CALCULATION COVER SHEET

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SUBJECT	Seismic SSI Analyses of Underground Vertical Ventilated Modules (VVM) Using SASSI	FILE NO.	
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RECORD OF ISSUES

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Nuclear Quality Assurance Category Yes ☒ No ☐

This calculation contains unverified assumptions that must be verified later. Yes ☐ No ☒
If yes, see summary of unverified assumptions.

Method of checking used: Mathematical Check ☒
Alternate Method ☐

This calculation documents the seismic soil-structure-interaction (SSI) analyses of the HI-STORM 100U, an underground storage system, using the SASSI computer program. A 5×5 underground cavity configuration is analyzed for six Multi-Purpose Canister (MPC) loading patterns. The input motions used were the design basis USNRC RG 1.60 response spectrum compatible horizontal and vertical time histories with maximum accelerations of 0.5 g's and 0.333 g's, respectively. Results of these analyses are used to assess the effects of the different loading patterns on the maximum displacement response, ovalization, and axial stresses in the outer steel shell liner of a single loaded cavity.

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RECORD OF REVISIONS

Revision	Description
0	Initial Issue of Calculation
1	Add Appendix A in response to NRC comments made during meeting on March 27, 2007 with Holtec International. 1

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ATTACHMENT 1 SELECTED SASSI INPUT FILES

Appendix A - INFLUENCE OF SSI RESPONSE OF VVM ARRAY ON SURROUNDING SOIL RESPONSE

In this appendix, the extent of the soil-structure-interaction (SSI) effect of the VVM array on the surrounding soil response is assessed. The maximum soil displacement at the surface with respect to the soil displacement at a depth of 18.6 feet is calculated and plotted versus distance from the edge of the pad. This displacement, as a function of the edge distance, is compared to the corresponding maximum relative displacement in the free-field between the surface and a depth of 18.6 feet to determine the extent of the influence of the VVM response on the soil response. The depth of 18.6 feet corresponds to the bottom of the VVMs. The VVM configuration for Case 1 (all 5 × 5 loaded) was chosen since Case 1 has the most structure mass and therefore, the results from Case 1 should bound the other cases.

The locations selected for calculating the soil response are shown in Figure A-1. Figure A-2 shows the comparison of the maximum horizontal relative displacements near the VVM array with the corresponding maximum horizontal relative displacement in the free-field. Figure A-3 shows the comparison of the maximum vertical relative displacements near the VVM array with the corresponding maximum vertical relative displacement in the free-field.

Appendix I

Alternate Vacuum Drying Analysis

I.1 INTRODUCTION

An isothermal boundary was used on the outside of the MPC shell for the analyses of the vacuum drying process presented in Appendix C. For normal onsite conditions in a HI-TRAC, the MPC shell and the HI-TRAC inner surface temperatures are substantially higher than the boiling point of water (see Table 4.5.4 of Reference I.2). This means that any water in the annulus between the MPC and the HI-TRAC inner shell would reach its boiling temperature. Since the heat transfer coefficient in the presence of boiling is very high, the difference between the temperature of the free fluid and the MPC outer wall would be small. Thus, the MPC surface temperature would be essentially the same as the fluid temperature, i.e., the boiling temperature. The isothermal MPC outer wall boundary condition used in Appendix C, therefore, corresponds to boiling in the gap. To evaluate the adequacy of this approach, an alternate calculation is performed and presented in this appendix for the vacuum drying process, wherein a convection boundary condition is used on the outside surface of the MPC shell. The convection boundary parameters, namely the sink temperature and surface heat transfer coefficient, are defined in a conservative manner as described below:

1) Water in the HI-TRAC annulus gap has reached boiling temperature (212°F). However, boiling heat transfer in the annulus gap is not credited in the analysis.
2) Heat dissipates from the MPC to a static column of water by conduction. In this, natural convection water motion is neglected and the heat transfer coefficient obtained is a theoretical lowerbound value.

Using the boundary conditions defined above, the peak cladding temperature is computed for the bounding canister (MPC-68 at maximum permitted heat load under vacuum drying (26 kW)).

I.2 METHODOLOGY

The thermal analysis methodology for the vacuum drying condition is described in detail in Appendix C. The only change to this methodology for the analysis in this appendix is replacing the isothermal boundary condition on the side of the MPC with a convection boundary condition. A heat transfer coefficient equivalent to conduction through the annulus gap water thickness was used. The water present in the annulus is not modeled explicitly, which is conservative as axial heat conduction through the water column is not credited in the analysis. Any motion of water due to buoyancy effects is also conservatively neglected.

I.3 CALCULATIONS

The same Computational Fluid Dynamics (CFD) models, as described in Appendix C, are used to perform the alternate vacuum drying analysis described in Section I.1. FLUENT CFD [I.1] code is used for the analysis. The list of input and output files is provided below:

```
Directory of G:\Projects\5014\REPORTS\HI-2043317\Appendix-I\fluent

05/03/2007  09:09 AM        65,656,455 3d68vac-cbc.cas
05/03/2007  09:09 AM        88,758,400 3d68vac-cbc.dat
01/22/2007  08:54 PM       457,513,515 3d68vac-cbc.ray
```

The surface heat transfer coefficient for the outer surface of the MPC is calculated using Mathcad. The calculations are attached to the end of this appendix.

I.4 RESULTS AND CONCLUSIONS

The peak cladding temperature from this alternate calculation is

The peak cladding temperature is below the regulatory limit of 1058°F. This confirms the adequacy of the calculations supporting the HI-STORM FSAR amendment.

I.5 REFERENCES

[I.1] FLUENT Computational Fluid Dynamics Software, Fluent Inc.

[I.2] HI-STORM FSAR, Holtec Report HI-2002444, Rev. 3.J.