the DSC models listed above may be stored inside a HSM model in accordance with LCO 3.1.4."

TS 4.4 is revised to add those DSC models (61BT and 32PT only) which may be transferred in the OS197L Transfer Cask. For the other DSC models, the use of the transfer cask is contained in the corresponding UFSAR sections or appendices.

5.5 Provide suggested text to revise TS 4.4 to address the following:

*Provide suggested text to revise TS 4.4.2 to better describe the TC temporary shielding, including the decontamination area shielding as well as the transfer trailer shielding. Alternatively, provide suggested text to revise the definitions in TS 1.1 to define the TC temporary shielding.

*If the definition of "Cask handling area" added to TS 1.1 (in response to RAI 5-3) extends outside of the fuel building, provide suggested text to revise TS 4.4.4 to specify that the interim cask cover may not be used outside of the fuel building.

*Provide suggested text to revise TS 4.4.5 to specify that, if placement of the outer top shield of the transfer trailer shield is delayed due to building load limits, placement of the outer top shield must occur as soon as the Transfer Trailer has been moved to an area with acceptable load limits. Additionally, specify that the user must plan accordingly to minimize, to the greatest extent practicable, the delay of the placement of the Outer Top Shield.

This information is necessary to ensure compliance With 72.236.

Response to 5.5

The previous TS 4.4.2 (now 4.4.1) is revised to eliminate the term "Temporary Shielding". The sentence has been revised to say that "The OS197L TC decontamination area shielding shall be used for all LOADING OPERATIONS when the TC is not in the spent fuel pool or suspended on the crane. The OS197L TC trailer shielding shall be used for all TRANSFER OPERATIONS".

As provided in Response to RAI 5.3, the previous Technical Specification 4.4.4 is deleted because the use of the interim cask cover is removed from the OS197L TC design. Therefore, the definition of CASK HANDLING AREA is no longer needed OS197L Cask.

The previous TS 4.4.5 (now 4.4.4) is revised to add the suggested clarification as follows: "The placement of the Outer Top Shield of the Transfer Trailer Shield on the loaded OS197L TC shall take place in the FUEL BUILDING unless the FUEL BUILDING load limit would be exceeded. In that case, the placement of the Outer Top Shield takes place outside the FUEL BUILDING. If placement of the Outer Top Shield of the Transfer Trailer Shield is delayed due to FUEL BUILDING load limits, placement of the Outer Top Shield must occur as soon as the transfer trailer has been moved to an area with acceptable load limits. The Licensee must plan accordingly to minimize, to the greatest extent practicable, the delay of the placement of this Outer Top Shield."

5.6 Provide suggested text to revise TS 5.1.1 to include TS 5.2.4(b, d, and e) in the list of technical specifications in the last sentence.

TS 5.1.1 addresses loading, unloading, and preparation of the DSC, and lists several LCOs that should be addressed in the user's program for implementing the FSAR requirements. TS 5.2.4(b, d, and e) have requirements far DSC closure welds, DSC smearable surface contamination levels, and transfer cask dose rates, respectively. These are all integral to a DSC loading and preparation program.

This revision is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.6

TS 5.1.1 is revised to include TS 5.2.4(b, d and e) and also TS 5.2.6.

5.7 Provide suggested text to revise TS 5.2.1 to clarify that any changes to the SAR, including the TS Bases, shall be provided to the NRC in accordance with 10 CFR 72.48. The last paragraph of TS 5.2.1 states: "Changes to the Technical Specification Bases implemented without prior NRC approval shall be provided to the NRC... " Provide suggested text to revise this statement to clarify that all licensing basis documents, including the technical specification bases, that are implemented without prior NRC approval must be provided to the NRC in accordance with the requirements of 10 CFR 72.48.

This revision is necessary to ensure compliance with 10 CFR 72.48.

Response to 5.7

The second sentence of last paragraph of Technical Specification 5.2.1 is revised as follows: "Changes to all of the licensing basis documents including the Technical Specification Bases implemented without prior NRC approval shall be provided to the NRC in accordance with 10CFR 72.48."

5.8 Provide suggested text to revise TS 5.2.4 to address the following;

*Provide suggested text to revise TS 5.2.4a, in the section pertaining to the user's ALARA assessment for the OS197L TC, to require an assessment of public doses considering the anticipated number of hours the OS1971 TC will remain unshielded during the entire ISFSI loading campaign. The staff notes that, for some site conditions, only a limited number of HSMs may be loaded in a year such that the OS197L TC may be used without risk of exceeding the dose limits in 10 CFR Part 20. Users are expected to meet the normal dose limits in 10 CFR Parts 20 and 72 during off-normal conditions (i.e., the accident dose rates only apply to accident conditions).

*Revise the next-to-last paragraph of TS 5.2.4a to read: "For the OS197L, approved written procedures shall be developed and followed that address normal, off-normal, and accident conditions. Specifically, these procedures shall address the impact on plant operations due to potentially-increased radiation levels from the unshielded loaded OS197L. These may include operator actions required by 10 CFR Part 50 TSs, security guard actions, control room habitability, and response to alarms set off by the loaded OS197L."

*The last paragraph of TS 5.2.4a states: "Remote operations or appropriate ALARA practices shall be used due to very high dose rates during movement of the loaded OS197L TC..." Revise the "or" to an "and" such that the TS requires both remote operations and appropriate ALARA practices.

*Provide suggested text to revise the last sentence of the last paragraph of TS 5.2.4a so that it provides more specific guidance regarding the remote operations necessary when the OS197L is unshielded. The staff suggests replacing the existing sentence with the following: "When remote operations are used, approved written procedures shall be in place to govern these operations. These procedures shall address such topics as redundancy of equipment, calibration, maintenance, operability, operator training and qualification, recovery/equipment malfunction plans, and lessons learned from past loading campaigns."

*Provide suggested text to revise TS 5.2.4e to require measurements to be taken at the surface (instead of 3 feet from the surface) of the TC. Historical considerations aside, this amendment request is proposing to update the TS to be consistent with the standardized TS as described in NUREG-1745, which calls for surface dose rates. Therefore, this TS needs to be appropriately updated to be consistent with the guidance in NUREG-1745. The staff notes that the licensee's radiation protection personnel will be making multiple measurements during cask loading operations; therefore, measurements that verify compliance with TS dose rate limits will be among those performed by these personnel and will thus be readily available. The applicant should properly justify selection of the dose rate limits, the number and locations of the associated measurements and the cask configuration for the TS Radiation Protection Program. Surface dose rate limits should be provided for each allowable TC/DSC combination. The dose rate limits for each TC/DSC configuration will ensure that licensees meet 10 CFR 72. 104(b), 20.1101(b), and 20.1301 requirements.

*Provide suggested text to revise TS 5.2.4e to include axial surface dose rate limits for the TC. Dose rate limits at the top surface of the TC serves as an important check against mis-loading of the DSCs; assemblies in the DSC basket periphery locations will not shield assemblies in the interior from the confirmatory measurements for these surface limits. Further, these limits also serve to ensure proper performance of the top areas of the cask system such that 10 CFR 72. 104(b) and (c) will be met per 10 CFR 72.236(d) for worker dose during operations with the TC. Thus, limits on the TC side alone are not sufficient. Dose rate limits for the wet welding configuration at the location(s) of the maximum dose rates based upon the shielding analysis would fulfill these objectives. The TS should specify the locations of both the measurements, which the applicant should demonstrate are the locations identified by the shielding analysis to have the highest dose rates.

*Justify the chosen dose rates in TS 5.2.4.e, and provide suggested text to revise the TS and/or bases, as appropriate, to clarify the TC/DSC configuration assumed when determining the TS dose rate limits. The bases for TS 5.2.4.e state that the dose rates are based on the shielding analysis for the various DSCs included in the UFSAR and its appendices, with some added margin for uncertainty. Discuss the added margin and justify its appropriateness. The staff notes that the current dose rates in TS 5.2.4.e are not clearly derived from the SAR. These dose rates should be revised, if necessary, to reflect the analyses presented in the SAR. If the dose rate values in the TS include extra margin beyond the conservatisms present in the shielding analyses, revise the TS bases to discuss the added margin With specificity - I.e., what percent and why that percentage is appropriate. Additionally, provide suggested text to revise the TS and/or bases, "s appropriate, to clarify the TC/DSC configuration assumed when determining the dose rates. Specifically, address whether water is assumed to be present in the neutron shield (for the designs with a liquid neutron shield) and in the DSC/TC annulus.

*Provide suggested text to revise TS 5.2.4e to require the licensee to establish a set of TC dose rate limits which are to be applied to DSCs used at the site to ensure the limits of 10 CFR Parts 20 and 72 are met. Specify both axial and radial locations where the licensee should set limits.

*Provide suggested text to revise the last paragraph in TS 5.2.4e to add text requiring the user to verify compliance with the dose limits in 10 CFR 72.104 and 10 CFR 20.

These revisions are necessary to ensure compliance with 72.236.

Response to 5.8

As documented in responses to RAI 5.1 and RAI 5.15, the maximum heat load allowed in the OS197L TC is 13 kW which reduces the dose rates on the bare OS197L TC to the same order of magnitude as the other Transfer Cask designs approved by the Staff. Technical Specification 5.2.4 "Radiation Protection Program" already has the requirements to establish all the required administrative controls to keep the dose rates ALARA. Therefore no additional changes are warranted.

However, the next-to-last paragraph of TS 5.2.4a to read: "For the OS197L, approved written procedures shall be developed and followed that address normal, off-normal, and accident conditions. Specifically, these procedures shall address the impact on plant operations due to potentially-increased radiation levels from the unshielded loaded OS197L. These may include operator actions required by 10 CFR Part 50 TSs, security guard actions, control room habitability, and response to alarms set off by the loaded OS197L."

The last paragraph of TS 5.2.4a is also revised to replace the word "or" with "and" as requested: "Remote operations and appropriate ALARA practices shall be used due to high dose rates during movement of the loaded OS197L TC..."

Item 3 regarding the worker doses associated with the use of the Interim Cask Cover is deleted because the Interim Cask Cover is deleted.

TS 5.2.4e is revised to require the TC dose rates for each payload at the surface instead of 3 feet from the surface. The number and location of the selected measurement points are supported by the Shielding Analysis.

Transnuclear does not believe that a technical justification exists to demonstrate that axial dose rate measurements can be employed to detect a majority of the misloaded fuel assemblies. However, axial and radial surface dose rate measurements are required per the revised TS 5.2.4e, relevant portions of which are shown below:

Dose Rate Limits with TC (except OS197L TC)

DSC Model	*Axial Surface Dose Rate Limit (mrem/hour)*	*Radial Surface Dose Rate Limit (mrem/hour)*
24P	*700*	*600*
52B	*700*	*600*
61BT	*800*	*1200*
32PT	*300*	*1000*
24PHB	*2000*	*1200*
24PTH	*900*	*1600*
24PTH-SLC	*900*	*650*
61BTH	*900*	*1500*
32PTH1	*900*	*700*

Dose Rate Limits with OS197L TC

DSC Model	*Axial Surface Dose Rate Limit (mrem/hour)*	*Radial Decontamination Area Shielding Surface Dose Rate Limit (mrem/hour)*
61BT	*800*	*400*
32PT	*300*	*400*

The following configuration shall be employed for all TC axial dose rate measurements:

- ***Neutron Shielding Material present in the TC neutron shield cavity***
- ***DSC / TC annulus filled with water***
- ***Water in the DSC cavity – fuel not fully covered***
- ***DSC shield plug installed***
- ***DSC inner top cover plate installed***
- ***Temporary shielding – equivalent to approximately 3" NS-3 and 1" steel present above the inner top cover plate***

The following locations shall be employed for all TC axial dose rate measurements:

- ***Five locations are chosen within a radius of approximately 25 inches (diameter of approximately 50 inches) around the DSC centerline. None of these measurements shall exceed the dose rate limits given above.***

The following configuration shall be employed for all radial dose rate measurements:

- ***Neutron Shielding Material present in the TC neutron shield cavity***
- ***DSC / TC annulus dry***
- ***DSC cavity vacuum drying is complete***
- ***DSC outer top cover plate welding completed***
- ***TC top lid installed***

In addition to the configuration above, decontamination area shielding approximately equal to 5.5" of steel is installed in the radial direction only for the OS197L TC.

The following locations shall be employed for radial dose rate measurements:

- ***Eight approximately equally spaced locations around the radial surface of the cask at an axial location corresponding to within approximately 24" of the center of the transfer cask. For the OS197L TC, dose rate measurements are taken on the surface of the decontamination area shielding. None of these measurements shall exceed the dose rate limits given above.***

Due to lower dose rates from the OS197L cask and in discussion with the staff, it is not necessary for the licensee to establish a set of TC dose rate limits to ensure that they meet the limits of 10CFR Parts 20 and 72.

As part of the requirements on the licensee to use any dry storage system, they have to meet the requirements of 10CFR72.104 and 10CFR20. It is not necessary to include specific requirement for the licensee to state that they need to meet the regulation again.

5.9 Provide suggested text to revise TS 5.3.1 to clarify that the stated distinction between the applicability of 10 CFR 72 and 10 CFR 50 is valid only with respect to lifting/handling height limits and to address the lift height restriction for the bottom most part of the body of the outer top shield.

The last paragraph of TS 5.3.1A states, "The requirements of 10 CFR Part 72 apply when the TC/DSC is in horizontal orientation on the transfer trailer. The requirements of 10 CFR 50 apply when the TC/DSC is being lifted/handled using the cask handling crane/hoist." Provide suggested text to revise this paragraph to clarify that these statements are applicable only to lifting/handling height limits.

Additionally, provide suggested text to revise TS 5.3.1 to specify that the bottom most part of the body of the outer top shield shall not be hoisted by the crane more than 4 inches above the top horizontal plate of the inner top shield. While the operating procedures have been modified to include this lift height restriction, it is also necessary to include this in the technical specifications. The shielding analysis for accident conditions is based in part on the assumption that this lift height restriction will be met. Therefore, to ensure compliance with the accident dose limits, this restriction needs to be included in the technical specifications.

These revisions are necessary to comply with 72.236(d).

Response to 5.9

TS 5.3.1A is revised to add the suggested clarification (This distinction is valid only with respect to lifting/handling height limits).

The design basis dose rates for TC handling accidents currently do not credit the presence of the Outer Trailer Shielding. Therefore, the additional suggestions on the hoist height of the crane are not necessary to ensure compliance with accident dose limits.

5.10 Provide suggested text to revise TS 5.3.4 to require inspection of the supplemental shielding following an accidental drop of the supplemental shielding.

TS 5.3.4 requires inspection of the DSC and the OS197L TC following an accidental drop of the supplemental shielding onto the OS197L TC. As the supplemental shielding is relied upon for radiological protection of the workers and the public, it is imperative that any damage to the supplemental shielding accrued from an accidental drop is identified. If the supplemental shielding is damaged such that there is a potential increase in radiological dose, the licensee must take mitigative measures to keep doses ALARA and, depending on the extent of the damage, to avoid exceeding dose limits in 10 CFR Parts 72 and 20.

This revision is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5-10

TS 5.3.4 is revised as follows: "The DSC and OS197L TC and the trailer shielding shall be inspected for damage and evaluated for further use after the accidental drop of the trailer shielding onto the OS 197L TC."

5-11 Revise TS 5.4.1 a to delete the text "or 3 feet from the HSM front surface," and provide suggested text to revise TS 5.4.2 to require surface dose rates (vice 3 feet from the surface) for all DSCs loaded in the HSM.

The staff notes that casks are operated in accordance with the amendment under which they are loaded. Therefore, the fact that some DSCs have been loaded using the older

TS that specified dose rates at 3 feet from the HSM front surface has no bearing on changing the TS now to specify dose rates at the front surface.
P.13

Provide suggested text to revise TS. 5.4,1 and 5.4.2 to require surface dose rates (vice 3 feet from surface) for all DSCs loaded in the HSM. Additionally, remove the footnote from the table allowing dose rate measurements at 3 feet from the HSM front surface. Historical considerations aside, this amendment request is proposing to update the TS to be consistent with the standardized TS as described in NUREG-1745, which calls for surface dose rates. Therefore, this TS needs to be appropriately updated to be consistent with the guidance in NUREG-1745. The staff notes that the licensee's radiation protection personnel will be making multiple measurements during cask loading operations; therefore, measurements that verify compliance with TS dose rate limits will be among those performed by these personnel and will thus be readily available. The applicant should properly justify selection of the dose rate limits, the number and locations of the associated measurements and the cask configuration for the TS Radiation Protection Program. Surface dose rate limits should be provided for each allowable HSM/DSC combination. The dose rate limits for each HSM/DSC configuration will ensure that licensees meet 10 CFR 72.104(b), 20.1101 (b), and 20.1301 requirements.

These revisions are necessary to ensure compliance with 10 CFR 72,236(d).

