TRANSNUCLEAR
AN AREVA COMPANY

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

Subject: Supplement to Submittal of Biennial Reports of 72.48 Evaluations Performed for the Standardized NUHOMS® System, Certificate of Compliance (CoC) 1004, Docket 72-1004

Pursuant to the requirements of 10 CFR 72.48(d)(2), this submittal provides summaries of 72.48 evaluations performed for the CoC 1004 Standardized NUHOMS® System. These evaluations were approved in 2006 (one item), 2008 (three items), 2011 (three items), and 2012 (six items), and they should have been provided in previous reports. Ten of the items are associated with non-conformances and three are associated with design changes. Resolution of Transnuclear corrective action report (CAR) 2013-16 includes preventative actions associated with this situation.

Enclosure 1 provides the supplemental 72.48 evaluation summaries, with design changes included in Enclosure 1 Part 1, and non-conformances included in Enclosure 1 Part 2. The summaries include indication as to whether the evaluation had associated Updated Final Safety Analysis Report (UFSAR) changes that were incorporated into the UFSAR for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Fuel, NUH003.0103.

Should you or your staff require additional information, please do not hesitate to contact me at 410-910-6878 or Clark Vanderniet at 410-910-6933.

Sincerely,

Donis Shaw
Licensing Manager

cc: B. Jennifer Davis (NRC SFST), provided in a separate mailing

Enclosure:

1. Supplemental Report of 10 CFR 72.48 Evaluations Performed for the Standardized NUHOMS® System

NMSS26

Supplemental Report of 10 CFR 72.48 Evaluations Performed for the Standardized NUHOMS® System

Enclosure 1 Part 1 - DESIGN CHANGES

***Licensing Review (LR) 721004-429, Rev. 0* – (incorporated into UFSAR Revision 11)**

Change Description

The change involved a revision to a dry shielded canister (DSC) procurement specification, which added a provision allowing the gap between the basket and the canister shell to be less than the normally specified gap at local areas such as circumferential weld seams. The requirement specified at such locations was changed to no interference at room temperature (i.e., the smallest acceptable local gap is zero).

Evaluation

The DSC basket provides compartments for the stored spent fuel, with structural support to maintain the geometric configuration of those compartments. It provides criticality safety by means of compartment spacing and neutron absorber plates between the compartments. It provides conduction paths for removal of the decay heat from the fuel, and rejection of that heat to the canister shell. It contributes to shielding the radiation from the spent fuel.

The canister shell provides confinement of radioactive material, structural support for the basket and for horizontal handling of the stored fuel, heat rejection to the surrounding horizontal storage module or transfer cask, and contribution to shielding the radiation from the fuel.

The smaller gap between the basket and shell enhances heat transfer, and has no effect on shielding. The primary effect is on the structural function of the shell and basket (i.e., an increase in the stresses in both due to differential thermal expansion). There is no effect on criticality safety or confinement, provided that the structural design requirements are satisfied.

A Transnuclear calculation evaluated stresses resulting from thermal expansion of the basket at the two locations where weld shrinkage from fabrication could result in a zero cold gap: (1) the bottom of the basket, near the weld of the inner bottom cover plate to the canister shell; and (2) near the middle of the basket height, near a circumferential weld seam in the shell. The calculation determined that for the controlling load combination, which includes thermal stresses, (off-normal, maximum thermal load, minimum ambient temperature) the controlling combined stress intensity is 93.26 ksi at the middle, compared to the 55.58 ksi reported in UFSAR Table P.3.7-8. The stress allowable in the UFSAR is based on the simplified elastic-plastic analysis requirements of NB-3228.5. The calculation demonstrated that these requirements are still satisfied (i.e., the stresses remain below the ASME design basis limit).

The eight 72.48 evaluation criteria were met.

Licensing Review (LR) 721004-570, Rev. 0 *– (incorporated into UFSAR Revision 11)*

Change Description

The change involved a revision to the flood stability calculation of horizontal storage module (HSM) Model 202, to be consistent with the analysis of other HSM models. The change was documented in a Transnuclear calculation, addressing the stability (overturning and sliding) evaluation of the HSM Model 202 for flood loads using the same method of evaluation as that employed for the Standardized HSM documented in UFSAR Section 8.2.

Evaluation

The HSM and its associated end shield walls have shielding, structural, thermal and environmental protection safety functions. Criticality and confinement functions are provided by the dry shielding canister (DSC) and are not part of the HSM design basis.

The primary function of the HSM is to provide a means for heat removal; structural support and environmental protection for a loaded DSC; and shielding to limit doses to the workers and public. This is achieved by the massive concrete walls and roof and the steel DSC support structure incorporated into the HSM design. The HSM provides gamma and neutron shielding on the sides and front with shield walls installed (rear walls for single-row arrays) and end shield walls for an HSM at the end of an array. The shield walls and massive HSM roof provide environmental protection from tornado-generated missiles and additional neutron and gamma shielding.

For the structural stability evaluation (overturning and sliding) of the HSM Model 202 for the design basis flood loading, there is no change to the flood load criteria (the maximum water height of 50 ft and maximum velocity of water of 15 ft/sec are not changed), and the evaluations performed conclude that the HSM Model 202 meets the stability criteria. The factor of safety against sliding for the HSM Model 202 is greater than that for the Standardized HSMs. Although the factor of safety against overturning for the HSM Model 202 is 1.31, compared to 1.55 for the Standardized HSMs, this factor is higher than the minimum factor of safety of 1.1.

Thus, there is no effect on design functions as a result of this change.

The eight 72.48 evaluation criteria were met.

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***Licensing Review (LR) 721004-1005, Rev. 0* – (not yet incorporated into the UFSAR)**

Change Description

The change involved allowing an additional dry shielded canister (DSC) R45 transition rail configuration, in order to reduce the time required for R45 rail fit-up and welding. The alternate configuration involves a one-piece bent plate for the R45 transition rail web/rib plate in lieu of implementing a two-welded-plate configuration. A Transnuclear calculation evaluated the alternate rail configuration using the same model and method used in the original calculation.

Evaluation

The transition rails support the fuel tubes and transfer mechanical loads to the DSC shell. They also provide a thermal conduction path from the basket assembly to the canister shell wall.