Response to 5.11

TS 5.4.1 is modified to specify two dose rate measurement locations instead of three. Further, TS 5.4.1 a. is modified to delete the text "or 3 feet from the HSM front surface" as suggested by the staff.

TS 5.4.2 is modified to specify dose rate limits at the surface of the HSM – specifically the front surface and door surface for the various DSC and HSM combinations. The number and locations of these dose rate measurements are also included in TS 5.4.2.

The following is an extract from the proposed modification to TS 5.4.2:

Dose Rate Limits for the Standardized HSM and HSM-H

DSC Model	*HSM Model*	*Dose Rate Limit Outside HSM Door (mrem/hour)*	*Dose Rate Limit HSM Front Surface (mrem/hour)*
24P	*Standardized HSM*	*100*	*100*
52B	*Standardized HSM*	*100*	*100*
61BT	*Standardized HSM*	*100*	*100*
32PT	*Standardized HSM*	*200*	*120*
24PHB	*Standardized HSM*	*50*	*60*
24PTH-SLC	*Standardized HSM*	*60*	*100*
61BTH Type 1	*Standardized HSM*	*100*	*100*
24PTH	*HSM-H*	*5*	*50*
61BTH Type 2	*HSM-H*	*5*	*30*
32PTH1	*HSM-H*	*5*	*30*

The number and locations of the dose rate measurements on the outside surface of the HSM door are indicated below:

- *Five locations within a radius of approximately 25 inches (diameter of approximately 50 inches) around the door centerline. The average of these dose rates shall be used for comparison against the dose rate limits.*

The number and locations of the dose rate measurements on the front surface of the HSM are indicated below:

- *Two dose rate measurements are taken for each front bird screen for the HSM-H. These dose rate measurements are approximately within 24 inches measured from the surface of the ISFSI pad and are approximately 6 inches from the centerline of each front bird screen. An average of these four measurements is calculated as the bird screen average dose rate for HSM-H.*
- *For other HSM models, three dose rate measurements are taken at the surface of each front bird screen (at an approximate mid-plane of the front bird screen) – one at an elevation corresponding to the door centerline, the second at an elevation of approximately 40 inches above the door centerline and the third at an elevation of approximately 80 inches below the door centerline. An average of these six measurements is calculated as the bird screen average dose rate for HSM.*
- *Six dose rate measurements are taken at various locations on the front surface of the HSM or HSM-H. These locations do not include the door exterior surface or the surface of the bird screen. An average of these six measurements is calculated as the front average dose rate for the HSM or HSM-H.*

The methodology to calculate the average front surface dose rate for compliance with the limits is described below:

- *The average dose rate for comparison against the limits for the Standardized HSM is computed as follows:*
  - *HSM dose rate = 0.90*front average + 0.10 *bird screen average*
- *The average dose rate for comparison against the limits for the HSM-H is computed as follows:*
  - *HSM-H dose rate = 0.98*front average + 0.02 *bird screen average*

5.12 Revise section B.10.5.2.4d to include the justification as to why checking only the top one foot of the DSC is acceptable, and how the survey is to be accomplished.

The goal of this TS is to evaluate the level of contamination on the DSC surface. Surveying the top one foot is meant to provide a representative sample of the entire surface. Therefore, the measurement must be taken before any effort is made to decontaminate the area to be assessed in the smear survey. Additionally, if decontamination is necessary, then it must be applied to the whole DSC, not just the top foot.

This revision is necessary to ensure compliance with 10 CFR 72.104.

Response to 5.12

TS Bases Section 10.5.2.4d is revised to add the following justification for checking only the top one foot of the DSC.

Using loading of 32PT DSC steps described in UFSAR Appendix M, Chapter M.8, Section M.8.1.1, Step 8 calls for filling the TC/DSC annulus with clean, demineralized water. An inflatable seal is then placed into the upper cask liner recess and the TC/DSC annulus is then sealed by

pressurizing the seal with compressed air. This operation protects the outside DSC surface below the annulus seal from any contamination due to spent fuel pool water.

The above use of the inflatable seal ensures that the TC/DSC annulus area below the seal is protected from any contamination due to spent fuel pool water and remains clean during the subsequent fuel loading steps inside the spent fuel pool. Hence, the only area which needs to be checked for contamination is the top one foot of the DSC surface. The operating procedure in UFSAR Appendix W, Section W.8.1.3 already has the steps for checking the contamination levels before starting the decontamination process. TN has had good success with the above design feature with several hundred DSCs loaded so far.

5.13 Revise Table W.2-1 as originally requested in RAI 5-25 (in the first-round RAI) and make conforming changes as needed in the text, tables, figures, and drawings.

The applicant has incorrectly interpreted the applicability of 10 CFR 72.104 and Interim Staff Guidance 13. These requirements apply to the TC, regardless of its location. In 10 CFR 72.236, the regulations state "radiation shielding and confinement features must be provided sufficient to meet the requirements in 72.104 and 72.106." The requirements of 10 CFR 72,236 make no exceptions for the TC if it is located within the Part 50 building. The applicant must therefore ensure that the cask design is such that the dose limits in 10 CFR 72,104 and 72.106 will be met. The staff notes that only the NRC's Office of the General Counsel (OGG) may interpret the regulations in Part 72.

Therefore, the "applicant's justification for their response to RAI 5-25 is invalid. Provide the information and revisions originally requested in RAI 5-25. Be sure to include any code alternatives, etc. in TS 4.2,3, as necessary. Additionally, provide suggested text to revise TS 4.3.3, item 6 to add a statement or a note cautioning that, depending on the layout of the licensee's site, it may be necessary to limit the number of HSMs loaded in a year or take other actions to limit potential doses due to the requirements of 10 CFR 72.104(13) and 10 CFR 20.1301.

This information is necessary to satisfy the requirements of 10 CFR 72.236 and 10 CFR 20 1301.

Response to 5.13

Technical Specification 4.2.3 is revised to add code alternatives for the Transfer Cask as requested. The Trailer Area Shielding is Important to Safety. The allowed contents in the OS197L Transfer Cask are modified such that the maximum decay heat load is limited to 13.0 kW per DSC. Further, only the 32PT and the 61BT DSC are considered as authorized DSCs for transfer with the OS197L TC. The neutron shield in the transfer cask is present during loading and transfer operations and use of the interim cask cover is removed. Therefore, the dose rates from the bare OS197L transfer cask are reduced by almost an order of magnitude when compared with Revision 1 of the Amendment 11 Application as documented in Response to RAI 5-15. These bare cask dose rates are in the same order of magnitude as other transfer cask designs previously approved by the staff. Therefore, TN believes that the information as added is consistent with the Staff expectations.

5.14 Clarify section W.2.3.S of the SAR.

Clarify the following statement: "Therefore, with the use of remote handling and the supplemental shielding features of the OS197L TC to protect occupational workers and members of the public against direct radiation and releases of radioactive material and to minimize dose following any off-normal or accident condition are the same as those for the OS197 TC System." Dose rates for the OS197L TC system by far exceed (by orders of magnitude) the dose rates of the OS197 TC system following any off-normal or accident condition. It is incorrect to state that the shielding features of the OS197L TC are the same as the shielding features of the OS197 TC. This statement needs to be clarified to avoid the misperception that the dose following off-normal or accident conditions are comparable between the OS197L TC and the OS197 TC.

This revision is necessary for compliance with 10 CFR 72.236(d).

Response to 5.14

The last sentence of Section W.2.3.5 has been revised to say:

"Therefore, with the use of remote handling and the decontamination area shielding and trailer area shielding features of the OS197L TC, the occupational workers and members of the public are protected against direct radiation and releases of radioactive material."

5.15 Clarify Section W.5.2.2 and provide suggested text to revise the Technical Specifications and Sections W.5.2.1 and W.5.2.2 as appropriate.

*The first bullet in Section W.5.2.2 states: "The response function results determined in Section W.S.2.1 indicate... " However, Section W.5.2.1 does not contain any response functions; rather Section W.5.2.1 states that response functions were developed for two bounding configurations, and that the functions were "similar to that documented in Appendix M, Section M.5.2.4." However, only limited further discussion is provided regarding the similarities and differences between the response functions determined for the as197L TC and those presented in Section M.5.2.4. Section W.5.2.1 seemingly indicates a change may be necessary to Figures 1-2 through 1-7 in the Technical Specifications as it states that the design basis source terms for the inner assemblies are different for the 32PT DSC loaded in the OS197L TC.

Justify, from both a thermal and radiological perspective, that the heat load zoning configurations in the technical specifications (Figures 1-2 through 1-7) are bounding for the 32PT DSC when loaded in the OS197L TC.

*The third bullet in Section W.5.2.2 states that the total gamma source terms of the design basis 32PT DSC and 24PHB fuel assemblies are "not significantly different." However, the fourth bullet states that "the gamma surface dose rates for the OS197 TC with the 32PT DSC are higher than that of the 24PHB DSC." Clarify why the gamma dose rates for the OS197L TC loaded with the 32PT DSC are higher than the dose rates for the OS197L TC loaded with the 24PHB, when the total source terms are "not significantly different."

This information is necessary to satisfy the requirements of 10 CFR 72.236.

Response to 5.15

The operation of the OS197L Transfer Cask is modified such that the maximum decay heat load is limited to 13.0 kW per DSC. Further, only the 32PT and the 61BT DSC are considered as authorized DSCs for transfer with the OS197L TC. The shielding and thermal evaluations documented in Chapter W.4 and W.5 are modified to include this change. Changes are also made to the Technical Specifications to include the allowable heat load zoning configurations and fuel qualification tables associated with this modification. The salient features of this modification from an operational standpoint include:

- ***Water to be filled in the neutron shield at all times***
- ***Use of the aluminum interim cask lid is deleted***

This will result in bare OS197L TC maximum dose rates below 10 Rem/hour during normal conditions of loading and transfer. The following table is a comparison of the dose rates for the OS197L TC.

Transfer Cask Configuration	Dose Rate Component	Normal Condition Dose Rates (mrem/hour) at Different Distances from Side Surface			
		On Side Surface	4.57 meters (15'	100 meters	609.9 meters (2000')
OS197L TC Bare Cask - B (Before Change)	Neutron	3,176	157	0.17	8.18E-5
	Gamma	83,570	6,999	7.84	1.80E-2
	Total	86,691	7,152	8.00	1.81E-2
OS197L TC Bare Cask - B (After Change)	Neutron	323	22.4	0.02	1.51E-5
	Gamma	9,521	824	1.41	1.45E-3
	Total	9,835	845	1.42	1.46E-3
OS197L TC Inner Trailer - K (Before Change)	Neutron	54.6	3.0	0.01	1.55e-5
	Gamma	1957	178	0.40	5.88e-4
	Total	2009	181	0.40	5.94e-4
OS197L TC Inner Trailer - K (After Change)	Neutron	59.4	3.5	0.01	1.47e-5
	Gamma	334	33.9	0.11	2.62e-4
	Total	392	37.4	0.12	2.77e-4

Transfer Cask Configuration	Dose Rate Component	Accident Condition Dose Rates (mrem/hour) at Different Distances from Side Surface			
		On Side Surface	4.57 meters (15')	100 meters	609.9 meters (2000')
OS197L TC Bare Cask - B (Before Change)	Neutron	3,691	187	0.20	1.06E-4
	Gamma	134,328	11,576	12.7	3.19E-2
	Total	138,019	11,763	12.9	3.20E-2
OS197L TC Bare Cask - B (After Change)	Neutron	4,194	174	0.20	4.97E-5
	Gamma	15,301	1,333	2.30	2.43E-3
	Total	18,209	1,438	2.31	2.43E-3
OS197L TC Inner Trailer - K (Before Change)	Neutron	860	49.1	0.11	7.97e-5
	Gamma	3090	280	0.60	8.47e-4
	Total	3939	329	0.70	9.22e-4
OS197L TC Inner Trailer - K (After Change)	Neutron	1457	74.4	0.18	1.15e-4
	Gamma	535	54	0.18	4.14e-4
	Total	1543	129	0.77	1.81e-3

5.16 Clarify the assumptions used to determine the dose rates presented in the tables in Section W.5 of the SAR, and revise Section W.1 to include a drawing of the interim top cask cover.

*Clarify in Section W.5.4.7 whether the MCNP models include water inside the DSC.

*Revise Figure W.5-5 to clarify what material was modeled (air or void) between the 0.1g" thick neutron shield panel and the 2.5" thick inner top supplementary trailer shielding. Similarly, clarify what material was modeled in the DSC/TC annulus.

This information is necessary to ensure compliance with 10 CFR 72.236.

Response to 5.16

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. All the items identified by the staff are clarified in Section W.5 and W.11, as applicable.

5.17 In Section W.5.4.7, clarify that shielding configurations 3, 5. and 8 represent normal conditions.

Section W.5.4.6 states that normal conditions consider the 32PT DSC in the OS197L TC with water In the neutron shield and 5.5 inches of supplemental trailer shielding. However, the conditions described in shielding configurations 3, 5, and 6 are unavoidable during normal operations of the OS197L TC with the 32PT DSC.

Further, Table W.5-1 should be revised to reflect that under normal conditions, when the neutron shield is drained and the interim cask cover installed, for the evolution of the OS197L TC from the decontamination area to the transfer trailer, the surface dose rate of the bare OS197L TC will be 87 rem/hr.

This information is necessary to ensure compliance with 72,236.

Response to 5.17

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. All the items identified by the staff are clarified in Section W.5, as applicable.

5-18 Define the terms "normal accident," "off-normal accident," "design-basis accident," (an implied term) and "beyond-design basis accident" used in Section W.5.4.9.

These terms do not have any regulatory significance. The use of "normal," off-normal," and "beyond-design basis" seem to imply some risk significance associated with the conditions these terms are used to describe. Clarify the meaning of these terms, and state whether their use indicates that a risk assessment was performed.

This information is required for compliance with 10 CFR 72.236(d).

Response to 5.18

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The water will always be present in the neutron shield cavity during all loading, unloading and normal and off-normal transfer operations. The terms currently employed to describe the various accidents are not used and all accident results (as appropriate) are documented. The term "beyond-design basis" and all associated evaluation for it are now deleted.

5.19 In Section W.5.4.9, Clarify that the loss of neutron shield is a normal condition that describes the evolution of the OS197L TC transfer cask from the decontamination area to the transfer trailer, when loaded with the 32PT DSC.

The first configuration discussed in Section W.5.4.9 describes the loss of water in the neutron shield. This configuration is encountered during normal operations involving the OS197L TC during the movement from the decontamination area to the transfer trailer.

However, this configuration is presented only as an accident condition. If this condition Is to be treated as one of the accident conditions analyzed, a disclaimer must be inserted into Section W.5.4.9 stating that this configuration is also encountered during normal operations.

This information is required for compliance with 10 CFR 72.236(d).

Response to 5.19

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The neutron shield will remain filled at all times during loading and transfer operations and therefore, any configuration involving an empty neutron shield is considered an accident condition.

5.20 Clarify the discussion in Section W.5.4.10.4.

*Clarify whether the temporary cask lid may be used only on the 32PT DSC or on the other DSCs as well. Based on the assumptions and statements in the calculations provided by the applicant, the staff believes that the temporary cask lid is only to be used with the 32PT DSC.

*Section W.5.4.10.4 discusses Tables W.5-6 through W.5-9, which list both radial and axial dose rates. The text states that the axial dose rates were determined assuming the DSC/TC annulus and the neutron shielding are both drained, but does not state what configuration was assumed for estimating the radial dose rates. Clarify whether the DSC/TC annulus and the neutron shielding were assumed to be filled or drained for the radial dose rates listed in Tables W.5-6 and W.5-7.

This information is required for compliance with 10 CFR 72.236(d).

Response to 5.20

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The use of the interim cask cover is no longer necessary for the OS197L TC. All of the items identified by the staff are clarified in Section W.5, as applicable.

5.21 Clarify Figure W.5-2 and the associated discussion in section W.5.4.7.

Revise Figure W.5-2 to clarify whether both neutron and gamma dose rates are included in the figure. Modify the discussion and the figure to specify both the shielding configurations and the locations being modeled. Additionally, explain why the above cask-support-skid dose rate increases from 0 to 1 meter. It may be necessary to provide a figure to describe the dose rate location that was being modeled.

This information is required for compliance with 72.236(d).

Response to 5.21

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The revision to Figure W.5-2 includes clarification for the dose rate location and discussion of the dose rate behavior.

5.22 In Section W.8, clarify whether water may be pumped out during the lift from the fuel pool for any DSCs other than the 32PT DSC. Additionally, clarify the required minimum amount of water to be pumped out for weight considerations.

As written, it is unclear on p. W.5-4 Whether water may be pumped out during the lift from the fuel pool for other DSCs certified for transfer in the OS197L TC. Additionally, it is unclear that there is a minimum amount of water that must be pumped out when lifting the 32PT DSC with the OS197L TC from the fuel pool. It is the staff's understanding that a minimum amount of water must be pumped out to achieve the 75-ton weight limit.

These revisions are required for compliance with 10 CFR 72.236.

Response to 5.22

Due to the change in the authorized contents (only 61BT and 32PT DSCs are allowed with a maximum heat load of 13 kW/DSC) and operational simplification for the OS197L TC (no water removed from the neutron shield of OS197L TC), a new shielding evaluation is documented in Chapter W.5.

The changes to the TC operations due to this modification are documented in Chapter W.8. Chapter W.8 is also revised to be consistent with the shielding evaluation documented in Chapter W.5.

5.23 Place warnings, as appropriate in Section W.8 of the SAR to alert the user that the OS197L TC dose rate may be as high as 87 rem/hr in the event that the neutron shield is to be drained to reduce weight during the transfer from the decontamination area to the transfer trailer.

The dose calculations in Section W.5 indicate that the already very high dose rate on the surface of the OS197L TC (when loaded with design-basis fuel in the 32PT DSC) will become as high as 87 rem/hr when the neutron shield is drained for weight considerations during the lift from the decontamination area to the transfer trailer. This very high dose rate poses occupational hazards and should be pointed out in the operating procedures for the system. Furthermore, it is important to highlight the very high dose rates associated with this evolution so that the user of the system can ensure compliance with Part 20 dose limits and have proper ALARA planning in place in case of an off-normal condition such as a crane hang-up.

This information is required for compliance with 10 CFR 72.236.

Response to 5.23

Due to the change in the authorized contents and operational simplification for the OS197L TC, the maximum dose rate on the surface of the bare OS197L TC will remain under 10 Rem/hour. However, to provide guidance to the general licensee during off-normal condition such as crane malfunction, a sample calculation is provided in Appendix W, Chapter W.10. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions. The occupational exposure calculations documented in Chapter W.10 are revised to reflect this modification.

5.24 Clarify whether spraying the TC with water as it is lifted from the pool may be accomplished remotely.

Step 19 of Section W.8.1.2 directs the user to lift the TC from the pool and spray the cask as it is raised from the pool. However, step 18 requires personnel to evacuate the area, due to the high dose rates from the loaded TC. Clarify whether this step may be performed remotely; if so, describe any role of the decontamination area Shielding (describe any spray or other systems built into the decontamination area shielding). If this step may not be performed remotely, revise the worker doses anticipated in section W.10 of the SAR accordingly.

This information is required for compliance with 10 CFR 72.236 and to assure compliance with the worker dose limits in 10 CFR Part 20.

Response to 5.24

UFSAR Appendix W, Section W.8.1.2 is revised to eliminate the spraying of the outside surfaces of the cask as it is raised from the spent fuel pool. Instead any loose contamination from the outside surface of the cask is removed when the cask is in the decontamination area shield. Section W.8.1.2 is revised accordingly.

The occupational exposure calculations documented in Chapter W.10 are revised to reflect this modification.

5.25 Justify the assertions that there are no necessary changes in sections W.8.3, W.8.4, W.8.5, W.8.6, W.8.7, or W.8.8. Additionally, if indeed no changes are necessary, provide clarification as to what is not being changed (e.g., no changes are necessary to SAR section 5.6).

Sections W.8.3, W8.4, W.8.5, W.8.6, W.8.7, and W.8.8 appear to refer to various parts of Section 5, which contains procedures for using a full-weight TC. It appears that there is a need for several changes to these sections to address use of the light-weight TC. For instance, Section W.8.4 appears to refer to Section 5.2 in the SAR. Either Section 5.2 needs to be revised to be consistent with the OS197L, or it needs to refer the reader to section W.8.4 in Appendix W, and that section needs to be revised to contain the appropriate information for the OS197L. Additionally, it seems unlikely that the first frame of the continuation of Figure 5.2-1 on page 5.2-5 is a correct depiction of how the decontamination of the OS197L should be handled. Ensure that any figures that are provided for Section W.8.4 correctly reflect modifications needed due to the high dose rates near the OS197L.

In addition to addressing the discrepancies between Section 5.2 and Section W.8.4, justify that there are no changes needed for Sections W.8.3, W.8.5, W.8.6, W.8.7, and W.8.8. Alternatively, change the appropriate parts of Section 5 to address the operational considerations for the light-weight TC.

If there are truly no changes to any of these sections, clarify what is not being changed so that it is clear to which part of the SAR the reader is being referred (i.e., Section 5 of the base SAR vs. the operating systems section of Appendix M). For example, revise the text in section W.8.8 to read "No change needed from information provided in SAR section 5.6."

This information is necessary for compliance with 10 CFR 72.236(d).

Response to 5.25

The changes to TC operations due to this modification are documented in Chapter W.8. Chapter W.8 is also revised to be consistent with the shielding evaluation documented in Chapter W.5. Additional clarification for documenting the "no change" analysis is provided per the suggestion of the staff.

5.26 Clarify and justify the assumptions supporting the analysis of the representative malfunction scenarios described in section W.10.1.

*Scenario 3 is described as "same as previous with more bounding assumptions for distances." It is unclear if "same as previous" refers to scenario 1 or 2. Additionally, clarify the assumptions used to determine worker dose, including the assumed axial and radial distance of the workers from the transfer cask and the amount of time each worker is assumed to be at each position.

*Clarify the second bullet on p. W.10-2, which states: "These dose rates are conservative for scenario 1 since water is present in the neutron shield and in the DSC." It is more conservative if water is not present in the neutron shield and in the DSC. Furthermore, the operating procedures require draining of some water from the DSC to meet the 75-ton weight requirement. Justify that it is conservative to have modeled water in the neutron shield and the DSC for this scenario.

*Justify the statement "[t]hese three scenarios conservatively bound all other postulated malfunctions involving remote handling equipment..." Specifically, address why the TC in the horizontal position conservatively bounds the scenario where the crane hangs up while the TC is at an angle as it is being lowered onto the transfer trailer.

*Clarify for which scenario the table on p. W.10-3 is applicable. Additionally, clarify what configuration was assumed for determining the radial and axial dose rates in this table. The dose rates presented here seemingly contradict the dose rates presented in section W.5 of the SAR (tables W.5-5, W.5-8, and W.5-9), which state that the radial surface dose rate with water in the neutron shield is 53 rem/hr (versus 0,192 rem/hr reported in section W.10). Section W.5 of the SAR does not provide axial dose rates with water in the neutron shield; however the dose rates in the table on p. W.10-3 do not seem to be supported by the axial dose rates presented in section W.5.

This information is necessary for compliance with 72.236(d).

Response to 5.26

Due to the change in the authorized contents and operational simplification for the OS197L TC, the maximum dose rate on the surface of the bare OS197L TC will remain under 10 Rem/hour. However, to provide guidance to the general licensee during off-normal condition such as crane malfunction, a sample calculation is provided in Appendix W, Chapter W.10. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions. The occupational exposure calculations documented in Chapter W.10 are revised to reflect this modification.

5.27 Justify the method of analysis used to determine the 100-meter dose rate of 144 mrem for the OS197L TC in SAR section W.11 (and also in NUH06L-0501).

Section W.11.1.4 (page W.11-4) states that the 100-meter dose for the OS197L TC was determined assuming that the OS197L TC was loaded with the 32PT DSC. Section W.11.1.4 also states that the 24PHB is expected to result in a higher 100-meter dose rate under accident conditions, based on the fact that the 24 PHS resulted in the highest 100-meter dose rate in the full-weight OS197 TC. Rather than calculating the accident dose rates for the OS197L loaded with the 24PHB, section W.11.1.4 uses ratios to scale the accident dose rates obtained for the OS197L TC loaded with the 32PT in order to obtain the doses that may be expected for the as197L loaded with the 24PHB.
The ratio method scales the dose rates for the OS197L loaded with the 32PT DSC (OS197L-32PT) as follows:

$$\frac{\text{OS197 - 24PI-IJ3 x OS 197L- 32PT}}{\text{UFSAR-32PT}}$$

Justify that this ratio method is appropriate, and be sure to address the different methodologies used to determine the OS197 TC dose rates and the OS197L TC dose rates. Further, discuss the difference in the quality of radiation between the 24 PHB and the 32 DSC. In the 32PT DSC, gamma radiation accounts for 83% of the source term, whereas in the 24PHB DSC, gamma radiation only accounts for 60% of the source term.

This information is necessary to demonstrate compliance with 10 CFR 72.236(d).

Response to 5.27

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5 that considers the bounding dose rate results for the two authorized DSCs – 32PT and 61BT.

The accident dose calculations in Chapter W.11 for the revised contents are directly obtained from the results shown in Chapter W.5.

5.28 Justify assumption 4.5 used to determine worker doses for crane failure in calculation NUH06L-0503.

Assumption 4.5 states that typical distances between the workers and the cask are assumed to be on the order of 10 meters, and that these distances are justified since this represents approximately twice the length of the cask. Explain why the length of the cask impacts the assumption of where the workers may be with respect to the cask.

This information is necessary to demonstrate compliance with 10 CFR 72.236(d).

Response to 5.28

Calculation NUH06L-0503 is revised to provide guidance to the general licensee during off-normal condition such as crane malfunction by including a sample calculation. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions.

5.29 Revise Section 10 of the SAR to include the additional considerations for enhancing radiation protection that are listed in section 6.0 of calculation NUH06L-0503.

The third paragraph of Section 6.0 of calculation NUH06L-0503 states some additional considerations for enhancing radiation protection. This paragraph should be reflected in Section 10 of the SAR, to help ensure that plant personnel take all necessary precautions when using the high-dose rate OS197L TC.

This information is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.29

Calculation NUH06L-0503 is revised to provide guidance to the general licensee during off-normal condition such as crane malfunction by including a sample calculation. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions. Chapter W.10 is revised to include this change and the additional considerations for enhancing radiation protection are included as necessary.

5.30 Justify the use of 50.8 meters for determining at what distance the axial maximum and the averaged value of angular dependent dose rates are equivalent.

In calculation NUH06I-0500, it was determined that there would be no difference between the axial maximum and the averaged value of the angular dependent dose rate distribution at distances greater than 50.8 meters. However, this distance (50.8 meters) was determined based on calculations for Configuration E. Configuration E surface dose rates are more than two orders of magnitude lower than the OS197L surface dose rates. Justify that the dose rate distribution is not angular-dependent at distances greater than 50.8 meters for the OS197L.

This information is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.30

Due to the change in the authorized contents and operational simplification for the OS197L TC, new dose rate and dose rate distributions are determined. The justification for dose rate angular distributions are included in the revised Chapter W.5.

5.31 In Calculation NUH06I-0503, clarify/revise the tables and discussions on pages 17 - 21 relating to scenarios 1 and 2.

The discussions indicate that scenario 2 results in higher doses than scenario 1, but the doses shown in the tables and text do not support this statement (specifically, 970 for scenario 1 is greater than the 956 given for scenario 2). Additionally, provide further explanation for how the backscatter correction factors were chosen. It is not inherently clear that the selected backscatter factors are appropriate. Further, clarify the discussion to expand on the assumptions used for calculating worker doses presented in Tables 5-4, 5-5, and 5-6. It is not clear what assumptions were made regarding the location of the workers, particularly for the steps involving traversing to the crane bridge and to the crane. Provide a fuller explanation of the assumptions used to determine what dose rates the workers were exposed to and for what periods of time.

This information is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.31

Calculation NUH06L-0503 is revised to provide guidance to the general licensee during off-normal condition such as crane malfunction by including a sample calculation. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions.

5.32 Justify the use of Configuration K axial dose rates to estimate Configuration B axial dose rates in Table 9-1 in calculation NUH06L-0504.

Table 9-1 states: "Configuration K dose rates are used because of poor convergence of tallies for top dose rates from Configuration B MCNP model in the current analysis. Such a usage is justified in a discussion of Section 5 suggesting that dose rates on Top of the TC within radial dimensions less than radius of TC are not dependent on shielding configuration types." Section 5 does not readily present an analysis supporting this conclusion, especially for distances greater than 0 from the TC top lid. Justify the use of Configuration K dose rates to determine Configuration B dose rates. If the applicant chooses to continue to make such a substitution rather than improving the MCNP model for Configuration B so that it converges appropriately, further discussion is needed to support the use of this method, especially at distances greater than the TC radius.

This information is needed to ensure compliance with 10 CFR 72.236(d).

Response to 5.32

Due to the change in the authorized contents and operational simplification for the OS197L TC, the use of an interim cask lid is not necessary. The axial dose rates from all configurations are identical and are bounded by those documented for the OS197 TC.

5.33 Revise SAR Appendix W to remove all instances of the statement "currently licensed DSCs."

The NUHOMS® system is quite complex, with several types of DSCs and TC designs. Given the ambiguity in the text regarding the definition of the "OS197 type TC" and the "standard TC," the SAR should clearly state which DSCs the OS197L TC is licensed to transfer. The staff notes in particular that the text on SAR p. W.3-1 should be revised, but emphasizes that the applicant is responsible for identifying other instances of similarly ambiguous text.

This revision is necessary for compliance with the requirements of 10 CFR 72.236.

Response to 5.33

SAR Appendix W (all chapters) is revised to delete the statement "currently licensed DSCs" and replace these words with 61BT and 32PT DSC models instead. The Technical Specification 4.4 is also revised accordingly.

5.34 Clarify the discussion in the second paragraph of Section W.5.4.8.3.

It is not clear from this discussion that the neutron streaming through the seams of the OS197L neutron shield is adequately analyzed. The discussion seemingly refers to a model that utilizes temporary shielding in addition to the OS197L TC. Clarify the configuration that was modeled to determine the increased neutron dose through the seams of the neutron shield.

This information is necessary to verify compliance with 10 CFR 72.236(d).

Response to 5.34

The weld seam region actually represent areas of dose depression where there is a reduction in the neutron and gamma dose rates. The discussion in Section W.5.4.8.3 is modified to provide the

necessary clarification for the models employed to determine the dose rates on the cask surface including dose rates in the vicinity of the weld seams.

The following RAIs reflect staff Quality Assurance concerns and questions.

5.35 Provide suggested text to revise TS 5.2.4 to address the following:

Revise 5.2.4a2 to indicate that the dose rates to be included are those on the surface, at the controlled area boundary, and in the most affected unrestricted area (if any). These values are needed to evaluate the impact on 10 CFR 72,104 and 10 CFR 20.1301 (a)(2) dose limits.

This revision is necessary to ensure compliance with 10 CPR 72.236.

Response to 5.35

Technical Specification 5.2.4A is revised based on responses to other RAIs discussed previously. Due to the change in the authorized contents and operational simplification for the OS197L TC, the maximum dose rate on the surface of the bare OS197L TC will remain under 10 Rem/hour. Therefore, TN believes that Technical Specification 5.2.4A is now consistent with the Staff expectations.

5.36 Revise SAR section 3.1.2.1 to include the remote handling and optical targeting system equipment in the first paragraph, which describes equipment required to implement the NUHOMS® system. Additionally, Table 3.1-7 should be revised as necessary.

While it is stated later in this section that the OS197L TC is described in detail in Appendix W, the opening paragraph in this section is generic to the NUHOMS® system. This paragraph should be revised to either address that additional handling and transfer equipment for the OS197L TC is discussed in Appendix W, or to mention the remote handling and laser/optical targeting system required for safe use of the OS197L TC. This revision is necessary to satisfy the requirements of 10 CFR 72.236(d).

Response to 5.36

SAR Section 3.1.2.1 is revised to address the important differences for the OS197L TC design consistent with the revised Appendix W.

5.37 Revise SAR Section 4.2.3.3 to address the following:

*Clarify that for the OS197L TC, the principal biological shielding is provided by the supplemental shielding used in the decontamination area and on the transfer trailer, Section 4.2.3.3 of the SAR states: "The transfer cask provides the principal biological shielding and heat rejection mechanism for the DSC and SFAs during handling in the fuel/reactor building..."This statement is not true for the OS197L TC, which requires the use of remote operations and supplemental shielding to provide sufficient biological shielding for safe handling. This statement needs to be revised to accurately reflect all the TCs included in the NUHOMS® system.

*Clarify the various terms used for the TC. SAR section 4.2.3.3 refers to the "NUHOMS® TC" the "standardized TC," and the "OS197," It is not clear what is meant by the various terms; they seem to be used interchangeably for the same

TC, but it is not evident that such an interpretation of the terms is valid.

*Revise the first sentence in the third paragraph of SAR section 4.2.3.3 to clarify that the OS197L is not documented in Appendix E, but is described in Appendix W.

*Revise the third paragraph on p. 4.2-10 in SAR section 4.2.3.3 to also discuss that remote operations and a laser/optical targeting system are used in conjunction with supplemental shielding to compensate for the lack of lead shielding. This revision is necessary to satisfy the requirements of 10 CFR 72.236(d).