The change had an adverse impact on the structural design function. The shielding, criticality, confinement and thermal design functions were not impacted as a result of the change. A structural calculation evaluated the proposed alternate of providing a one-piece bent stainless plate in lieu of two-piece welded rib plates. Hypothetical accident conditions (HAC) basket stresses were evaluated for side drop orientations of 45°, 60°, 90°, 161.5° and 180°. Side drop accident loadings were incrementally applied from 1g to 100g for HAC conditions, with maximum stress intensities reported at 75g. The highest stress increase occurred on the canister for the 161.5° side drop impact on one transfer cask support rail. The maximum stress change exhibited was an increase of 12.28 ksi where the stress value reported in UFSAR Table T.3.7-5 was 28.72 ksi at 75g, and the new stress value was 41.00 ksi at 76g. Although the stress increased as a result of the change to the R45 rail rib plate, the maximum stress exhibited is below the allowable stress intensity of 56.97 ksi. The maximum increase in the stress values previously reported is an increase of approximately 42.8% in the canister components: 28.72 ksi to 41.00 ksi. The proposed alternate is acceptable for use.

The eight 72.48 evaluation criteria were met.

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Enclosure 1 Part 2 - NONCONFORMANCES

LR 721004-422, Rev. 0 ***– (no associated UFSAR change)***

Change Description

The change involved nonconforming horizontal storage module (HSM) DSC (dry shielded canister) support-rail holes, which are required to be 6 inches +/- 1/16 in diameter, but were actually 6 1/8 inches to 6 1/2 inches in diameter. Three rails had this condition.

Evaluation

Holes are designed into the DSC support rails to increase air flow in the bottom portion of the DSC. The rails function to support the DSC. The rails do not provide shielding, confinement, or criticality control.

The larger holes in the rails will allow greater air flow and, therefore, improve heat transfer. The nonconforming holes reduce the rails' shear area and section properties by less than 1%. Therefore, the stresses increase by less than 1%. Maximum stresses increase from 23.44 ksi to 23.68 ksi, which is below the allowable limit of 24.4 ksi. The shear stress ratio of .96 increases to .97, which is below the allowable limit of 1.0. The rails, therefore, will perform their design functions.

The eight 72.48 evaluation criteria were met.

***LR 721004-650, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved the evaluation of potential foreign material that may be present in one dry shielded canister (DSC) to be stored by a Transnuclear (TN) client. This is not a change to the general design of the CoC 1004 Standardized NUHOMS® System.

The client provided a description of the foreign material that may have fallen into the DSC during loading operations. The bounding quantities are as follows:

- 0.16 lb of carbon steel, with no coatings (½ inch x ½ inch x 2¼ inches)

The DSC is loaded with fuel with a decay heat of 7.21 kW.

Evaluation

This foreign material was evaluated based on storage within the specific DSC and the specific horizontal storage module (HSM), and transfer in the specific transfer cask (TC), as described in the CoC 1004 licensing basis.

The DSC has containment, shielding, criticality control, and thermal safety functions. The primary function of the DSC is to provide confinement for the spent nuclear fuel. This is achieved by the stainless steel shell and inner and outer cover plates (top and bottom ends) which are integral to the shell assembly. The DSC provides gamma shielding at its ends by the use of thick end plugs. These provide ALARA dose rates at the top of the canister (for DSC drying and sealing operations) and at the bottom (for minimizing dose rates at the HSM doorway). Shielding in the radial direction is not a safety function of the DSC, although the DSC shell provides a small amount of shielding due to the shell thickness.

Criticality control is provided by the DSC's internal basket assembly.

The primary pressure boundary maintains an inert (helium) dry atmosphere inside the DSC to minimize pressure boundary and fuel degradation during storage in the HSM.

The effect of the potential introduction of foreign material into the 61BT DSC is evaluated as follows:

Carbon steel is stable and will not volatize, so the foreign material will not add any gas volume to the canister.

STRUCTURAL:

There are two concerns regarding the introduction of a small amount of foreign material. The first is the impact of the foreign material on the DSC pressure boundary. The second is the impact, if any, of the foreign material on the internal DSC environment, or atmosphere, including internal pressure.

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Impact of Foreign Material on DSC Pressure Boundary and Fuel Assemblies

The foreign material of concern could induce corrosion of the DSC components and/or fuel assemblies in an environment that is conducive to corrosion (an environment with water, air, or other electrolyte present). However, vacuum drying of the DSC reduces the quantity of water, air, or other oxidizing agents to 0.25 volume percent or less. This level of concentration of oxidizing agent with the balance of the DSC free volume filled with inert helium gas will not support any significant corrosion in the DSC. Therefore, although the debris in the DSC (carbon steel) could potentially cause some corrosion in an air/water environment, the lack of an oxidizing agent in the DSC and the inert helium gas fill of 99.75% of the free volume of the DSC, will preclude any corrosion of the pressure boundary, basket (or other DSC components), or fuel assemblies (FAs).

To quantify any impact of the foreign material on corrosion of the pressure boundary, corrosion rates for stainless steel were researched. Smithells Metals Reference Book 6th Edition, Butterworths, 1983, gives uniform corrosion rates for 18 Cr, 8 Ni stainless steel in an industrial atmosphere (approximately 21% O_2 and mildly corrosive) of 0.001 mm/year, or 0.0004 inch/year. The nominal DSC shell is 0.500 inches thick. A conservatively assumed rate of 0.0004 inch/year, which assumes a gaseous environment with O_2 and other corrosive gases, still would require over 125 years to reduce the nominal thickness 10%, a value that would still not significantly degrade the pressure boundary. Again, it should be noted that the DSC internal atmosphere is not industrial air, but dry helium.

The second is the impact of the material on the FAs.

To quantify any impact of the foreign material on corrosion of the fuel cladding, corrosion rates for zirconium were researched. Metals Handbook® 9th Edition, Corrosion, ASM International, 1987, provides an extremely conservative case of liquid hydrochloric acid on zirconium, and gives a rate of < 0.001 inch/year. The cladding thickness for the FAs involved is 0.028 inches or greater and full thickness corrosion would require more than 30 years. Again, it should be noted that the DSC internal atmosphere is not liquid hydrochloric acid, but dry helium. Therefore, the full thickness corrosion would require approximately the same number of years (125 years) as stainless steel.