Response to 5.37

SAR Section 4.2.3.3 is revised to address the important differences for the OS197L TC design consistent with the revised Appendix W.

5.38 Revise SAR section 4.7.3.2 to clarify the following:

*On p. 4.7-5. clarify what is meant by the "typical transfer cask." Additionally, clarify what specific TC designs are encompassed by the "standardized/OS197 type casks." Revise the text to clarify that the OS197L TC, despite what its name may indicate, is not the "typical" TC as it provides much less radiological shielding and requires the use of remote handling equipment and supplemental shielding for safe operations, Make this revision in any other applicable place in the SAR, e.g., p. 4.2-9 refers to the "OS197 type cask" and the "standardized cask."

*On p. 4.7-5, revise the text to state that the OS197L TC does not contain any lead shielding. Section 4.7.3.2 describes the "standardized/OS197 type casks" as steel-lead-steel designs. This section then describes the OS197L TC but does not mention that the lead shielding is removed.

*Revise the text at the bottom of page 4.7-6 that states, "The transfer cask is designed to provide adequate shielding to maintain the maximum radiation surface dose to less than 5 R/hr combined gamma and neutron for a cask drop accident event assuming a complete loss of neutron shielding" This statement is not true for the OS197L TC, which has a surface dose rate exceeding 100 rem/hr for the complete loss of neutron shielding event. Additionally, to be accurate, the dose rate described should be in rem per hour, not R per hour.

These revisions are necessary to satisfy the requirements of 10 CFR 72.236(d).

Response to 5.38

SAR Section 4.7.3.2 is revised to address the important differences for the OS197L TC design consistent with the analysis documented in the revised Appendix W, Section W.5.

5.39 Revise SAR Section 7.1.2 (specifically items C and D) so it appropriately accounts for the OS197L TC.

Items C and D have not been revised to reflect the significant differences between the OS197 and 08197L TCs. The OS197L transfer cask is not heavily shielded, as item C describes the transfer cask to be. Additionally, the fuel loading procedures are unique for the OS197L TC, which requires item D to be revised accordingly to accurately describe the NUHOMS® system.

These revisions are necessary to satisfy the requirements of 10 CFR 72.236(d).

Response to 5.39

SAR Section 7.1.2 items C and D are revised to address the important differences for the OS197L TC design consistent with the revised Appendix W.

5.40 Correct the apparent discrepancies in SAR section 10:

*Table 10-2 states that the bases for TS 5,2.4e are located in B 10.5.2.4e. While this part of the bases does address TS 5.2.4e, the transfer cask dose rate evaluation program is also discussed in bases B 10.5.3.4. However, TS 5.3.4 discusses the supplemental shielding drop onto the OS197L TC. It does not appear that bases exist for TS 5.3.4.

*Bases B 10.5.3.4 discusses the transfer cask dose rate evaluation program. TS 5.2.4e provides transfer cask dose rates for the OS197L TC. These dose rates are discussed in Appendix W. However, B 10.5.3.4 does not list Appendix W.

*Add Appendix W to the list of bases in SAR section 10.

Correction of these apparent discrepancies is necessary for compliance with the requirements of 10 CFR 72.236(d).

Response to 5.40

The bases for TS 5.3.4 has been changed to address TS 5.3.4, "Supplemental Shielding Drop onto OS197L TC." It no longer contains a listing and therefore Appendix W is not added to any list in this particular bases. The bases for TS 5.2.4.e, "Transfer Cask Dose Rates," previously included mention of Appendix W in a listing, and continues to do so.

5.41 Clarify the assumptions used to determine the dose rates presented in the tables in Section W.5 of the SAR, and revise Section W.1 to include a drawing of the interim top cask cover.

*Clarify the assumed thickness and material used to model the interim top cask cover. Section W.3.9 states that the interim top cask cover is a 1-inch-thick aluminum plate. Sections W.5.4.6.2 and W.5.4.10.4 state that the interim top cask cover was modeled as a 2-inch-thick aluminum plate, Figure W.5-5 on p. W.5-30 shows that the interim cask lid is 1.5 inches thick, Figure W.5-5 on p. W.5-31 shows that the interim cask lid is stainless steel, and implies that the modeled thickness was 2 inches. Correct the text and figures as necessary to clarify what thickness (1, 1.5, or 2 inches) was actually modeled, as well as what material (aluminum or steel).

This information is necessary to ensure compliance with 10 CFR 72.236.

Response to 5.41

Due to the change in the authorized contents and operational simplification for the OS197L TC, the use of the interim cask cover is no longer necessary for the OS197L TC. Appendix W of the SAR is revised to include this change.

5.42 Clarify and explain apparent discrepancies in the tables in Section W.5.

*Clarify whether the dose rates listed for the OS197L TC were calculated assuming that the interim (aluminum) cask lid was installed in Table W.5-2.

*Clarify in Table W.5-2 that the dose rates listed occur under normal conditions for when the OS197L TC, loaded with the 32PT DSC, is moved from the decontamination area to the transfer trailer.

*Explain the apparent discrepancies between the dose rates reported in Table W.5-7 and the dose rates listed in Tables W.5-5 and W.5-6. The radial surface dose rates listed for the bare as197L TC (with and without water in the neutron shield) are significantly lower than the radial surface dose rates listed in Tables W.5-5 and W.5-6. Justify why there is such a large difference in these dose rates. Additionally, clarify what dose rates were used in the worker dose assessment in SAR section 10.

*Discuss the distinction between the "absolute maximum" and the "maximum" radial positions/dose rates listed in Table W.5-8.

*Clarify the location of the dose rates listed in Tables W.5-12, W.5-13, and W.5-14. This information is required for compliance with 10 CFR 72.236(d).

Response to 5.42

Due to the change in the authorized contents and operational simplification for the OS197L TC, new dose rate and dose rate distributions are determined. The clarifications and justifications for dose rate angular distributions and the apparent discrepancies currently reported in the SAR are included in the revised Chapter W.5.

5.43 Correct the text in Technical Specification 5.2.4 and in Sections W.8.1.2 and W.8.1.5 so that both remote operations and other mitigating ALARA practices are required.

The use of remote operations is required by Technical Specification 4.4.3, which states "The bare OS197L (Light Weight, 75 ton Version) TC shall be handled using remote operations... " Technical Specification 5.2.4 and Sections W.8.1.2 and W.8.1.5 state:
"Licensee [sic] shall use remote operations or other mitigating ALARA practices... "
Revise the text to change the "or" to "and," such that the use of remote operations is not optional, and to avoid non-compliance with Technical Specification 4.4.3. Remote operations are essential for keeping doses to an acceptable level when using the OS197L TC, and are required per the technical specifications.

Ensure that this revision is made in any other sections of the SAR, CoC, and TS, as necessary.

This revision is necessary for compliance with 10 CFR 72.236(d).

Response to 5.43

Technical Specification 5.2.4 is revised as suggested (see the response to RAI 5.8). Appendix W.8 is revised to be consistent with revised Technical Specification 5.2.4.

5.44 Clarify and make any necessary corrections to sections W.8.1.2 and W.8.1.6:

*Step 21 of Section W.8.1.2 (page W.8-17) states, "Placement of the shielding bell shall be periodically (every hour) performed ... " (Emphasis added.) It seems unlikely that the shielding bell needs to be placed more than once, so it seems that some text may have been omitted, or otherwise incorrectly edited.

*Step 20 of section W.8.1.6 (page W.8-27) states, "Install the DSC axial in retainer through the HSM door opening." It appears that extra text has been added or text has been incorrectly edited.

These revisions are necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.44

The affected sentence of Step 21 (now Step 19) of Section W.8.1.2 has been revised to say that the "Placement of the shielding bell shall be performed in accordance with the plant's heavy load procedures."

Step 20 of Section W.8.1.6 has been revised to say "Install the DSC axial retainer through the HSM opening."

5.45 Clarify, by revising the drawing of the decon area cask shielding assemblies and/or the steps in section W.8.1.3, how the decontamination and evaluation of contamination levels can be accomplished.

Step 1 of Section W.8.1.3 refers to the DSC removable contamination limits in TS 5.2.4d. This is being applied to the TC. It is not clear to staff how either the decontamination or surveys will be accomplished with the TC and DSC inside the supplemental shielding.

Step 4 of Section W.8.1.3 refers to the exposed surfaces of the DSC shell. It is not clear to staff what surfaces of the DSC Shell will be exposed and how either the decontamination will be accomplished or the TC/DSC annulus seal removed with the TC and DSC inside the supplemental shielding.

This revision is necessary for compliance with 10 CFR 72.236(d).

Response to 5.45

SAR Chapter W.8 is revised to add additional clarifications and correct discrepancies for the decontamination of the DSC and TC surfaces and for the evaluation of the contamination levels.

5.46 Clarify and justify the assumptions supporting the analysis of the representative malfunction scenarios described in section W.10.1.

This information is necessary for compliance With 10 CFR 72.236(d).

Response to 5.46

Due to the change in the authorized contents and operational simplification for the OS197L TC, the maximum dose rate on the surface of the bare OS197L TC will remain under 10 Rem/hour. However, to provide guidance to the general licensee during off-normal condition such as crane malfunction, a sample calculation is provided in Appendix W, Chapter W.10. This sample calculation can be used as a guidance to evaluate the occupational exposure to recover from off-normal crane malfunction event based on the site specific conditions. The occupational exposure calculations documented in Chapter W.10 are revised to reflect this modification.

5.47 Revise the wording on Page W.11-3 as originally requested in RAI 5-54 (of the first round of RAIs) to indicate that the total dose at 100 meters is at the controlled area boundary, not the "site boundary" Note that this was corrected in the first instance where it appeared, but not the second.

Page W.11-3 reports the total dose at the "site boundary," which is a term defined in 10 CFR Part 20 and is not necessarily the same as the controlled area boundary, which is defined in 10 CFR Part 72.

This information is required to comply with 10 CFR 72.236(d).

Response to 5.47

The wording on Page W.11-3 is revised as suggested.

5.48 Clarify/justify the values in the tables in calculation NUH06L-0504 and include discussion as appropriate in SAR section W.5, especially as pertains to the tables.

*Explain the apparent discrepancy between the total dose rate values and the gamma plus neutron dose rates. In several of the tables in this calculation, the value given for total radiation dose rate is not equal to the sum of the gamma plus neutron dose rates.

*Explain the apparent discrepancy in the relative errors for the total dose rate values. The value for the relative error of the total dose rate is often less than the value of one or both of the relative errors that were presumably used in its calculation.

This information is necessary to ensure compliance with 10 CFR 72.236(d).

Response to 5.48

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The reporting of dose rates includes clarification for the apparent discrepancies as noted by the staff.

5.49 Provide clarification regarding the response to (original) RAI 5-16.

*Explain the apparent discrepancy regarding the rejection of a three shell (steel, lead, steel) configuration. This is precisely the construction of the standard OS197 transfer cask. The response to RAI 5-16, as well as calculation NUH06L-0501, stated, "... use of a three shell configuration (inner, lead and outer) results in the degradation of the thermal performance of the TC due to introduction of additional thermal resistance... " The OS197 TC is a three shell configuration (steel-lead-steel), and is used for the same DSCs that are proposed for use in the OS197L TC. Why is the three-shell configuration problematic for the OS197L with respect to thermal performance, but not for the OS197?

*Explain the apparent discrepancy regarding the weight of Configuration C. The response to RAI 5-16 states that Configuration C did not meet the 75 ton weight requirement. However, calculation NUH06L-0500 indicates that Configuration C is within the 75-ton weight limit. Calculation NUH06L-0501 states that Configuration C was not considered because the design did not meet structural performance requirements, and does not mention weight as a concern. Clarify the apparent discrepancies between the statements in the response to RAI 5-16 and the statements in calculations NUH06L-0500 and NUH06L-0501.

This information is needed to verify compliance with 10 CFR 72.236(d).

Response to 5.49

The degradation of the thermal performance discussed in RAI 5-16 is specific to the OS197L TC and considers the relative differences between the 2 and 3-shell configurations.

The various configurations evaluated in NUH06L-0500 provided a sensitivity evaluation of the effect of cask radial shielding design on the dose rates – no attempt was made to determine the exact thickness of the radial shielding. The ALARA evaluation discussed in the original RAI 5.16 provided the basis for the selection of the current design of the OS197L TC to meet all the design objectives including weight considerations.

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The ALARA evaluation is revised to clarify the apparent discrepancies identified by the staff and to include the basis for the reduction of the radiological source term that resulted in the dose rate reduction.

The following RAIs are editorial.

5.50 Correct the typo in TS 5.2Ae: "TRANSFER CASK (TC)" should be "TRANSFER... "

Response to 5.50

The typo in TS 5.2.4e has been corrected.

5-51 Correct the typo in TS 5.304: "damaged" should be "damage".

Response to 5.51

The typo in TS 5.3.4 has been corrected.

5-52 Revise section 5 of the SAR to add a statement at the beginning of the section indicating that the operating procedures for the OS197L TC are in Appendix W.

The text is not currently clear in that the operating procedures for use of the OS197L TC are significantly different and are captured in Appendix W of the SAR. It is necessary to be as clear as possible with regards to the operating procedures to avoid human error, especially when dealing with such a high dose rate TC as is the OS197L.

Response to 5.52

A statement at the beginning of the section as suggested by the staff is included in the revised Chapter 5.

5-53 Correct the apparent typo in B 10.5.2.4a: 10 CFR 72.21.2(b)(2)(i)(C) should be 10 CFR 72.212(b)(2)(i)(C).

Response to 5.53

TS Bases B.10.5.2.4a has been corrected.

5-54 Correct the apparent typo on drawing number NUH-03-8012.

Note 9 on drawing NUH-03-8012 refers to the "DEACON AREA SHIELDING." The staff believes this should be the "DECON AREA SHIELDING."

Response to 5.54

Drawing NUH-03-8012, Note 9 typo has been corrected.

5-55 Correct several typos in SAR section W.5. Please note that while the staff has identified several typos, the applicant should ensure that any typos the staff has not specifically identified should also be corrected.

*In the second paragraph of section W.5, the staff believes that the 61BT and 52B DSCs referred to should be the 61BTH and the 32PTH DSCs.

*In section W.5.1, correct the statement: "A brief description of the various Shielding configurations evaluated herein in provided in Figure W.5-1..." (Emphasis added).

*In section W.5.2.1, correct the statement: 'The results of the ANISN evaluation demonstrate that the dose rates on an around the OS19L... " (Emphasis added).

*Correct the various instances of: "OS19L" (pp. W.5-2. W.5-6, W.5-8, W.5-9) and "OS19lL" (p. W.5-6).

*In Section W.5.4.8.1, p. W.5-9, the staff believes that the reference to "Section W.5.4.7.2" should be a reference to Section W.5.4.8.2, and that the reference to "Section W.5A.7.3" should be a reference to Section W.5.4.8.3.

*In Section W.5.4.10.1, p. W.5-12, the third sentence states: "The DSC cavity contains water..." The staff believes that this should state that the DSC cavity does not contain water.

*In Section W.5.4.10A, revise the following sentence so that it is grammatically correct: "During this operation, the TC neutron shield is empty and a temporary 2" aluminum cask lid consisting is utilized for weight management." (Emphasis added.)

Response to 5.55

Due to the change in the authorized contents and operational simplification for the OS197L TC, a new shielding evaluation is documented in Chapter W.5. The revised Chapter W.5 is reviewed for elimination of typos and editorial inconsistencies.

5-56 Correct the typo in step 14 of Section W.8.1.5 (page W.8-25), where the user is directed to check for "streaming" rather than "steaming." Additionally, correct any other instances of this typo.

Response to 5.56

Step 14 (now Step 11) of Section W.8.1.5 (page W.8-25) has been corrected to replace "streaming" with "steaming".

5-57 Correct the apparent typo in step 19 of section W.8.1.3.
Step 19 of Section W.8.1.3 refers to the TC dose rates in TS 5.3.4e. There is no TS 5.3.4e. The staff believes that step 19 should refer to TS 5.2.4e, which contains TC dose rates.

Response to 5.57

Step 19 (now Step 17), SAR Section W.8.1.3, has been revised to correct the typo by replacing TS 5.3.4e with 5.2.4e.

5-58 Correct the typo on the Second line at the top of p. W.10-2: "bar" should be "bare."

Response to 5.58

The phrase is no longer in W.10.

CHAPTER 7 Materials Evaluation

7.1 Add footnotes requiring testing of the boron content, similar to Current footnotes (2) and (3), to the other models in the table in Section 4.1 of Amendment 11.

The boron in the plates is used for criticality control. Inadequate boron in the plates could allow unexpected criticality to occur.

This information is needed to verify compliance with 10 CFR part 72.124 (b) Criteria for nuclear criticality safety.

Response to 7.1

Section 4.1 has been revised to add the footnotes requiring testing of the boron content for the 61BT, 32PT, 24PTH, 61BTH and 32PTH1 DSCs.

7.2 Modify SAR Section 5.1.1.9 to describe the operations and condition limitations that are necessary to prevent oxidation of the fuel during dry cell loading. Any limitations to prevent oxidation during unloading should be included by reference in the Technical Specifications.

Section 5.1.1.9 of the SAR suggests the possibility of unloading operations outside of a spent fuel pool (i.e., in a dry cell). The proposed operations descriptions are the same as for wet unloading in a spent fuel pool except for the removal of operations involving filling and draining the MPC with water. However, the operations overlook the prevention of fuel oxidation, a critical issue when spent fuel is exposed to an oxidizing gaseous atmosphere. The concerns expressed for fuel oxidation during loading in Interim Staff Guidance (ISG) No. 22, "Potential Rod Splitting Due To Exposure To An Oxidizing Atmosphere During Short-Term Loading Operations In LWR Or Other Uranium Oxide Based Fuel," also hold for unloading. ISG-22 discusses fuel oxidation, the conditions for which it can occur and means for its prevention. As stated in ISG-22, fuel oxidation can result in gross cladding breaches and create shielding, criticality and fuel dispersal concerns. The ISG further indicates that the oxidation concern extends to intact fuel as well, since intact fuel may have pinhole leaks and hairline cracks, which provide a path for the loading atmosphere to reach the fuel.

The applicant should provide a description of the essential operations and condition limitations through which fuel oxidation is prevented in Section 5.1.1.9 of the SAR. One way to prevent fuel oxidation is to limit dry cell unloading to only that fuel which is known to have no breaches (including pinhole leaks and hairline cracks). This limitation will necessitate the use of an appropriate method to ensure to a high level of confidence that a fuel assembly does not have any cladding breaches. As stated previously, the staff believes 4-sided visual inspections of an assembly, alone, are insufficient to provide the necessary confirmation. Methods such as sipping, ultrasonic testing, and a review of reactor records can provide the necessary level of confidence.

For dry unloading of fuel containing cladding breaches, 138-22 provides possible options to control and/or prevent fuel oxidation. One of these is to maintain the fuel rods in an inert environment. In developing the necessary operations and limitations, the applicant will need to consider impacts on other areas such as contamination control.

Note that if any discussion on unloading is added to appendix W it would also have to address the issue in this RAI.

This information is needed to confirm compliance with 10 CFR 72.236(h) and 72.236(1).

Response to 7.2

TS 5.1.1 is revised to include the following:

"During unloading of fuel from the DSC, appropriate precautions shall be taken to limit the oxidation of the fuel. The recommendations of ISG-22, Revision 0 can be used as a guideline to address fuel oxidation concerns."

Section 5.1.1.9 of the UFSAR is also revised to adequately address this issue.

List of Additional Changes, Not Associated with the RAI

	Additional Change	Reason for the Change
1	Note 1 in Technical Specification Table 1-1d for 61BT and Table 1-1u for the 61BTH is changed from "Any fuel channel thickness from 0.065 to 0.120 inch is acceptable on any of the fuel designs." to "Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs."	The analysis is based on average fuel channel thickness. This clarification will allow the TS to be consistent with the analysis and provide for verbatim compliance with the TS without causing any need for interpretation.
2	Technical Specification Table 1-1l for 24PTH DSC, first bullet for the Control Components (CCs) is revised to add 24PTH-S DSC also.	This change is made to be consistent with the analysis and it was an oversight in the original submittal.
3	Technical Specification 4.2.4, ASME Code Alternatives, is revised to add the provision of requesting an exemption in accordance with 10 CFR 72.4.	This change is consistent with current NRC practice for ASME Code Alternatives and was inadvertently left out in the previous submittal.
4	Technical Specification 4.1, Canister Criticality Control, is revised to add the provision of requesting approval of exemptions in accordance with 10 CFR 72.4.	This change is consistent with the current NRC practice for ASME Code Alternatives (NUREG-1745 Page 30 of 32) and satisfies the staff expectation that any deviations from the critical parameters of Acceptance Testing would need staff review and concurrence. The change will provide for one-time requests to allow for fabrication nonconformances only, and is not a request for changes to any criteria or specifications important to safety in the TS.
5	Technical Specification 4.2.1 is revised to clarify the requirement of copper content for the DSC support structure for ISFSIs located in coastal salt water marine atmosphere. Specifically "For weld filler material used with carbon steel, 1% or more nickel bearing weld material would also be acceptable in lieu of 0.20% copper content."	This change is requested because nickel bearing weld material is available in more forms than the copper-bearing weld material and weld filler material with 1% or more nickel would have salt corrosion resistance equal to or better than weld material with 0.2% copper. The following reference evaluates corrosion resistance testing of steels with various amounts of copper, nickel, chromium, silicon, and phosphorus. It shows that 1% nickel with only residual amounts of the other elements corroded 9.6 mils in 15.5 years at Kure Beach, compared to 11.2 mils for 0.24% copper, with residual amounts of the other elements. Larrabee, C. P. and Coburn, S. K. (1962). "The Atmospheric Corrosion of Steels as Influenced by Changes in Chemical Composition." Proceeding of First International Congress on Metallic Corrosion, Butterworths, London, pages 276-285. (included herein as Enclosure 4)

	Additional Change	Reason for the Change
6	TS Tables 1-3a through 1-3h refer to Page A-71; they are revised to correct this typo, as follows: "The page that follows Table 1-3h provides . . "	"Page A-71" is a remnant from the Amendment 10 TS, and other similar table sets use this new approach for identifying the location of the table notes.
7	The headers and sub headers from Tech Spec Pages 3-9 to 3-12 are revised to correct the section number to be consistent with other sections.	Consistency with other sections and the format shown in NUREG-1745.
8	TS 5.2.4.e, changed to correct a typo "as soon possible" to "as soon as possible"	Editorial correction.
9	TS and UFSAR code exceptions table entries for NCA-1140 have the phrase "so long the materials meet all" is changed to "so long as the materials meet all". This change is made to UFSAR Tables 4.8-1 and 4.8-2 and to every NCA-1140 line item in TS 4.2.4.	Editorial correction.
10	In TS Table 1-1g, the 20 Poison Plate columns are removed. This table was also changed in pending Amendment 10 and has been kept consistent in the Amendment 11 TS. Accordingly, UFSAR Tables M.2-3 and M.6-1 and SAR drawing NUH-32PT-1004-SAR are changed, consistent with both amendments, and included herein.	The 20 Poison Plate option for the 32PT basket will no longer be offered.
11	Use of the term "(continued)" at the top and bottom of certain technical specifications pages is changed to match the NUREG-1745 format.	To match the NUREG-1745 format.
12	In TS 5.2.6, the phrase "remains below the flammability limit" is changed to "remains below the flammability limit of 4%".	Staff recently requested this change in an identical TS associated with CoC 1030 Amendment 1.

The Atmospheric Corrosion of Steels as Influenced by Changes in Chemical Composition

C. P. LARRABEE and S. K. COBURN

The method used for testing steels in the atmosphere is described and the types and relative corrosivity of different atmospheres compared. The results of long-time-exposure tests are plotted to show the shapes of time–corrosion curves of steels with varying corrosion resistances.

The effect on corrosion resistance of steels having variations in chromium, copper, nickel, phosphorus and silicon is given for each element and when present in certain combinations. Data are taken from individual 15-year tests in industrial, semi-rural and marine atmospheres. Two hundred and seventy steels with three variations of chromium content, five of copper, two of nickel, three of phosphorus and three of silicon were tested.

Introduction

The earliest extensive atmospheric-exposure tests of various ferrous materials were those started in 1916 by the American Society for Testing Materials (ASTM). Two hundred and sixty corrugated sheets—either 0·032 in. or 0·064 in. thick—of open-hearth irons, hand-puddled wrought irons, both basic and acid open-hearth steels, and bessemer steels were exposed at each of three atmospheric-test locations. The above types of steels had copper contents varying between 0·02 and 0·5 per cent. Visible perforation was considered to be the sign of failure. The more copper the materials contained, the longer was the 'life' of the materials. The higher phosphorus content of the copper-containing acid open-hearth and also bessemer steels contributed to corrosion resistance. A final report of this investigation has been given[1]. After this investigation, nothing more was done on the subject in the United States until in 1929, when work was started that resulted in the commercial introduction, in 1933–5, of high-strength, low-alloy steels. Early claims for these materials stated that they had four to six times the corrosion resistance of carbon steel. This ratio has been fully substantiated by later work.

Since the introduction in 1933 of USS Cor-Ten high-strength low-alloy steel (a product of the United States Steel Corporation), extensive atmospheric testing of hundreds of different experimental compositions has been conducted. The results of 15·5-year atmospheric exposures of 270 different steels in three atmospheres are discussed here.

Test Conditions

Because several years of exposure are necessary before perforation data are available in the ASTM tests, the authors used loss-of-weight methods in the present investigation. Pickled specimens, usually 4 × 6 in. for convenience in weighing, were supported on porcelain insulators mounted on metal frames placed at 30 degrees to the horizontal, facing south (an angle and direction of exposure used by the ASTM). For steel specimens thus exposed in industrial and semi-rural atmospheres, the ratio of the weight losses of the skyward surface to the groundward surface has been shown[2] to be about 38 to 62. The involved test sites in the present discussion are industrial: Kearny, New Jersey (5 miles west of lower Manhattan in New York City); semi-rural: South Bend, Pennsylvania (36 miles north-east of Pittsburgh, Pennsylvania); and marine: Kure Beach, North Carolina (800 feet from the ocean surf). The corrosivity of these sites, and that of the rural site at State College, Pennsylvania (used as a basis of comparison), as measured by specimens of steel and of zinc, has been determined[3] and is shown in Table 1. Note that with longer exposure, the relative corrosivity for steel increases at Kure Beach and decreases at Kearny; whereas for zinc the opposite is true. The explanation for the Kure Beach results lies in (1) the increase with time of the corrosion rate of steel caused by the accumulation of sea salt on the groundward side of the steel specimens and (2) the development of a protective film of corrosion product on the zinc specimens in marine atmosphere. The prevailing wind at this site is off-shore except during storms.

Table 1

Relative corrosivity of atmosphere at three test sites, with those at State College, Pennsylvania, as unity*

	Steel Exposed for Periods of				*Zinc Exposed for Periods of*			
	1 yr	*2 yr*	*4 yr*	*8 yr*	*1 yr*	*2 yr*	*4 yr*	*8 yr*
State College, Pa. (Rural)	1·0 (8)	1·0 (7)	1·0 (5)	1·0 (1)	1·0 (8)	1·0 (7)	1·0 (5)	1·0 (1)
South Bend, Pa. (Semi-rural)	1·5 (8)	1·5 (7)	1·6 (5)	1·7 (1)	1·5 (8)	1·6 (7)	1·7 (5)	1·8 (1)
Kure Beach, N.C. (Marine)	2·0 (8)	2·5 (7)	3·5 (4)	5·8 (1–5 yr)	1·7 (8)	1·4 (7)	1·2 (5)	1·1 (1)
Kearny, N.J. (Industrial)	3·3 (8)	2·7 (7)	2·5 (5)	2·6 (1)	2·6 (8)	3·1 (7)	3·8 (5)	4·2 (1)

Note: A numeral in ( ) indicates the number of such successive test periods.
*From Report of Committee B-3, *Proceedings, ASTM*, 1959, 59, 200.

In the industrial atmosphere (Kearny) and the semi-rural atmosphere (South Bend), the rust films on steel become relatively more protective with time than they do in the marine atmosphere, but for zinc the corrosion rate increases with time.

Time–Corrosion Curves

The protective nature of the rust films that develop on steels, particularly in industrial atmospheres, has been thoroughly discussed elsewhere[4,5]. The relative protective nature of the rust films on three steels is shown in *Figure 1* with the compositions of the materials in Table 2. It has been calculated that the average corrosion rate on the skyward side of these steels between the third and twentieth year of exposure was 0·018 mil/year for the early Cor-Ten steel, 0·223 mil/year for structural copper steel, and 0·383 mil/year for structural carbon steel. The rates on the groundward surface were 1·5 times as much. The data in *Figure 1* also show that atmospheric corrosion is a function of the composition and not the thickness of the steel.

Note in *Figure 1* that the corrosion of the early Cor-Ten steel, copper steel and carbon steel was essentially linear, after 1, 3 and 5 years, respectively. If the attack had continued to progress at the first-year rate, the losses of thickness after 20 years would have been 26 mil for the early Cor-Ten steel, 48 for structural copper steel, and 94 mil for structural carbon steel instead of the losses of 2·2, 7·0 and 13·0 mil, respectively, as actually calculated from losses of weight.

Table 2

Compositions and losses of thickness of steels in *Figure 1*

Material Identification	*Composition, per cent*								*Losses of Thickness Calculated from Losses of Weight, years*									
	C	Mn	P	S	Si	Cu	Ni	Cr	*0·5†*	*1·0**	*1·5†*	*2·5**	*3·5†*	*5·0**	*7·5†*	*10·0**	*15·5†*	*20·0**
Structural carbon steel	0·17	0·57	0·019	0·05	0·043	0·05	0·02	0·02		4·7		6·3		7·9		9·8		13·0
Structural copper steel	0·18	0·49	0·024	0·034	0·025	0·32	0·02	0·02		2·4		3·1		3·8		5·0		7·0
Early Cor-Ten steel	0·09	0·30	0·16	0·035	0·93	0·42	0·03	1·1		1·3		1·4		1·6		1·8		2·2
Later Cor-Ten steel	0·06	0·48	0·11	0·030	0·54	0·41	0·51	1·0	1·1		1·2		1·4		1·6		1·2	

*Average of specimens of different thicknesses. Range of losses shown in *Figure 1*.
†Test started 5 years later than other.

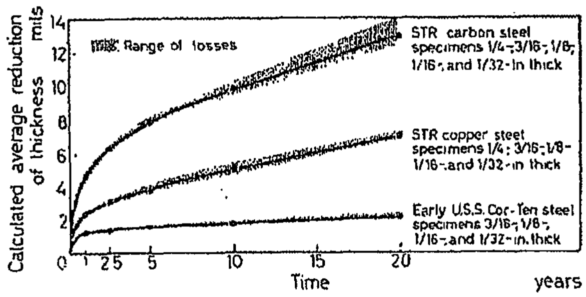


Figure 1. Comparative corrosion of steels of varying thicknesses, industrial atmosphere, Kearny, New Jersey. (1 ft. square specimens)

The average calculated loss in thickness of the early Cor-Ten steel specimens after 2·5 years (*Figure 1*) was 1·4 mil. Because the corrosion rate was so low thereafter (0·018 mil/year), there appears to be a limit to the amount of alloying elements that, added to a steel, further improve its atmospheric-corrosion resistance. This is borne out by the fact that in the test discussed later, a Cor-Ten steel of approximately the presently produced composition and having somewhat different alloy content than the early Cor-Ten gave losses that lie within the band of losses for the four different thicknesses of the early Cor-Ten steel shown in *Figure 1*. This is evident from the data in Table 2. The authors have postulated that the amount of alloying elements necessary to give a calculated average loss of 2 to 3 mil in 15 years in a given atmosphere would be sufficient to give an unpainted structure of that steel, having a minimum thickness of $\frac{3}{16}$ in., almost an 'indefinite' service life if it were boldly exposed in that particular atmosphere. A minimum loss of about that thickness (1 mil on each surface) is necessary to supply the iron which is converted into the very protective rust film.

Experimental Work

The 270 experimental steels, identified in Table 3, were made in a 30-lb. high-frequency furnace and cast into 1 × 6 × 12 in. slabs. All the melts were deoxidized with aluminium before alloying elements were added. The slabs were reheated and cross-rolled to about a ⅛-in. thickness, normalized at 1,850°F, and pickled. The sheets were sheared into 4 × 6 in. pieces and weighed; these were exposed in October and November of 1942. All the specimens at each location were placed on the racks during the same day, because previous work had shown[6,7] that the weather conditions which exist immediately after metals are exposed have a considerable influence on subsequent corrosion losses.

A specimen of each steel was removed after 0·5, 1·5, 3·5, 7·5 and 15·5 years except at South Bend where there were no 0·5- or 1·5-year removals. The rusted specimens were cleaned in a molten bath of sodium hydroxide containing 1 to 2 per cent of sodium hydride, and reweighed. Cleaned specimens were not re-exposed. Table 3 gives the results of the 15·5-year removals.

Discussion

Figure 1 shows that the slope of a time–corrosion curve after 5 years can be used as a good indication of the corrosion resistance of a steel in that particular atmosphere: the flatter the curve, the smaller the loss. Because the slope of the curve from 5·0 to 15·5 years is a function of the 15·5-year loss, only the latter figures are presented in Table 3. To make Table 3 easy to study, unessential data are omitted. The exact analyses for the elements unintentionally varied: carbon, manganese and sulphur, the limits of which are shown in a footnote to the table, are not given. When an element was not intentionally added to a particular heat, the composition in Table 3 is shown as *R* (residual); the limits of these residuals are also shown in a footnote.