The conclusion from both of these searches is that both the stainless steel pressure boundary and the zirconium cladding are resistant to corrosion and it would take more than 60 years, even assuming unrealistic environments, to reduce thickness to a level of concern. Therefore, corrosion from a very small amount of foreign material in a dry helium (inert gas) atmosphere is not a concern for the pressure boundary or the fuel cladding.

Given that the foreign material is carbon steel, the material will maintain its form during vacuum drying and storage conditions. The melting point of carbon steel is well above the bounding temperatures that will be seen inside the canister during vacuum drying and accident conditions such as blocked vents. The maximum calculated cladding temperature for this design, using a design basis heat load of 18.3 kW is 827 °F, is well below the melting point of carbon steel.

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Impact of Foreign Material on DSC Internal Pressure

The impact of the foreign material on DSC pressurization is assessed. The DSC free volume is 214.86 ft^3. As pressure is inversely proportional to volume, one can calculate the pressure increase due to a reduction in free volume in the canister due to the presence of the foreign material (½ inch x ½ inch x 2¼ inches carbon steel piece). The volume of the carbon steel piece is 0.0003 ft^3 ($0.5 \times 0.5 \times 2.25 / 12^3$). This reduction in volume is well within the accuracy of the calculated free volume inside the canister of 214.86 ft^3, therefore, there is no impact on the internal pressure in the canister due to the presence of the foreign material.

This ensures that the debris in the DSC will not adversely impact DSC pressure.

MECHANICAL:

There is no adverse impact. The foreign material has a small enough weight and volume (much less than 1 lb and 0.0003 ft^3 in the canister) that no problems are anticipated in successfully vacuum drying. Before leaving the fuel building for storage, the vacuum drying and sealing operations will have been performed successfully. It can be inferred that any reflooding operations would be similarly unaffected. Given that the debris is still intact, it would either be retained as it was before, or it would become dislodged during horizontal transfer and is now "loose" in the DSC. In either case, this debris is not large enough to block reflooding through the siphon tube, nor would it interfere with subsequent gas venting. During fuel unloading, there are no required changes to the procedures for opening the DSC, testing the atmosphere within the DSC, and removing the closure plates. The change addressed here does not affect system loading and unloading operations, nor does it alter any DSC handling operations.

THERMAL:

There is no adverse impact. The limiting source term is unchanged. There are no changes to the acceptance criteria for these fuel types. The volume of the foreign material is not sufficient to alter the DSC internal atmosphere and, thus, alter gaseous heat transfer.

SHIELDING:

There is no adverse impact. The introduction of foreign material into the DSC does not change the source term limits of the fuel qualification table. The shielding analysis does not explicitly rely on the DSC internal gas environment. The volume of the foreign material is very small, contains no significant material susceptible to activation (no cobalt) and, thus, will not significantly alter the long-term source term.

CRITICALITY:

There is no adverse impact. The DSC will be drained, successfully vacuum dried, and sealed. The very small amount of foreign material will not create a concern during future reflooding. The fuel cladding will not be breached by this small amount of foreign material, within a dry helium atmosphere. Thus, the cladding will not be breached and there will be no dispersal or reconfiguration of pellet material. The FA will not become "damaged". Thus, there is no adverse impact on criticality of including the small amount of foreign material.

WEIGHT:

There is no adverse impact. The weight of the foreign material is less than 0.2 lb. This will not change the DSC center of gravity location or exceed any weight limits.

CONFINEMENT:

There is no impact on the confinement capabilities of the DSCs, as there are no new leak paths introduced. As stated previously, the foreign material will not adversely impact the stainless steel DSC pressure boundary.

The eight 72.48 evaluation criteria were met.

***LR 721004-874, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved nonconforming gaps and misalignments between horizontal storage modules (HSMs) and HSM components during installation at a client site.

- HSM side-to-side gaps are required to be 6 ± 3/4 inches, but in one case the gap is 7 1/16 inches.
- HSM back-to-back gaps are required to be ≤ 3/4 inches, but in one case the gap is 7/8 inches; in another case the gap is 1 3/16 inches; and in another case the gap is 1 1/16 inches.
- Adjacent HSM front faces are required to be flush within 1/4 inches, but in one case they are 3/8 inches out-of-flush, and in another case they are 5/16 inches out-of-flush.
- HSM roof and base edges are required to be aligned within 1/4 inches, but in one case the roof and base are aligned at 7/16 inches.

Evaluation

The HSM provides structural protection to the dry shielded canister (DSC); provides heat transfer for decay heat removal; and provides radiation protection (shielding) from the spent fuel within the DSC to maintain dose rates ALARA at and around the ISFSI.

The effects of the non-conformances are limited to the shielding function of the HSM. A Transnuclear calculation was completed to evaluate effects on shielding due to the existing condition of the HSMs. The calculation documents a shielding evaluation that determines the average and maximum HSM surface dose rates using a bounding gap of 8 inches between adjacent HSMs. The results of the calculation indicate that the dose rates remain bounded by those reported in the UFSAR. Therefore, the shielding design function, as described in the UFSAR, is not adversely affected.

The shielding evaluation method used in the calculation is a different method than originally employed in the UFSAR shielding evaluations. The original method was based on the use of the 2D Discrete Ordinates Transport (DORT) code, and the new method was based on the use of the general purpose 3D Monte Carlo N-Particle code – MCNP5. MCNP5 is a state-of-the-art shielding analysis code and has been reviewed and approved by the NRC for the same application. Therefore, this is not a departure from a method of evaluation.

The eight 72.48 evaluation criteria were met.

***LR 721004-902, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved a nonconforming dry shielded canister (DSC) outer top cover plate with a thickness measurement in one measured location of 1.20 inches. The minimum thickness required by the UFSAR was 1.21 inches.

Evaluation

The design function of the outer top cover plate is to provide structural resistance to the DSC. The outer top cover plate is a redundant closure that protects the inner top cover plate and adds some structural support.

The structural design function is the only adversely effected function of the DSC for this condition. The effects of this non-conformance were analyzed in a Transnuclear calculation and are shown in the following table:

Stress Type	Greatest Load Combination	Stress Ratio	Multiplicative Factor	New Stress Ratio
Membrane Stress	HSM-8	0.36	$t_{nom} / t_{min} = 1.04$	0.38
Bending / Load Combination Stress	HSM-6	0.91	$t_{nom}^2 / t_{min}^2 = 1.08$	0.99

The stress ratio is defined as:

SR = Stress Intensity (Calculated) / Max Allowable Stress

Because the stress ratios remain less than 1, structural integrity for all accident and off-normal conditions is maintained.