Table 3

Corrosion data from three test sites

Material Identification	Composition, per cent*					Average Reduction of Thickness, mils†		
						Kearny, N.J.	South Bend, Pa.	Kure Beach, N.C.
	Cu	Ni	Cr	Si	P	15·5 yr	15·5 yr	15·5 yr
1	0·012	R‡	R‡	R‡	R‡	28·8§	12·3	52·0§
2	0·040	R	R	R	R	8·8	7·9	14·3
3	0·10	R	R	R	R	7·9	7·8	12·0
4	0·24	R	R	R	R	6·1	6·4	11·2
5	0·45	R	R	R	R	5·3	6·0	10·4
6	0·008	1·0	R	R	R	6·1	5·2	9·6
7	0·05	1·0	R	R	R	5·5	5·1	9·0
8	0·11	1·0	R	R	R	4·8	4·9	8·2
9	0·20	1·0	R	R	R	4·4	4·6	8·0
10	0·47	1·0	R	R	R	3·9	4·1	7·2
11	0·012	R	0·61	R	R	41·7§	16·5	15·8§
12	0·06	R	0·69	R	R	8·8	7·3	10·0
13	0·10	R	0·64	R	R	6·0	6·4	9·8
14	0·22	R	0·63	R	R	4·6	5·7	9·0
15	0·48	R	0·61	R	R	3·9	5·1	8·2
16	0·012	1·0	0·60	R	R	5·4	5·0	7·3
17	0·06	1·0	0·63	R	R	4·0	4·4	6·8
18	0·12	1·0	0·60	R	R	3·5	4·2	6·5
19	0·22	1·0	0·59	R	R	2·9	3·6	6·4
20	0·46	1·0	0·60	R	R	2·7	3·2	5·9
21	0·016	R	1·3	R	R	16·5	11·3	18·8
22	0·05	R	1·3	R	R	8·6	6·6	9·1
23	0·12	R	1·3	R	R	4·3	5·0	8·2
24	0·22	R	1·3	R	R	3·5	4·5	8·3
25	0·46	R	1·2	R	R	2·9	4·1	7·8
26	0·016	1·0	1·3	R	R	4·0	4·1	5·8
27	0·06	1·1	1·3	R	R	3·3	3·4	5·5
28	0·12	1·0	1·2	R	R	2·7	3·2	5·1
29	0·21	1·0	1·2	R	R	2·4	3·0	5·0
30	0·44	1·1	1·2	R	R	2·2	2·9	4·7
31	0·012	R	R	0·22	R	14·7	10·1	21·5§
32	0·06	R	R	0·23	R	7·8	7·1	11·0
33	0·10	R	R	0·18	R	6·7	6·9	10·4
34	0·22	R	R	0·20	R	6·0	6·1	9·9
35	0·48	R	R	0·18	R	5·0	5·4	8·9
36	0·020	1·0	R	0·23	R	5·2	4·9	8·8
37	0·05	1·0	R	0·22	R	4·5	4·6	8·0
38	0·12	1·0	R	0·27	R	4·3	4·4	7·3
39	0·22	1·0	R	0·24	R	4·2	4·3	7·2
40	0·46	1·1	R	0·18	R	3·8	3·9	6·8
41	0·016	R	0·66	0·31	R	19·1	13·8	15·0§
42	0·06	R	0·69	0·27	R	7·7	7·4	8·7
43	0·11	R	0·69	0·26	R	5·3	6·9	8·5
44	0·20	R	0·68	0·16	R	4·3	6·2	8·5
45	0·47	R	0·65	0·15	R	3·6	5·4	8·0
46	0·012	1·0	0·68	0·25	R	4·4	4·7	6·4
47	0·06	1·0	0·70	0·24	R	3·3	4·0	5·9
48	0·10	1·0	0·66	0·15	R	3·3	4·1	6·0
49	0·22	1·1	0·67	0·15	R	2·8	3·8	5·7
50	0·47	1·0	0·66	0·21	R	2·6	3·3	5·1
51	0·016	R	1·3	0·27	R	13·9	9·7	13·6
52	0·05	R	1·2	0·29	R	8·3	6·3	7·7
53	0·10	R	1·2	0·24	R	5·7	5·4	7·6
54	0·20	R	1·2	0·16	R	3·5	4·7	7·7
55	0·48	R	1·2	0·15	R	2·9	4·2	7·3

* In all steels C was less than 0·1, Mn was 0·25 to 0·40 and S was less than 0·020.
† Calculated from loss of weight.
‡ R = 0·010 or less for P, 0·1 or less for Si, 0·1 or less for Cr and 0·05 or less for Ni.
§ Estimated from time–corrosion curve of earlier losses because this specimen had corroded so badly it had fallen from the rack and was lost.

Table 3 (*continued*)

Material Identification	Composition, per cent*					Average Reduction of Thickness, mils†		
						Kearny, N.J.	South Bend, Pa.	Kure Beach, N.C.
	Cu	Ni	Cr	Si	P	15·5 yr	15·5 yr	15·5 yr
56	0·012	1·0	1·3	0·24	R	3·4	3·5	5·1
57	0·05	1·0	1·2	0·25	R	3·1	3·2	4·9
58	0·10	1·0	1·3	0·22	R	2·5	2·9	4·6
59	0·22	1·0	1·2	0·24	R	2·1	2·7	4·3
60	0·46	1·0	1·2	0·19	R	1·9	2·5	4·4
61	0·016	R	R	0·61	R	14·2	9·1	13·1
62	0·06	R	R	0·56	R	6·7	6·4	8·4
63	0·11	R	R	0·47	R	5·7	6·4	8·6
64	0·22	R	R	0·47	R	5·1	6·0	8·2
65	0·51	R	R	0·47	R	4·6	5·1	7·3
66	0·016	1·0	R	0·57	R	4·3	4·3	6·0
67	0·044	1·0	R	0·47	R	4·1	4·1	6·5
68	0·09	1·0	R	0·47	R	4·2	4·2	6·1
69	0·24	1·0	R	0·52	R	4·0	3·8	5·6
70	0·48	1·0	R	0·52	R	3·7	3·5	4·9
71	0·016	R	0·64	0·59	R	12·3	8·5	7·9
72	0·06	R	0·68	0·51	R	6·0	5·9	7·1
73	0·11	R	0·68	0·53	R	4·1	5·0	6·3
74	0·20	R	0·76	0·61	R	3·1	4·0	5·5
75	0·46	R	0·69	0·52	R	3·0	4·2	5·7
76	0·016	1·0	0·71	0·49	R	3·6	3·7	5·0
77	0·05	1·0	0·67	0·50	R	3·1	3·4	4·7
78	0·12	1·1	0·62	0·58	R	2·8	2·9	4·2
79	0·22	1·0	0·69	0·62	R	2·5	2·8	4·1
80	0·48	1·0	0·67	0·50	R	2·3	2·7	4·2
81	0·016	R	1·3	0·56	R	9·3	6·3	8·1
82	0·06	R	1·3	0·54	R	5·9	4·1	5·8
83	0·11	R	1·3	0·54	R	3·4	3·4	5·3
84	0·20	R	1·3	0·58	R	2·6	3·0	4·9
85	0·44	R	1·2	0·50	R	2·4	3·2	5·4
86	0·020	0·89	1·3	0·51	R	3·1	2·9	4·3
87	0·05	1·0	1·2	0·48	R	2·7	2·4	4·0
88	0·11	1·0	1·3	0·56	R	2·2	2·1	3·5
89	0·22	1·0	1·3	0·46	R	1·9	2·1	3·7
90	0·44	0·94	1·2	0·44	R	1·9	2·1	4·0
91	0·020	R	R	R	0·06	7·8	6·9	14·1
92	0·06	R	R	R	0·06	5·9	5·8	10·1
93	0·11	R	R	R	0·06	5·3	5·8	9·6
94	0·21	R	R	R	0·06	4·9	5·1	9·1
95	0·48	R	R	R	0·07	3·9	4·2	7·6
96	0·020	1·1	R	R	0·06	4·1	4·2	8·1
97	0·06	1·0	R	R	0·06	4·0	4·0	7·5
98	0·11	1·1	R	R	0·06	3·8	4·0	7·2
99	0·21	1·0	R	R	0·06	3·5	3·6	6·8
100	0·48	1·1	R	R	0·06	3·1	3·1	6·0
101	0·020	R	0·66	R	0·06	11·1	8·5	11·6
102	0·05	R	0·66	R	0·06	7·5	6·3	9·1
103	0·12	R	0·63	R	0·06	4·6	5·2	8·3
104	0·22	R	0·63	R	0·06	3·6	4·4	7·6
105	0·45	R	0·64	R	0·06	3·1	3·9	6·8
106	0·016	1·0	0·60	R	0·06	4·0	4·0	6·5
107	0·06	1·1	0·62	R	0·06	3·4	3·5	6·2
108	0·10	1·1	0·62	R	0·06	3·1	3·6	5·9
109	0·24	1·0	0·66	R	0·06	2·6	3·0	5·2
110	0·45	1·0	0·65	R	0·06	2·5	2·9	5·0
111	0·020	R	1·3	R	0·06	8·7	6·8	9·0
112	0·06	R	1·3	R	0·06	5·5	4·9	7·4
113	0·11	R	1·3	R	0·05	4·0	4·3	7·0
114	0·23	R	1·3	R	0·06	2·6	3·5	6·2
115	0·46	R	1·3	R	0·06	2·6	3·4	6·1

Table 3 (*continued*)

Material Identification	*Composition, per cent**					*Average Reduction of Thickness, mils†*		
						Kearny, N.J.	*South Bend, Pa.*	*Kure Beach, N.C.*
	Cu	Ni	Cr	Si	P	*15·5 yr*	*15·5 yr*	*15·5 yr*
116	0·020	1·0	1·2	*R*	0·06	3·5	3·4	5·0
117	0·06	1·0	1·3	*R*	0·06	2·9	2·9	5·0
118	0·10	1·0	1·3	*R*	0·06	2·4	2·7	4·6
119	0·20	1·0	1·2	*R*	0·07	2·0	2·5	4·2
120	0·47	1·0	1·2	*R*	0·06	2·0	2·2	4·1
121	0·016	*R*	*R*	0·25	0·06	9·5	6·9	11·6
122	0·05	*R*	*R*	0·25	0·06	6·4	5·5	9·3
123	0·10	*R*	*R*	0·18	0·06	5·7	5·3	9·2
124	0·21	*R*	*R*	0·25	0·06	4·9	4·8	8·2
125	0·47	*R*	*R*	0·18	0·06	4·4	4·4	7·8
126	0·020	1·0	*R*	0·20	0·06	4·2	4·1	7·6
127	0·05	1·0	*R*	0·22	0·06	4·1	4·0	7·1
128	0·10	1·0	*R*	0·20	0·06	4·0	3·8	6·8
129	0·20	1·0	*R*	0·19	0·06	3·9	3·6	6·3
130	0·46	1·1	*R*	0·18	0·06	3·2	3·2	5·9
131	0·012	*R*	0·58	0·27	0·06	12·0	9·2	10·5
132	0·044	*R*	0·61	0·18	0·06	7·0	6·4	8·0
133	0·10	*R*	0·61	0·26	0·06	4·1	5·1	6·8
134	0·17	*R*	0·66	0·19	0·06	3·7	4·9	7·1
135	0·45	*R*	0·65	0·22	0·06	3·0	4·0	6·2
136	0·012	1·0	0·63	0·20	0·07	3·8	3·9	5·5
137	0·042	1·1	0·61	0·17	0·06	3·3	3·7	5·4
138	0·08	1·0	0·66	0·23	0·06	2·8	3·2	4·7
139	0·22	1·1	0·53	0·15	0·06	2·9	3·4	5·3
140	0·45	1·0	0·65	0·17	0·05	2·5	3·0	4·6
141	0·008	*R*	1·3	0·30	0·06	9·5	6·9	7·5
142	0·044	*R*	1·3	0·24	0·05	5·8	4·7	6·1
143	0·12	*R*	1·3	0·25	0·06	2·9	3·4	5·4
144	0·20	*R*	1·2	0·22	0·06	2·7	3·5	5·6
145	0·43	*R*	1·3	0·17	0·05	2·5	3·3	5·6
146	0·012	1·0	1·2	0·29	0·07	3·1	2·8	4·3
147	0·044	1·1	1·3	0·24	0·06	2·8	2·6	4·3
148	0·09	1·0	1·3	0·23	0·06	2·3	2·4	4·0
149	0·21	1·0	1·2	0·17	0·05	2·2	2·4	4·2
150	0·44	1·1	1·3	0·15	0·06	1·9	2·2	3·9
151	0·012	*R*	*R*	0·53	0·06	9·5	6·8	9·5
152	0·044	*R*	*R*	0·50	0·06	5·9	5·5	7·8
153	0·08	*R*	*R*	0·53	0·06	4·5	4·9	7·0
154	0·22	*R*	*R*	0·51	0·06	3·7	4·2	6·2
155	0·45	*R*	*R*	0·42	0·06	4·1	4·3	6·6
156	0·012	1·0	*R*	0·47	0·06	3·8	3·6	6·3
157	0·05	1·0	*R*	0·52	0·07	3·5	3·3	5·5
158	0·12	1·0	*R*	0·54	0·06	3·4	3·3	5·1
159	0·23	1·0	*R*	0·56	0·06	3·2	3·2	4·8
160	0·45	1·0	*R*	0·51	0·06	3·2	3·1	4·6
161	0·016	*R*	0·58	0·53	0·06	10·4	7·1	7·6
162	0·009	*R*	0·59	0·49	0·07	9·6	6·6	7·1
163	0·10	*R*	0·66	0·57	0·06	3·4	3·8	5·0
164	0·22	*R*	0·67	0·55	0·06	2·6	3·4	4·7
165	0·45	*R*	0·65	0·50	0·06	2·5	3·1	4·6
166	0·016	1·1	0·52	0·53	0·07	3·3	2·9	4·3
167	0·05	1·0	0·64	0·47	0·06	3·0	2·8	4·5
168	0·09	1·0	0·70	0·48	0·06	2·7	2·5	4·1
169	0·23	1·0	0·67	0·57	0·06	2·3	2·2	3·5
170	0·44	1·1	0·67	0·47	0·06	2·2	2·2	3·6
171	0·012	*R*	1·2	0·64	0·06	7·6	4·3	5·1
172	0·06	*R*	1·3	0·53	0·06	3·7	2·8	4·1
173	0·10	*R*	1·2	0·52	0·06	3·2	2·7	4·2
174	0·20	*R*	1·3	0·56	0·06	2·3	2·3	4·0
175	0·45	*R*	1·3	0·46	0·06	2·1	2·5	4·5

Table 3 (*continued*)

Material Identification	Composition, per cent*					Average Reduction of Thickness, mils†		
						Kearny, N.J.	South Bend, Pa.	Kure Beach, N.C.
	Cu	Ni	Cr	Si	P	15·5 yr	15·5 yr	15·5 yr
176	0·008	1·0	1·2	0·46	0·06	2·8	2·1	3·8
177	0·044	1·0	1·3	0·52	0·06	2·6	2·1	3·5
178	0·10	1·0	1·0	0·54	0·07	1·9	1·7	3·1
179	0·21	1·0	1·2	0·48	0·06	1·9	1·8	3·3
180	0·45	1·0	1·3	0·49	0·06	1·7	1·7	3·3
181	0·012	R	R	R	0·10	7·5	6·3	13·1
182	0·06	R	R	R	0·10	5·2	4·7	9·4
183	0·11	R	R	R	0·09	4·7	4·6	8·6
184	0·20	R	R	R	0·10	4·4	4·3	8·4
185	0·49	R	R	R	0·10	3·6	3·6	7·1
186	0·019	1·0	R	R	0·09	4·0	3·5	7·2
187	0·06	1·0	R	R	0·09	3·6	3·4	6·7
188	0·09	1·0	R	R	0·09	3·4	3·3	6·6
189	0·21	1·1	R	R	0·09	3·1	3·1	6·0
190	0·43	0·93	R	R	0·09	2·8	2·7	5·6
191	0·020	R	0·70	R	0·08	9·8	7·4	9·4
192	0·044	R	0·59	R	0·10	6·6	5·3	8·2
193	0·11	R	0·63	R	0·09	3·6	4·5	7·0
194	0·22	R	0·64	R	0·09	3·2	3·9	6·8
195	0·45	R	0·63	R	0·09	2·9	3·6	6·0
196	0·012	1·1	0·64	R	0·09	3·8	3·7	6·0
197	0·05	1·0	0·58	R	0·12	2·9	3·1	5·4
198	0·11	1·0	0·65	R	0·10	2·6	2·8	5·0
199	0·21	1·0	0·64	R	0·10	2·3	2·8	4·8
200	0·44	1·0	0·62	R	0·09	2·2	2·6	4·6
201	0·016	R	1·3	R	0·08	8·0	6·1	7·9
202	0·040	R	1·2	R	0·10	5·4	4·3	6·5
203	0·10	R	1·1	R	0·11	3·5	3·6	5·9
204	0·20	R	1·2	R	0·08	2·5	3·1	5·8
205	0·46	R	1·3	R	0·08	2·3	2·7	5·4
206	0·016	1·0	1·2	R	0·11	3·3	2·9	4·6
207	0·035	1·0	1·3	R	0·09	2·6	2·5	4·2
208	0·11	1·0	1·2	R	0·08	2·3	2·3	4·2
209	0·18	1·0	1·3	R	0·09	1·9	2·1	3·8
210	0·41	0·95	1·2	R	0·08	1·9	2·1	3·9
211	0·024	R	R	0·26	0·09	7·5	6·2	10·3
212	0·05	R	R	0·24	0·08	5·7	5·2	9·0
213	0·08	R	R	0·18	0·09	4·9	4·6	8·4
214	0·22	R	R	0·29	0·09	4·4	4·4	7·3
215	0·48	R	R	0·18	0·10	4·1	3·9	6·9
216	0·024	0·94	R	0·31	0·10	3·9	3·4	6·2
217	0·06	1·0	R	0·29	0·09	3·6	3·6	6·3
218	0·10	1·0	R	0·23	0·08	3·7	3·6	6·3
219	0·20	1·0	R	0·16	0·11	3·3	3·2	5·7
220	0·44	1·1	R	0·24	0·08	2·9	3·0	5·3
221	0·016	R	0·62	0·23	0·09	8·8	7·3	8·5
222	0·05	R	0·63	0·27	0·08	4·7	5·1	6·7
223	0·09	R	0·63	0·26	0·08	3·5	4·5	6·3
224	0·20	R	0·68	0·28	0·09	2·8	3·6	5·6
225	0·41	R	0·65	0·26	0·09	2·8	3·7	5·5
226	0·012	1·1	0·62	0·26	0·08	3·4	3·5	5·1
227	0·040	1·0	0·70	0·23	0·08	3·0	3·1	5·0
228	0·10	1·0	0·69	0·27	0·09	2·6	2·8	4·4
229	0·21	1·0	0·61	0·17	0·10	2·3	2·8	4·6
230	0·42	1·0	0·61	0·17	0·11	2·2	2·4	4·0
231	0·014	R	1·2	0·32	0·11	6·9	5·0	6·0
232	0·05	R	1·2	0·28	0·10	5·2	4·0	5·5
233	0·09	R	1·3	0·23	0·08	2·9	3·3	5·3
234	0·22	R	1·3	0·27	0·09	2·3	2·7	4·7
235	0·48	R	1·3	0·27	0·09	2·1	2·6	4·6

Table 3 (*continued*)

Material Identification	*Composition, per cent**					*Average Reduction of Thickness, mils†*		
						Kearny, N.J.	*South Bend, Pa.*	*Kure Beach, N.C.*
	Cu	Ni	Cr	Si	P	*15·5 yr*	*15·5 yr*	*15·5 yr*
236	0·020	1·0	1·2	0·21	0·10	2·8	2·3	4·2
237	0·040	1·0	1·2	0·20	0·08	2·6	2·2	4·1
238	0·10	1·0	1·3	0·23	0·09	2·2	2·1	3·8
239	0·21	1·0	1·2	0·18	0·10	1·9	2·0	3·8
240	0·45	1·0	1·3	0·25	0·08	1·8	1·8	3·8
241	0·012	*R*	*R*	0·54	0·10	6·3	5·2	7·8
242	0·05	*R*	*R*	0·54	0·10	4·5	4·4	6·6
243	0·10	*R*	*R*	0·48	0·11	4·0	4·0	6·3
244	0·23	*R*	*R*	0·53	0·10	3·7	3·7	5·8
245	0·49	*R*	*R*	0·56	0·10	3·3	3·5	5·0
246	0·008	1·0	*R*	0·46	0·10	3·6	3·2	5·7
247	0·05	1·0	*R*	0·46	0·11	3·3	2·9	5·3
248	0·09	1·0	*R*	0·53	0·11	3·2	2·8	4·9
249	0·18	1·0	*R*	0·47	0·10	3·1	2·8	4·6
250	0·45	1·0	*R*	0·60	0·08	2·9	2·5	3·9
251	0·012	*R*	0·59	0·55	0·11	7·5	5·2	6·0
252	0·05	*R*	0·62	0·55	0·10	4·5	3·7	4·7
253	0·09	*R*	0·68	0·53	0·08	3·0	3·2	4·7
254	0·21	*R*	0·62	0·60	0·11	2·3	2·4	3·9
255	0·44	*R*	0·57	0·47	0·08	2·6	3·2	4·7
256	0·020	1·0	0·65	0·51	0·10	3·0	2·5	4·3
257	0·06	1·1	0·66	0·42	0·09	2·6	2·4	4·3
258	0·10	1·1	0·69	0·50	0·09	2·3	2·1	3·9
259	0·21	1·1	0·66	0·50	0·10	2·1	2·0	3·7
260	0·45	1·0	0·67	0·62	0·09	2·0	1·9	3·5
261	0·016	*R*	1·2	0·56	0·11	6·2	3·6	4·6
262	0·05	*R*	1·2	0·54	0·11	3·8	2·6	3·9
263	0·08	*R*	1·3	0·58	0·08	2·6	2·3	3·8
264	0·21	*R*	1·2	0·62	0·10	1·9	1·7	3·3
265	0·44	*R*	1·2	0·60	0·11	1·7	1·7	3·5
266	0·008	1·0	1·2	0·50	0·12	2·6	1·9	3·9
267	0·05	1·0	1·2	0·58	0·11	2·4	1·7	3·3
268	0·10	1·0	1·2	0·57	0·08	2·0	1·6	3·1
269	0·24	1·0	1·3	0·43	0·09	1·9	1·7	3·5
270	0·46	1·0	1·3	0·59	0·09	1·6	1·3	3·2

It is unfortunate that the thicknesses of a few of the least-resistant steels were not greater; if they had been, the resulting very high losses would be somewhat more exact than those estimated by extending time-corrosion curves of the earlier losses. For instance, the steel on the first line of Table 3 with no alloying elements was corroded so badly after 15·5 years at Kearny and at Kure Beach that the specimen fell from the test rack and was lost. Other work has shown that a time-corrosion curve of a poorly resistant steel can be projected from its earlier losses with an accuracy of about ±5 per cent.

All of the effects of changes in compositions as shown by the 270 steels in Table 3 will not be discussed here, but attention will be called to a few of the outstanding examples that illustrate how minor changes in composition sometimes are major factors in determining the atmospheric corrosion losses of a particular steel.

The greatest change in corrosion with a relatively small change in composition is that caused by an increase in copper content from 0·01 to 0·04 per cent (steels Nos 1 and 2, Table 3). This is shown in *Figure 2* and is in accordance with the findings of Buck[8]. *Figure 2* shows the results of 15·5 years' exposure in three atmospheres, whereas Buck used the results of a 1·5-year exposure in a very severe industrial atmosphere. Both Buck and the present authors achieved a further improvement in corrosion resistance by increasing the copper content of the steels (Nos 3 to 5); however, this rate of improvement is much

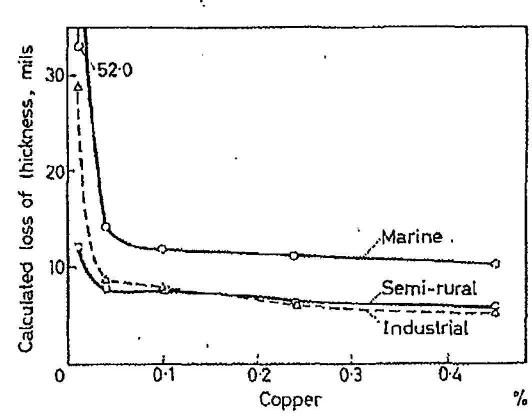


Figure 2. Effect of copper content on atmospheric corrosion of steels during 15·5 years' exposure in industrial atmosphere

less marked than that produced by the 0·01 to 0·04 per cent increase.

A peculiar and unexplainable phenomenon is the effect of 0·6 per cent chromium with low (0·01 per cent) copper content and residual amounts of other alloying elements (steel 11). As shown in *Figure 3* for the industrial atmosphere and in Table 3 for the semi-rural atmosphere, the presence of 0·6 per cent chromium decreases the corrosion resistance. With a copper content of 0·1 per cent and above (Nos 13 to 15), the presence of chromium is somewhat beneficial in all atmospheres. This has been shown previously with other materials[5]. Chromium at 1·3 per cent (No. 21) improves the corrosion resistance even with only 0·01 per cent copper.

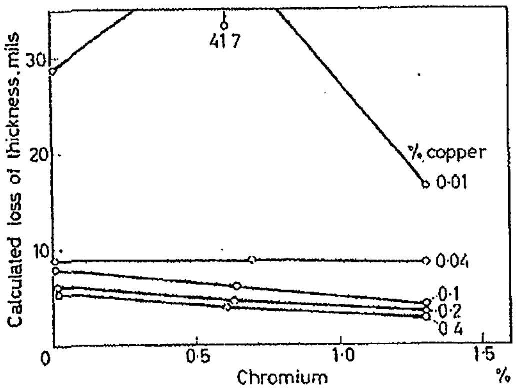


Figure 3. Effect of chromium content on atmospheric corrosion of five steels with increasing copper contents during 15·5 years' exposure in industrial atmosphere

Previous unpublished work at this Laboratory has shown that the improvement in atmospheric-corrosion resistance of a steel is nearly linear with increasing nickel content. In other words, if a series of steels had been made with 0·5 per cent nickel, the losses would have been about half way between those given in Table 3 for steels with 1 per cent nickel and those with residual nickel (Nos 6 and 1, for example). For this reason, nickel was added only at the 1 per cent level. The beneficial effect of nickel and chromium over chromium alone is evident by comparing the losses of Nos 11 to 15 with Nos 16 to 20. The previously mentioned deleterious effect, in an industrial atmosphere, of 0·6 per cent chromium in the presence of only 0·01 per cent copper is eliminated.

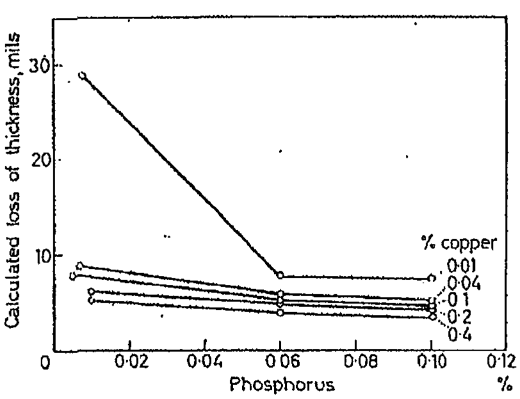


Figure 4. Effect of phosphorus content on atmospheric corrosion of five steels with increasing copper contents during 15·5 years' exposure in industrial atmosphere

Buck[8] discussed the beneficial effect of phosphorus in the presence of copper. An example of the effect of phosphorus and copper can be obtained by comparing the losses of Nos 1 to 5, 91 to 95 and 181 to 185. Some of the results are shown in *Figure 4* for an industrial atmosphere.

The effect of silicon in the presence of copper and in the absence of other alloying elements is shown in Table 3 by comparing the losses of Nos 1 to 5, 31 to 35 and 61 to 65. These exposure results from an industrial atmosphere are shown graphically in *Figure 5*. The data in Table 3 and *Figure 5*

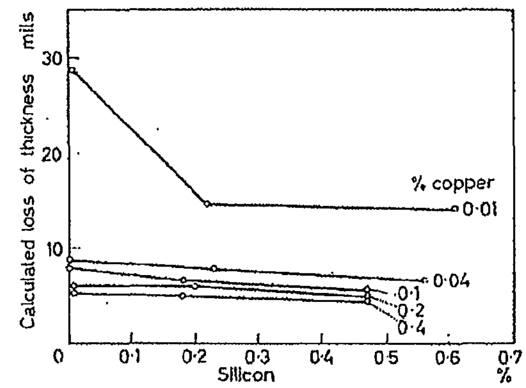


Figure 5. Effect of silicon content on atmospheric corrosion of five steels with increasing copper contents during 15·5 years' exposure in industrial atmosphere

reveal that the presence of 0·2 per cent silicon reduces the loss by almost half in industrial and marine atmospheres for the 0·01 per cent copper steel, but decreases the steels with higher copper contents only slightly. Increasing the silicon to 0·6 per cent only slightly decreases the losses.

Effects of Combinations of Alloying Elements

In a 0·1 per cent phosphorus–0·5 per cent copper steel, the presence of 0·6 per cent silicon reduces the loss in industrial atmosphere from 3·6 (No. 185) to 3·3 mil (No. 245) and the addition of 1·2 per cent chromium further decreases the loss to 1·7 mil (No. 265). When 1 per cent nickel is added to the latter steel (No. 265), the loss of the resulting steel (No. 270) is reduced only from 1·7 to 1·6 mil in an industrial atmosphere, 1·7 to 1·3 mil in a semi-rural atmosphere, and 3·5 to 3·2 mil in a marine atmosphere.

It is evident that in so far as this series is concerned, the addition of the higher percentages of each alloying element decreases the corrosion loss. However, it is also evident that when economic factors are considered there is a limit to the amount of each alloying element that one is justified in specifying to obtain corrosion resistance commensurate with cost.

Many other comparisons can be made from the data in Table 3. However, it is well to remember that qualities other than atmospheric-corrosion resistance are necessary in a steel. Because of the protracted time necessary to determine the corrosion resistance of a steel, the authors have developed data such as those shown in Table 3 to estimate the probable corrosion resistance of almost any low-alloy steel developed for its other properties by finding the relative corrosion loss of the steel nearest to it in composition. This eliminates the necessity of waiting a number of years to obtain an approximation of the corrosion resistance of a new steel.

Summary

The weight losses of 270 steels with systematic variations of copper, nickel, chromium, silicon and phosphorus after exposure for 15·5 years in an industrial, a semi-rural and a marine atmosphere, respectively, show that:

(1) Increasing the copper content of a steel from 0·01 to 0·04 per cent makes more difference in corrosion resistance than does the addition of a similar amount of any other element investigated.

(2) Further increases in copper content are beneficial but not to so great an extent as shown by the smaller addition.

(3) Improvements in corrosion resistances are made by relatively small additions of nickel, chromium, silicon and phosphorus, singly, but the greatest improvements are obtained by the addition of specific combinations of these alloying elements.

(4) The effects of each element are not additive; therefore, the availability of data from long-time exposure tests of many steels is necessary for a rapid estimation of the corrosion resistance of steels with particular combinations of alloying elements.

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3 *Proceedings, ASTM*, 1959, **59**, Report of Committee B-3

4 LAQUE, F. L., *Proceedings, ASTM*, 1951, **51**, 495

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6 SCHRAMM, G. N. and TAYLERSON, E. S., *Symposium on Outdoor Weathering of Metals and Metallic Coatings, ASTM*, 1934, Philadelphia, Pennsylvania

7 ELLIS, O. B., *Proceedings, ASTM*, 1949, **49**, 152

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Discussion

Dr. J. C. HUDSON (British Iron & Steel Research Association, London, S.W.11): I should like the authors' views as to the reasons for the slowing down of the rate of rusting with time. The relative degree of slowing down seems to vary for different steels as in the following test results by BISRA.

	Loss in weight g per specimens per year, *First 2 years* A	*Loss in weight* g per specimens per year, *6th–15th year* B	*Ratio* A/B
Ordinary mild steel	210	153	0·73
do. Cu 0·5%	150	128	0·85
do. Cr 1·06%, Cu 0·6%	126	42	0·33

Dr. W. H. J. VERNON, O.B.E. (53 Revell Road, Kingston-on-Thames, Surrey): The authors' statement about the linear relationship in atmospheric corrosion resistance with increasing nickel content prompts the question to what extent this linearity persists (in the absence of other alloying elements) beyond 1·0 per cent.