The eight 72.48 evaluation criteria were met.

LR 721004-941, Rev. 0 *– (no associated UFSAR change)*

Change Description

The change involved a client site and plans to expand the ISFSI to add a single row array of horizontal storage modules (HSMs). The HSM base units to be used did not include embedments for rear shield wall attachment, because they were constructed for a double array arrangement. This single array arrangement required the rear shield walls to be connected to the HSM base unit using bolts through core holes drilled through the HSM base rear wall.

Evaluation

The HSM provides shielding and structural protection to the dry shielded canister (DSC) stored inside the HSM. A Transnuclear calculation evaluated the effects of the through-wall core drill holes on the HSM base rear wall capacities and associated load combination demand-to-capacity ratios. The tables below summarize the results of the evaluation.

Table 1 Comparison of Highest Combined Shear Forces/Moments

to Base Rear Wall Capacities

Load Combination (Comb)	Quantity	Vi kip/ft	Vo1 kip/ft	Vo2 kip/ft	M1 in-kip/ft	M2 in-kip/ft
Comb 1 thru 5 and 7	Computed Demand	25.34	10.35	11.54	67.08	59.21
	Capacity	51.0	12.7	13.6	203	305
	Ratio	0.50	0.81	0.85	0.33	0.19
Comb 6a and 6b	Computed Demand	15.03	7.03	6.40	85.95	39.33
	Capacity	46.5	12.1	12.9	182	273
	Ratio	0.32	0.58	0.50	0.47	0.14

Table 2 Comparison of Highest Combined Axial Forces/Moments to Base Rear Wall Capacities

Load Combination (Comb)	Quantity	p (Comp.) kip/ft	p1 (Tens.) kip/ft	p2 (Tens.) kip/ft	M1P in-kip/ft	M2P in-kip/ft
Comb1 thru 5 and 7	Computed	89.96	18.30	30.12	67.08	59.21
	Capacity	329.1	42.4	60.2	116	152
	Ratio	0.27	0.43	0.50	0.58	0.39
Comb 6a and 6b	Computed	35.47	8.55	22.61	85.95	39.33
	Capacity	296.0	37.9	53.9	141	158
	Ratio	0.12	0.23	0.42	0.61	0.25

The tables show the computed demand forces and moments resulting from the additional seismic loading imposed on the HSM base unit rear wall by the connected rear shield wall. Also shown are the revised (decreased) rear wall capacities, which were conservatively calculated assuming that rebar is cut at the four through-wall hole locations of the HSM base in both the horizontal and vertical directions. The maximum demand-to-capacity ratio is calculated as 0.85 and corresponds to the seismic load combination. As expected, this ratio is increased from the original ratio due to decreased steel cross section because of the rebar cuts. However, this demand-to-capacity ratio remains below the controlling demand-to-capacity ratio of 0.98 calculated based on the demand and capacities shown in UFSAR Table 8.2-18 (Load combination 8: demand shear load = 42.73 k/ft and shear capacity = 44.00 kip/ft; resulting in a demand-to-capacity ratio = 0.98).

The evaluation of the connection hardware showed that the maximum tensile stress, due to the pull loads in the connecting bolts, is 6.7 ksi versus an allowable of 94.5 ksi. This load is also significantly lower than the concrete cone pull out capacity. Hence, the connection hardware is not controlling.

Therefore, the evaluation shows that the rear wall with four through-wall core drills used to connect and support the rear shield wall is acceptable.

The eight 72.48 evaluation criteria were met.

LR 721004-956, Rev. 0 ***– (no associated UFSAR change)***

Change Description

The change involved placement of stainless steel shims under one horizontal storage module (HSM) end wall.

Evaluation

The HSM end wall provides structural protection and shielding to the HSM units and the dry shielded canister (DSC) stored inside the HSM. The end wall also contributes to providing stability to the HSM array system during accident conditions.

Placement of stainless steel shims under one HSM end wall panel was analyzed. This resulted in a change in the safety factors against sliding of the HSM modules due to seismic, flood and tornado-generated loads, as evaluated in the UFSAR, as follows:

HSM sliding due to seismic load:

Safety factor against sliding in the original analysis = 1.44

Actual Safety factor against sliding with shims = 1.24, which is greater than 1.1 and, therefore, is acceptable.

HSM sliding due to flood load:

Safety factor against sliding in the original analysis = 2.55

Actual safety factor against sliding with shims = 2.2, which is greater than 1.1 and, therefore, is acceptable.

HSM sliding due to tornado generated wind load:

Safety factor against sliding in the original analysis = 2.1

Actual safety factor against sliding with shims = 1.80, which is greater than 1.1 and, therefore, is acceptable.

HSM sliding due to tornado generated missile load:

Total distance one module slides in the original analysis = 0.34 inches

Actual distance one module slides with end wall and shims placed = 0.68 inches

However, this sliding distance will be significantly reduced due to the presence of more than one module next to one another. Therefore, the sliding displacement of the modules due to a massive missile impact is insignificant and will not cause any structural damage.

All results were determined to be acceptable.

The eight 72.48 evaluation criteria were met.

***LR 721004-979, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved the use of one horizontal storage module (HSM) door-attachment embedment, placed tilted off-the-horizontal downward by 9 degrees while using a bent stud in attachment of the HSM door to the base in order to accommodate the tilted door-attachment embedment. This resulted in a change in the direction of the load applied to the door attachment embedment and associated fastener stud, and in turn a change to the safety factors.

Evaluation

The HSM door attachment embedment resists loads on the HSM door and is used to fasten the HSM door to the HSM base. A Transnuclear calculation evaluated this configuration, with the following results:

Tension Load on Embedment:

Increased tension load on embedment due to 9 degrees tilt = 11.24 kips

Steel tensile capacity of embedment = 41.6 kips, which is greater than 11.24 kips; therefore, this is acceptable.

Tilted embedment concrete break out capacity in tension = 55.7 kips, which is greater than 11.24 kips; therefore, this is acceptable.