The results shown in *Figure 2* on the influence of copper have a personal appeal to me, having been privileged, under the guidance of Mr. Larrabee at Kure Beach in 1948, to see a number of series of copper-bearing steels in each of which the member of lowest copper content had disappeared from the rack! Undoubtedly those results have influenced British practice in the adoption of a steel containing not less than 0·2 per cent copper as a standard of reference among ferrous materials. The extensive field tests of Hudson and Stanners (*J. Iron & Steel Inst.* 1955, **180**, 271) provide abundant confirmation of the wide scatter of results among steels of low but nominally identical copper content and the virtual constancy of results from individual steels of different copper contents in the higher ranges. The explanation to be attached to the characteristic disposition of the 'Buck curve' (*Figure 2*) connecting extent of corrosion with the copper content of the steel still provides an intriguing question. Buck's own view, in common, I believe, with that of Mr. Larrabee, was that the falling part of the curve represents the nullification of the bad effects of sulphur by the additions of copper (copper sulphide being considered not so deleterious as ferrous sulphide). There can be little doubt that this mechanism must be a contributory factor, probably an important one. Nevertheless, I have not yet seen convincing evidence that it is the whole of the story. One thinks of the influence of rain, essential to the mechanism of protection by copper; similarly, for example, the marked superiority of copper-bearing sleeper plates over those of ordinary steel in the open track 'little difference between the two' inside a tunnel (Hudson, J. C., 6th Report of the Corrosion Committee, *Iron & Steel Inst.*, Special Rep., No. 66, 1959, 10).

I believe, with Copson, that the build-up of a complex within the rust is all-important. Elsewhere (*J. Iron & Steel Inst.* 1960, **196**, 334) I have called attention to the fact that whereas the content of copper within the rust increases linearly with the content of copper in the steel, the content of (SO_4) in the rust increases steeply as the copper content of the steel approaches the region of 0·2 per cent, beyond which it remains constant for all further increments of copper in the steel. I have attempted to link this behaviour with the known behaviour of copper metal itself in inland atmospheres, whereby it is able to build up a complex in which, when once the primary valency of Cu is satisfied, further entry of copper into the product is used up in the form of $Cu(OH)_2$ (increasing basicity) as required by the co-ordination formula, $\{Cu[(OH)_2Cu]_n\}SO_4$ where n has a limiting value of 3. The analogy may or may not be true; but if it be not, I feel that some alternative explanation is required to account for the respective mode of increase of Cu and (SO_4) in the corrosion product with increasing content of copper in the steel. Mr. Larrabee's views would be welcome.

Mr. J. DEARDEN (British Railways Research Dept., London Road, Derby): I should like to point out that the slow rusting characteristics of certain low alloy steels depend on their rust remaining intact. This may not always obtain and there are plenty of examples in equipment used in Civil Engineering, Mining, Agriculture and Transport where the rust is inevitably removed by abrasion and wear. We have reported (Dearden, J. and Swindale, J. D. *J. Iron & Steel Inst.* 1957, **185(2)**, 227) the results of tests involving the alternate abrasion and corrosion of eleven ferrous metals. The abrasion applied in these tests must have been more severe than that which occurs on the bottom plates of steel coal wagons, since the advantage of using slow rusting steels in such severe conditions has been proved by Hudson (*J. Iron & Steel Inst.* January, 1960, **194**(1), 45). I have confirmed this result by measurements on the steel doors of five coal wagons after five years' service; the steels tested included copper-bearing and Cor-Ten steels, and the losses in thickness were in the inverse order of their hardness, showing that resistance to abrasion was involved as well as resistance to corrosion under the conditions obtaining at the bottoms of coal wagons.

THE AUTHORS (in reply): The obvious reply to Dr. Hudson is that the rust formed on the steels containing various combinations of alloying elements gives progressively more protection to the steel. We cannot venture upon a fundamental explanation of this phenomenon.

In reply to Dr. Vernon's first question, the linear relationship in atmospheric corrosion resistance with increasing nickel content is shown by examination of the data in the following table.

Nickel (per cent)	*Loss in weight (grams) in the interval between 3·5 and 7·5 years, in industrial atmosphere*
1·5	3·6
2·0	3·4
3·7	3·2
5·4	2·7
8·8	2·2

With regard to Dr. Vernon's second point, we cannot doubt the results of his analyses of the rusts nor those of Dr. Copson. It is unfortunate that the rusts on the specimens of sulphur-free steels having 0·0001 and 0·2 per cent copper and which corroded at the same rate in the atmosphere as a steel having 0·03 per cent sulphur and 0·2 per cent copper, were not analysed for copper and sulphate (Larrabee, C. P., *Corrosion*, 1953, **9**, 259). However, in our opinion, these results show that the major effect of copper is to combine with the sulphur in the steel.

I agree with Mr. Dearden that abrasion, as well as corrosion resistance, plays a part in the life of coal wagons or other similar service.

List of Changed CoC, Technical Specifications and UFSAR Pages Associated with Amendment 11, Revision 2 for RAI. No. 2

Changed Page	Associated RAI or Other Item
CoC Page 1	Amendment 11 mark ups made to the Amendment 10 Rulemaking version
CoC Page 2	RAI 5.1
CoC Page 3	Amendment 11 mark ups made to the Amendment 10 Rulemaking version
CoC mark-up Inserts A and B	RAI 5.1
TS Page v	Added four new tables to list of tables
TS Page vi	Added two new figures to list of figures
TS Page 1-1	RAI 5.3
TS Page 1-2	Shifted information
TS Pages 1-3 to 1-10	Additional Change No. 11
TS Page 2-1	RAI 5.4
TS Pages 3-1 to 3-8	Additional Change No. 11
TS Pages 3-9 to 3-11	Additional Change No. 7 Additional Change No. 11
TS Page 3-12	Additional Change No. 7
TS Page 4-2	Commitment from RAI No. 1 Response (Reference 2 in cover letter) Additional Change No. 11
TS Page 4-3	Additional Change No. 4
TS Page 4-4	Additional Change No. 5 Additional Change No. 11
TS Page 4-5	RAI 2.1 Additional Change No. 11
TS Pages 4-6, 4-9, 4-10, 4-12, 4-13, 4-15, 4-16, 4-18, 4-20, 4-22, 4-24, 4-26	Additional Change No. 9
TS Page 4-27 and 4-28	RAI 5.13
TS Page 4-29	Additional Change No. 3
TS Page 4-30, 4-31	Additional Change No. 11
TS Page 4-33	RAIs 5.1, 5.3, and 5.5
TS Page 5-1	Additional Change No. 11
TS Page 5-2	RAI 5.6
TS Page 5-3	RAI 5.7 Additional Change No. 11
TS Page 5-4	Additional Change No. 11
TS Page 5-5	RAI 5.8 Additional Change No. 11
TS Page 5-6	RAI 5.8 RAI 5.43 Additional Change No. 11
TS Page 5-7	RAI 5.8 Additional Change No. 8 Additional Change No. 11
TS Page 5-8	RAI 5.8
TS Page 5-9	Additional Change No. 11
TS Page 5-10	Additional Change No. 12
TS Page 5-11	RAI 5.9 Additional Change No. 11
TS Page 5-12	RAI 5.10
TS Page 5-13	RAI 5.11 Additional Change No. 11
TS Page 5-14	RAI 5.11 Additional Change No. 11

List of Changed CoC, Technical Specifications and UFSAR Pages Associated with Amendment 11, Revision 2 for RAI. No. 2

Changed Page	Associated RAI or Other Item
TS Page T-3	RAIs 5.1 and 5.15
TS Page T-4	Table 1-1d changed per Additional Change No. 1
TS Page T-5	RAIs 5.1 and 5.15
TS Page T-7	Table 1-1g changed per Additional Change No. 10
TS Page T-11	RAIs 5.1 and 5.15
TS Page T-13	Table 1-1l changed per Additional Change No. 2
TS Page T-23	Table 1-1u changed per Additional Change No. 1
TS Pages T-53 through T-60	Tables 1-3a through 1-3h changed per Additional Change No. 6
TS Pages T-76 through T-80	New tables, per RAIs 5.1 and 5.15
TS Pages F-29 and F-30	New figures, per RAIs 5.1 and 5.15
UFSAR 1.2-3	Change to base SAR to account for Appendix W
UFSAR 1.2-10 and 1.2-11	Added a table note to account for different operations for the OS197L
UFSAR 1.3-3	Change to base SAR regarding the OS197L TC
UFSAR 1.3-4	Added a note regarding transfer equipment described in Appendix W
UFSAR 1.3-5	Added a note to account for different operations for the OS197L
UFSAR 1.3-10	Added supplemental shielding to list of components (OS197L TC only)
UFSAR 3.1-4	RAI 5.36
UFSAR 3.1-5	Shifted text due to Page 3.1-4 change
UFSAR 3.1-6	Shifted text due to Page 3.1-4 change
UFSAR 3.1-13	RAI 5.36
UFSAR 4.2-9	RAI 5.37
UFSAR 4.2-10	RAI 5.37
UFSAR 4.2-11	Shifted text due to Pages 4.2-10 and -11 changes
UFSAR 4.2-26a	Figure 4.2-15a changed from “75 Ton Transfer Cask” to “OS197L Transfer Cask”
UFSAR 4.7-1	RAI 5.37
UFSAR 4.7-5	RAI 5.38
UFSAR 4.7-6	RAI 5.38
UFSAR 4.7-7	RAI 5.38
UFSAR 4.7-7a	Shifted text due to Page 4.7-7 changes
UFSAR 4.7-10	RAI 5.37
UFSAR 4.7-11	Shifted text due to Page 4.7-10 change
UFSAR 4.8-3	Additional Change No. 9
UFSAR 4.8-6	Additional Change No. 9
UFSAR 5.1-1	RAI 5.52
UFSAR 5.1-14	RAI 7.2
UFSAR 5.1-15	Shifted text due to Page 5.1-14 change
UFSAR 5.1-16	Shifted text due to Page 5.1-14 change
UFSAR 5.1-17	Shifted text due to Page 5.1-14 change
UFSAR 5.7-1	RAI 7.2
UFSAR 7.1-1	RAI 5.39
UFSAR 7.1-2	RAI 5.39
UFSAR 10-3	Editorial corrections to TS cross Amendment 10/Amendment 11 cross-reference list

List of Changed CoC, Technical Specifications and UFSAR Pages Associated with Amendment 11, Revision 2 for RAI. No. 2

Changed Page	Associated RAI or Other Item
UFSAR 10-4	• The table row which accounted for the previous commitment that the OS197L shall not be used for plants with 100 ton crane capacity has been removed. • In the table row regarding the NRC request associated with supplemental shielding, "(75 ton version)" is deleted, and the TS reference is changed. • Editorial corrections to various other rows.
UFSAR 10-30	RAI 5.53
UFSAR 10-31	RAI 5.12
UFSAR 10-34	RAI 5.40
UFSAR 10-35	This new page, created by Amendment 11 Revision 1, is no longer needed, due to changes to Page 10-34.
UFSAR Drawing NUH-32PT-1004-SAR (4 sheets)	Sheet 2 changed per Additional Change No. 10
UFSAR M.2-15	Table M.2-3 changed per Additional Change No. 10
UFSAR M.6-30	Table M.6-1 changed per Additional Change No. 10
UFSAR W.1-1 to W.1-3	Changes made based on the new approach described in the responses to RAI 5.1
UFSAR W.1-4	Changes made based on the new approach described in the responses to RAI 5.1 plus clarification of
UFSAR W.1-5	The two drawings added with the response to RAI No. 1 are added to the list of drawings. Reference 1.3, which is to represent the most current amendment to CoC 1004, is changed from Amendment 8 to Amendment 9
UFSAR W.1-6	Changes made based on the new approach described in the responses to RAI 5.1
UFSAR W.1-7	Table updated based on new approach described in the responses to RAI 5.1
UFSAR W.1-9	The interim cask lid has been removed from Figure W.1-1
UFSAR Drawing NUH-03-8011-SAR	Changes to title block for consistency
UFSAR Drawing NUH-03-8012-SAR	RAI 5.54, plus changes to title block for consistency
UFSAR W.2-1 to W.2-3	Changes made based on the new approach described in the responses to RAIs 5.1 and 5.15
UFSAR W.2-4	RAI 5.14 plus changes made based on the new approach described in the responses to RAIs 5.1 and 5.15
UFSAR W.2-5	Table W.2-1 was previously on Page W.2-4, but due to added information is now on Page W.2-5
UFSAR W.2-6 to W.2-15	Changes made based on the new approach described in the responses to RAIs 5.1 and 5.15
UFSAR W.3-1	RAI 5.33, plus changes made based on the new approach described in the responses to RAI 5.1
UFSAR W.3-2	Changes made based on the new approach described in the responses to RAI 5.1
UFSAR W.3-4	RAI 5.41, plus changes made based on the new approach described in the responses to RAI 5.1
UFSAR W.3-5	Changes made based on the new approach described in the responses to RAI 5.1

List of Changed CoC, Technical Specifications and UFSAR Pages Associated with Amendment 11, Revision 2 for RAI. No. 2

Changed Page	Associated RAI or Other Item
UFSAR W.4-1 through W.4-34	All changes were made based on the new approach described in the responses to RAIs 5.1 and 5.15, plus RAIs 3.1 through 3.4
UFSAR W.5-1 through W.5-20	Note 1: Along with the specific RAIs called out for certain W.5 pages below, all changes were made based on the new approach mentioned in the responses to RAIs 5.1, 5.15 through 5.20, 5.22, 5.25, 5.27, 5.30, 5.42, 5.48, 5.49 and 5.55
UFSAR W.5-21	RAI 5.34
UFSAR W.5-22 through W.5-39	Note 1
UFSAR W.5-40	RAI 5.21
UFSAR W.5-41 through W.5-48	Note 1
W.6 and W.7	No changes made
UFSAR W.8-1 through W.8-15	Note 1: Along with the specific RAIs called out for certain W.8 pages below, all changes were made based on the new approach described in the responses to RAIs 5.22, 5.25, 5.43, and 5.45
UFSAR W.8-16	RAIs 5.24 and 5.44
UFSAR W.8-17 and W.8-18	Note 1
UFSAR W.8-19	RAI 5.57
UFSAR W.8-20 through W.8-22	Note 1
UFSAR W.8-23	RAI 5.56
UFSAR W.8-24	Note 1
UFSAR W.8-25	RAI 5.44
UFSAR W.8-26 through W.8-28	Note 1
W.9	No changes made
UFSAR W.10-1	RAIs 5.23, 5.24, 5.26, 5.29, and 5.46
UFSAR W.10-2	RAIs 5.23, 5.26, 5.29, and 5.46
UFSAR W.10-3	RAIs 5.23, 5.26, 5.29, and 5.46
UFSAR W.10-4	RAIs 5.23, 5.26, 5.29, and 5.46
UFSAR W.10-5	RAIs 5.23, 5.26, 5.29, and 5.46
UFSAR W.11-1	Changes made related to the limitation that only the 61BT and 32PT DSCs are authorized for transfer in the OS197L
UFSAR W.11-2	RAIs 5.16 and 5.27
UFSAR W.11-3	RAIs 5.16, 5.27 and 5.47
UFSAR W.12-1	Updated to reflect Amendment 9, which is the current effective amendment
W.13 and W.14	No changes made

Enclosure 7 to TN E-28173

UFSAR Drawings NUH-32PT-1004-SAR, NUH-03-8011-SAR and NUH-03-8012-SAR
(Public versions)

SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

REVISION	DESCRIPTION	DATE
0	INITIAL ISSUE	

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M.

INTERPRET WELD SYMBOLS PER ANSI / AWS 2.4

U.S. Patent No. 4,780,269 Transnuclear, Inc.

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL BASKET ASSEMBLY - TUBE OPTIONS

DRAWING NO.	SCALE	SHEET	REVISION
NUH-32PT-1004SW-SAR	NONE	1 OF 4	0

NUH-32PT-1004SW-SAR 2 OF 4

SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-32PT-1004SW-SAR	2 OF 4	0

SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® OS197L
ONSITE TRANSFER CASK SUPPORT SKID
SUPPLEMENTAL SHIELDING

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8011-SAR	NONE	1 OF 4	0B

SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8011-SAR	2 OF 4	0B

SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

NUH-03-8011-SAR | 3 OF 4 | 0B

SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8011-SAR	4 OF 4	08

SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION	TRANSNUCLEAR AN AREVA COMPANY
DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M	SAFETY ANALYSIS REPORT NUHOMS® OS197L ONSITE TRANSFER CASK DECON AREA CASK SHIELDING ASSEMBLIES
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	DRAWING NO. NUH-03-8012-SAR · SCALE NONE · SHEET 1 OF 1 · REVISION 0B

Enclosure 8 to TN E-28173

Listing of Proprietary Computer Files Enclosed

Disk ID No. (size)	Discipline	System	File Series (topics)	Number of Files
Disk 1 CD (375 MB)	Thermal	OS197L	001-OS197L_13kW_100F.cas 002-OS197L_13kW_100F.dat 003-OS197L_13kW_100F.cdb (OSL197L Transfer Skid Performance for 13 kW and 100°F Ambient Conditions)	001 to 003 total of 3 files
	Thermal	OS197L	004-OS197L_13kW_117F.cas 005-OS197L_13kW_117F.dat 006-OS197L_13kW_117F.cdb (OSL197L Transfer Skid Performance for 13 kW and 117°F Ambient Conditions)	004-006 total of 3 files