Ultimate tensile capacity of embedment is higher than the embedment concrete capacity in tension; therefore, the connection is not ductile. Thus, the concrete capacity in tension is limited to 50% as assumed in the existing HSM structural evaluation.

Tilted embedment concrete break out capacity in tension = 0.50 x 55.7 kips = 27.9 kips, which is greater than 11.24 kips; therefore, this is acceptable.

Minimum Edge Distance:

Minimum edge distance required (m) = 7.4 inches

Minimum edge distance for embedment = 9.58 inches, which is greater than 7.4"; therefore, this is acceptable.

Shear Load on Embedment:

Shear load on embedment = 1.8 kips

Concrete shear capacity of embedment = 34.7 kips

The connection is considered non-ductile; therefore, concrete capacity is limited to 50%, as assumed in the existing HSM structural evaluation. Concrete shear capacity of embedment = 1/2 x 34.7 = 17.4 kips, which is greater than 1.8 kips; therefore, this is acceptable. The ductility requirement is satisfied.

Steel shear capacity of embedment = 25.4 kips, which is greater than 1.8 kips; therefore, this is acceptable.

<u>Tension Load on Fastener:</u>

Tension load on fastener = 11.24 kips

Steel tensile capacity of fastener = 94.5 ksi x 1.41 = 133 kips, which is greater than 11.24 kips; therefore, this is acceptable.

<u>Shear Load on Fastener:</u>

Shear load on fastener = 1.7 x 1.8 = 3.1 kips [1.7 load factor for shear is consistent with the existing HSM structural evaluation].

Steel shear capacity of fastener = 57.7 ksi x (32.8 / 36.0)(1) x 1.41 = 74.1 kips, which is greater than 3.1 kips; therefore, this is acceptable.

(1) 32.8 ksi is the yield strength of ASTM A36 steel. 32.8 / 36.0 = the reduction ratio of steel strength due to elevated temperature of 200 °F. This is conservative and was used for consistency with the existing HSM structural evaluation.

<u>Combined Tension and Shear:</u>

(Embedment-steel): Total tension and shear steel area required = 0.48 in^2, which is less than 1.41 in^2; therefore, this is acceptable.

(Embedment-concrete): 8.5.1.3 of ACI-349-85 is met by satisfying the requirements for concrete strength in tension and shear, as shown above. Ductility requirements are fulfilled by limiting the concrete allowable strength to 50% of concrete capacity, as assumed in the existing HSM structural evaluation.

(Fastener): Tension-shear interaction ratio = (11.24 / 133) + (3.1 / 74.1) = 0.13, which is less than 1; therefore, this is acceptable [method of verification is consistent with the existing HSM structural evaluation].

The eight 72.48 evaluation criteria were met.

***LR 721004-1039, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved placement of stainless steel shims under one horizontal storage module (HSM) rear shield wall.

Evaluation

The HSM rear shield wall provides missile protection and additional shielding for a dry shielded canister (DSC) stored in the HSM. The rear shield wall is credited in the stability analysis of the HSM array during an accident.

The shims change the rear shield wall coefficient of friction to lower than what is assumed in the HSM stability calculation. A Transnuclear calculation evaluated the placement of stainless steel shims under one HSM rear shield wall. The results showed that the module is expected to move 0.74 inches compared to 0.58 inches reported in the original calculation. When considering the impact of three modules arranged in a single array, the movement is increased to 0.19 inches compared to 0.12 inches reported in the original calculation. The evaluation of three modules is conservative when considering these particular modules are arranged in a 14-module single array. Therefore, sliding displacement of the module due to a massive tornado-missile impact is insignificant and will not cause any structural damage.

In summary, the proposed activity will not impact the rear shield wall's ability to perform its design function.

The eight 72.48 evaluation criteria were met.

***LR 721004-1071, Rev. 0* – (no associated UFSAR change)**

Change Description

The change involved completion of a Transnuclear (TN) calculation to evaluate horizontal storage modules (HSM) loaded with dry shielded canisters (DSCs) at a client site for seismic accelerations obtained from a site-specific soil-structure interaction (SSI). Two different configurations were evaluated, based on the planned loading combinations of HSMs and DSCs.

Evaluation

The design functions of the HSM are to provide support and protection for the DSC, convection air flow for cooling, and shielding from radiation emanating from the DSC. The TN calculation evaluated the effects on the stability of the HSMs loaded with DSCs on the ISFSI base mat for seismic loads.

The following evaluations were performed:

Configuration 1:

Configuration 1 - Overturning due to Seismic Loads:

HSM peak vertical seismic acceleration = 0.18g
DSC peak vertical seismic acceleration = 0.18g
HSM peak horizontal seismic acceleration = 0.28g
DSC peak horizontal seismic acceleration = 0.405g
The HSM stabilizing moment M_{ST} = 20,387 kip-inch
The HSM overturning moment M_{OT} = 14,566 kip-inch

Stabilizing moment is greater than the overturning moment such that a single HSM module will not overturn during a seismic event. The factor of safety against overturning = 20,387 / 14,566 = 1.40, which is greater than the allowable safety factor of 1.1 reported in the UFSAR and the licensing basis structural calculation.

Configuration 1 - Sliding due to Seismic Load

The friction force resisting sliding = 172.94 kips
The applied horizontal seismic force = 109.5 kips
The force required to slide the HSM is larger than the resulting lateral seismic force and, therefore, the HSM will not slide.
The factor of safety against sliding is 172.94 / 109.5 = 1.58, which is greater than 1.1. Therefore, the sliding factor of safety is within the allowable value.

Stability Evaluation of the DSC on the Support Rails inside the HSM

Stabilizing moment = 1,220 kip-inch

Overturning moment = 1,043 kip-inch

Because the stabilizing moment is greater than the overturning moment, the DSC will not uplift from the support structure rails inside the HSM. The margin of safety against DSC lift off from the DSC support rails = 1220 / 1043 = 1.17. The required factor of safety against overturning is 1.1. Therefore, the overturning factor of safety is within the allowable value.

The DSC will not slide in the transverse direction due to the oppositely inclined rails. Hence the DSC is stable in the transverse direction. However in the longitudinal direction, the DSC may slide on the rails due to seismic load, but the canister stop plates and the seismic retainer will provide restraint.

Seismic stresses of the DSC inside the HSM

The enveloped maximum accelerations at the center of gravity of the DSC as obtained from the site specific SSI analysis are 0.405g in the horizontal direction, and 0.18g in the vertical direction. These accelerations are also bounded by the enveloped load of 2g axial, 2g transverse, and 2g vertical for which the analysis results are reported in the current structural evaluation. Therefore, the DSC components are qualified to the maximum site-specific accelerations obtained from the SSI analysis of client ISFSI site.

Shear Stress in DSC Basket Rail Stud due to Site-Specific SSI Analysis Seismic Load

Basket seismic axial/transverse acceleration = 0.405g

Basket seismic vertical acceleration = 0.18g

The maximum axial inertial load generated by the basket and fuel assemblies during a seismic event = 26,699 lb

Stress area in the rail stud welds = 7.037 in^2

Shear stress generated in the stud welds = 3.79 ksi, which is less than 26.63 ksi (Level C shear stress allowable)

DSC Axial Retainer Evaluation for Site-Specific SSI Analysis Seismic Load

Maximum spectral horizontal acceleration at CG = 0.405g

Maximum spectral vertical acceleration at CG = 0.18g

The load on the axial retainer = 22.34 kips

Axial stress in 2-inch diameter steel rod = 22.34 / 3.1416 = 7.1 ksi, which is less than 18.7 ksi

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Configuration 2

Configuration 2 - Overturning with End Shield Wall due to Seismic Loads:

HSM and shield wall peak vertical seismic acceleration = 0.18g

DSC peak vertical seismic acceleration = 0.18g

HSM and shield wall peak horizontal seismic acceleration = 0.28g

DSC peak horizontal seismic acceleration = 0.405g

The HSM stabilizing moment M_{ST} = 36,943 kip-inch

The HSM overturning moment M_{OT} = 22,989 kip-inch

The stabilizing moment is greater than the overturning moment, so the single HSM module will not overturn during a seismic event. The factor of safety against overturning = 36,943 / 22,989 = 1.61, which is greater than the allowable safety factor of 1.1 reported in the UFSAR and the licensing basis structural calculation.

Configuration 2 - Overturning of Single Free Standing Module due to Seismic Loads:

HSM and shield wall peak vertical seismic acceleration = 0.18g

DSC peak vertical seismic acceleration = 0.18g

HSM and shield wall peak horizontal seismic acceleration = 0.28g

DSC peak horizontal seismic acceleration = 0.405g

The HSM stabilizing moment M_{ST} = 20,759 kip-inch

The HSM overturning moment M_{OT} = 16,073 kip-inch

The stabilizing moment is greater than the overturning moment, so a single HSM module will not overturn during a seismic event. The factor of safety against overturning = 20,759 / 16,073 = 1.29, which is greater than the allowable safety factor of 1.1 reported in the UFSAR and the licensing basis structural calculation.

Configuration 2 - Sliding due to Seismic Load

The friction force resisting sliding = 222.28 kips

The applied horizontal seismic force = 123.4 kips

The force required to slide the HSM is greater than the resulting lateral seismic force and, therefore, the HSM will not slide.

The factor of safety against sliding is 222.28 / 123.4 = 1.80, which is greater than 1.1. Therefore, the sliding factor of safety is within the allowable value.

Stability Evaluation of the DSC on the Support Rails inside the HSM

Stabilizing moment = 1,283.7 kip-inch

Overturning moment = 1,098.2 kip-inch

Because the stabilizing moment is greater than the overturning moment, the DSC will not uplift from the support structure rails inside the HSM. The margin of safety against DSC lift off from the DSC support rails = 1283.7 / 1098.2 = 1.17. The required factor of safety against overturning is 1.1. Therefore, the overturning factor of safety is within the allowable value.

The DSC will not slide in the transverse direction due to the oppositely inclined rails. Hence, the DSC is stable in the transverse direction. However in the longitudinal direction, the DSC may slide on the rails due to seismic load, but the canister stop plates and the seismic retainer will provide restraint.

Seismic Stresses in the HSM Concrete Module and the Steel Support Structure

Maximum acceleration at the CG of the HSM is 0.405g in the horizontal direction, and 0.18g in the vertical direction obtained from the SSI analysis at the client site. Therefore, in order to qualify the HSM concrete and support steel components for the client ISFSI site, a scale factor of 1.095 (0.405g / 0.37g) may be used conservatively.

Concrete components and support steel components have a maximum stress ratio of 0.91 and 0.70, which is less than 1.0 for a scale factor of 1.095, and is acceptable.

Seismic Stresses of the DSC inside the HSM

The SSE enveloped maximum accelerations at the center of gravity of the DSC, as obtained from the site-specific SSI analysis, are 0.405g in the horizontal direction and 0.18g in the vertical direction. These accelerations are also bounded by the enveloped load of 2g axial, 2g transverse, and 2g vertical for which the analysis results are reported in the current structural evaluation. Therefore, the DSC components are qualified to the maximum site-specific accelerations obtained from the SSI analysis of client ISFSI site.

Shear Stress in DSC Basket Rail Stud due to Site-Specific SSI Analysis Seismic Load

Basket accelerations of 0.405g in the axial direction, 0.405g in the transverse direction, and 0.18g in the vertical direction were conservatively used for this evaluation. During the seismic event, the inertial load of the basket and fuel assemblies in the axial direction will produce shear stress in the basket rail stud welds. This stress is computed for a bounding acceleration of 2g in the axial direction, 2g in transverse direction, and 2g is reported in the UFSAR and the licensing basis structural calculation.

DSC Axial Retainer Evaluation for Site-Specific SSI Analysis Seismic Load

Maximum spectral horizontal acceleration at CG = 0.405g

Maximum spectral vertical acceleration at CG = 0.18g

Shear load on the seismic retainer = 61 kips

The load on the axial retainer = 23.49 kips

Axial load of 23.49 is less than shear load of 61 kips and, therefore, this is acceptable.

The evaluation shows that the Configuration 1 and Configuration 2 combinations of HSMs and DSCs will remain stable and structurally adequate when subjected to the seismic loads obtained from site-specific SSI analysis at the client ISFSI site. The stress in the HSM concrete and steel components will remain within the allowable. The DSCs on the support rails will not lift off and the stresses in the DSC components will be within the code allowable.

The eight 72.48 evaluation criteria were met.

LR 721004-1074 Rev. 0 ***– (no associated UFSAR change)***

Change Description

The change involved an evaluation, requested by a client, for foreign material that may not be readily retrievable from fuel assemblies (FAs) before loading into a dry shielded canister (DSC). An inspection identified 33 FAs that have metal debris, 6 FAs that have paint chip debris, and 6 FAs that have plastic/fiber debris. This is not a change to the generic design of the CoC 1004 Standardized NUHOMS® System.

The Transnuclear client provided a description of the foreign material. There are three types of debris present within the FAs that require evaluation: (1) stainless steel or carbon steel metal debris in various geometries, (2) small size (1/2 inch x 1/4 inch or smaller) paint chips, and (3) plastic or fiber debris.

The worst-case values for each type of foreign material are obtained by conservatively assuming that all of the identified values of the debris described above are loaded into a single DSC, as follows:

- All of the metal debris (stainless steel, carbon steel, or a combination) from 33 FAs: various sizes with a cumulative weight of all listed metal debris for the 33 assemblies of approximately 0.17 lb.
- Paint chips (Ameron Amerlock epoxy) from 6 FAs: various sizes with a cumulative weight of 0.000269 lb ÷ 6 FAs times 32 FAs or roughly 0.0014 lb (conservatively assumes paint chips within all FAs).
- Plastic and fiber debris (cloth strings, string mesh, plastic, plastic tape, and nylon wrap) from 6 FAs: various sizes with a cumulative weight of 0.006214 lb ÷ 6 FAs times 32 FAs or approximately 0.0331 lb (conservatively assumes debris within all FAs).

Evaluation

The DSC has confinement, shielding, criticality control, and thermal safety functions. The primary function of the DSC is to provide confinement for the spent nuclear fuel. This is achieved by the stainless steel shell and inner and outer cover plates (top and bottom ends), which are integral to the shell assembly. The DSC provides gamma shielding at its ends by using thick end plugs. These provide ALARA dose rates at the top of the canister (for DSC drying and sealing operations) and at the bottom (for minimizing dose rates at the HSM doorway). Shielding in the radial direction is not a safety function of the DSC, although the DSC shell provides a small amount of shielding due to the shell thickness.

Criticality control is provided by the DSC's internal basket assembly and soluable boron credit.

Heat transfer is provided by the helium atmosphere within the DSC and the aluminum/stainless steel in the basket and rails.

The primary pressure boundary, which is 304 stainless steel, maintains an inert (helium) dry atmosphere inside the DSC to minimize pressure boundary and fuel degradation.

The effect of the potential introduction of foreign material into the DSC is evaluated. This material was identified in the fuel assemblies and cannot be removed prior to fuel loading into the DSC:

- 0.17 lb of either stainless steel or carbon steel, or a mix, per DSC.
- 0.0014 lb of paint chips per DSC.
- 0.0331 lb of plastic and fiber debris (cloth strings, string mesh, plastic, plastic tape, and nylon wrap) per DSC.

One concern that exists, due to the presence of foreign material, is that it could volatize, which would result in an increase in the gas volume within the DSC. Both the stainless steel and carbon steel are stable and will not volatize, so no contribution from this debris is calculated.

To calculate the added volume due to vaporization of the non-metallic material, it is conservatively assumed that the helium atmosphere inside the DSC is @ 14.7 psia (0 psig), in order to maximize the impact of any contribution from the organic foreign material. Assuming that the weight of the non-metallic foreign material fully converts into hydrogen (the gas with the lowest density and, thus, the greatest volume increase), results in an added hydrogen gaseous volume of (0.0345 lb)/0.0056 lb/ft^3 = 6.2 ft^3 of hydrogen. This is a very conservative assumption since much of the material is of heavier elements that will result in lower volumes of gas.

STRUCTURAL:

There are two concerns regarding the introduction of a small amount of foreign material. The first is the impact of the foreign material on the DSC pressure boundary. The second is the impact, if any, of the foreign material on the internal DSC environment, or atmosphere, including internal pressure.

Impact of Foreign Material on DSC Pressure Boundary and FAs

The foreign materials of concern could induce corrosion of the DSC components and/or fuel assemblies in an environment that is conducive to corrosion (an environment with water, air, or other electrolyte present). However, the vacuum drying of the DSC reduces the quantity of water, air, or other oxidizing agents to 0.25 volume percent or less. This level of concentration of oxidizing agent with the balance of the DSC free volume filled with inert helium gas will not support any significant corrosion in the DSC. Therefore, although the debris in the DSC (paint chips, plastic, fiber, carbon steel, and stainless steel) could potentially cause some corrosion in an air/water environment, the lack of an oxidizing agent in the DSC and the inert helium gas fill of 99.75% of the free volume of the DSC, will preclude any corrosion of the pressure boundary, basket (or other DSC components) or FAs.

To quantify any impact of the foreign material on corrosion of the pressure boundary, corrosion rates for stainless steel were researched. Smithells Metals Reference Book 6th Edition, Butterworths, 1983, gives uniform corrosion rates for 18 Cr, 8 Ni stainless steel in an industrial atmosphere (approximately 21% O_2 and mildly corrosive) of 0.001 mm/year, or 0.0004 inch/year. The nominal DSC shell is 0.500 inches thick. A conservatively assumed rate of 0.0004 inch/year, which assumes a gaseous environment with O and other corrosive gases, still would require over 125 years to reduce the nominal thickness 10%, a value that would still not significantly degrade the pressure boundary. Again, it should be noted that the DSC internal atmosphere is not industrial air, but dry helium.

The impact of the material on the FAs is discussed in the following:

To quantify any impact of the foreign material on corrosion of the fuel cladding, corrosion rates for zirconium were researched. Metals Handbook® 9th Edition, Corrosion, ASM International, 1987, provides an extremely conservative case of liquid hydrochloric acid on zirconium, and gives a rate of < 0.001 inch/year. The nominal cladding thickness for the FAs involved is 0.0243 inches and full thickness corrosion would require more than 24 years. Again, it should be noted that the DSC internal atmosphere is not liquid hydrochloric acid, but dry helium.

The conclusion from both of these searches is that both the stainless steel pressure boundary and the zirconium cladding are resistant to corrosion and it would take many years, even assuming unrealistic environments, to reduce thickness to a level of concern. Therefore, corrosion from a very small amount of foreign material in a dry helium (inert gas) atmosphere is not a concern for the pressure boundary or the fuel cladding.

Given that this foreign material is placed within the DSC, three scenarios are possible for the plastic, fiber, and paint chip debris materials:

1. The plastic, fiber, and paint chip material did not melt/vaporize during vacuum drying (VD) operations and remains present at the start of HSM storage. This material is then present in an inert dry atmosphere (helium).

2. The plastic, fiber, and paint chip material decompose/melt during VD operations, but did not vaporize. Thus, it remains as a solid reconfigured piece of material.

3. The plastic, fiber, and paint chip material melt and vaporize during VD operations and all that remains is residue.

In all three cases, if this material is in contact with the pressure boundary (304 stainless steel) there is no concern of boundary degradation, given the dry inert atmosphere. If this material were in contact with the FA, specifically the cladding, the worst-case result would be localized cladding corrosion. Given the extremely small amount of foreign material (approximately 0.2 lb) and the inert dry helium atmosphere, cladding breach would not occur. Even if a non-mechanistic conservative assumption is made that the pin gas inventory is released, the release of fill gas is already an analyzed event and this foreign material does not increase the severity of the event.

The DSC water inventory weight ranges from 10,750 lb to 14,230 lb depending on the DSC model used. As discussed above, the weight of plastic, fiber, and paint chips per DSC is estimated at 0.0345 lb, which yields a plastic, fiber, and paint chip concentration of 0.0345/10,750 (using smallest volume) = 3.2 ppm (parts per million). This extremely small concentration will have no impact on reflooding operation. This is a conservative assessment for a reflood condition. This quantity of foreign material (plastic, fiber, and paint debris) in an inert DSC will have no impact on the performance of the DSC or fuel cladding.

Impact of Foreign Material on DSC Internal Pressure

The impact of the foreign material on DSC pressurization was assessed. The DSC free cavity volume varies depending on the DSC model used and ranges from 220,163 in^3 to 236,095 in^3. The smallest volume of 220,163 in^3 or 127.4 ft^3 will be conservatively considered. Assume that the helium atmosphere is @ 14.7 psia (0 psig), in order to maximize the impact of any contribution from off-gassing of the debris. As determined above, the conservative estimate for additional gas volume from non-metallic debris is 6.2 ft^3. This then results in a pressure increase of (6.2) / 127.4 = 4.9%.

The design pressure used for DSC analysis is 15 psig for normal, 20 psig for off-normal, and 125 psig for accident cases. The actual pressure values calculated are approximately 6.5 psig for normal, < 15.0 psig for off-normal, and approximately 106-113 psig for accident conditions, respectively. In all cases, the pressure increase due to the foreign material (conservatively calculated) of 4.9% is less than the "available" margin between the calculated and design pressure. Therefore, the 4.9% increase in calculated pressure will not exceed the previously specified DSC design pressure.

The internal pressure calculated above is conservative for the associated fuel assemblies because the design basis FAs with 208 fuel rods are employed for this purpose. The associated FAs are based on the Westinghouse 14x14 design with 179 fuel rods. This will result in a lower internal pressure due to reduced contribution from fission gas release – approximately 14% reduction in the fission gas release contribution. This difference will serve to reduce the impact of the 4.9% increase in the calculated internal pressure.

Thus, there is no adverse impact on canister internal design pressure, as the internal pressure, even considering the added gas volume (conservatively calculated), is less than the design limit.

The hydrogen combustible limit of 4% is addressed by standard procedural requirements, for all DSC closure and opening operations that require monitoring for hydrogen. If hydrogen levels are above the set limits, the canister will be purged with helium to reduce the hydrogen concentration to acceptable limits before any welding/cutting. This ensures that the debris in the DSC will not adversely impact DSC pressure or combustibility limit.

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MECHANICAL:

There is no adverse impact. The foreign material has a small enough volume (approximately 0.2 lb per DSC), that no problems are anticipated in successful vacuum drying. Before leaving the building for storage, the vacuum drying and sealing operations will have been performed successfully. It can be inferred that any reflooding operations would be similarly unaffected. Assuming that the debris is still intact, it would be either retained as it was before, or it would become dislodged during horizontal transfer and is now "loose" in the DSC. In either case, this debris is not large enough to block reflooding through the siphon tube, nor would it interfere with subsequent gas venting. During fuel unloading, there are no required changes to the procedures for opening the DSC, testing the atmosphere within the DSC, and removing the closure plates. The change addressed by this evaluation does not affect system loading and unloading operations, nor does it alter any canister handling operations.

THERMAL:

There is no adverse impact. The limiting source term is unchanged. There are no changes to the acceptance criteria for these fuel types. The volume of the foreign material is not sufficient to alter the DSC internal atmosphere and, thus, alter gaseous heat transfer. Any gas generated from breakdown of the foreign material will only add to the internal atmosphere (e.g., the assumed helium for gaseous heat transfer is not reduced).

SHIELDING:

There is no adverse impact. The introduction of foreign material into the DSC does not change the source term limits of the fuel qualification table. The shielding analysis does not explicitly rely on the DSC internal gas environment. The volume of the foreign material is very small, contains no significant material susceptible to activation (no cobalt), and thus, will not significantly alter the long-term source term.

CRITICALITY:

There is no adverse impact. The DSC will be drained, successfully vacuum dried, and sealed. The very small amount of foreign material will not create a concern during future reflooding. As shown previously, the concentration of dissolved materials (conservatively assuming that it all goes into solution following reflood) is very low, and thus, will not adversely change k_{eff}. The fuel cladding will not be breached by this small amount of foreign material within a dry helium atmosphere. Thus, the cladding will not be breached, and there will be no dispersal or reconfiguration of pellet material. The FA will not become "damaged". Thus, there is no adverse impact on criticality of including the small amount of foreign material.

WEIGHT:

There is no adverse impact. The weight of the foreign material is approximately 0.2 lb. This will not change the DSC center of gravity location or exceed any weight limits.

CONFINEMENT:

There is no impact on the confinement capabilities of the DSC, as there are no new leak paths introduced. As stated previously, the foreign material will not adversely impact the stainless steel DSC pressure boundary.

The eight 72.48 evaluation criteria were met.