From: "Mason, Mike" <Mike.Mason@transnuclear.com>
To: Joseph Sebrosky <JMS3@nrc.gov>
Date: 8/3/05 12:01PM
Subject: NUHOMS HD

Attached is our revised draft response for resolution of the end drop issue.

CC: "Neider, Tara" <tara.neider@transnuclear.com>

72-1030

Mail Envelope Properties (42F0EA4F.75B : 1 : 34651)

Subject:	NUHOMS HD
Creation Date:	8/3/05 12:06PM
From:	"Mason, Mike" <Mike.Mason@transnuclear.com>
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32CHPT3appendices-Rev 3.pdf	198631	
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TRANSNUCLEAR

E-22577
August 3, 2005

Mr. Joe Sebrosky
Spent Fuel Project Office, NMSS
U.S. Nuclear Regulatory Commission
11555 Rockville Pike M/S 0-6-F-18
Rockville, MD 20852

Subject: NUHOMS® HD Storage System Docket No. 72-01030.
(TAC No. L23738)

Dear Mr. Sebrosky:

Transnuclear, Inc. formally requests the removal of the fuel cladding 75g end drop analysis presented in Chapter 3, Section 3.5.3.2 and cladding one-foot end drop analysis described in Appendix 3.9.8, Section 3.9.8.10 of the NUHOMS® HD System Safety Analysis Report. The SAR did not demonstrate the structural integrity of the fuel cladding during these events. However, as stated in Section 3.1.1.4 of SAR (new section added with this submittal), the end drop evaluation is not considered a credible event during 10CFR72 transfer operations. All lifts of the DSC in the transfer cask prior to transfer are governed under the nuclear plant's 10 CFR 50 Heavy Lifts Program.

As a result of the changes requested above, enclosed are revised SAR pages on a replacement basis. Additional revised SAR pages from our response to RAI2 (E-22383) will be incorporated into the FSAR and Section 3.9.8.14 will be deleted.

Evaluations of the end drop on the DSC, basket and transfer cask are adequately addressed in the current Safety Analysis Report and no revisions are necessary.

Transportability in accordance with 72.236(m), is addressed below.

Although it has not been demonstrated that the fuel cladding will remain intact during an end drop, the DSC canister and internals have been evaluated for an end drop load of 75 g's. This value is equal or higher transportation systems using impact limiters. It is the intent to license the 32PTH canister for transport inside a transport cask with impact limiters similar to the MP-197. This cask was drop tested on the end. Measured acceleration values were between 62 and 70 g's. Therefore it is reasonable to expect that a transport cask with impact limiters can be designed to limit the g-loads for the end drop to less than 75 g's. Fuel cladding evaluations for this type of load have been successfully performed in other applications, and will be evaluated in the transport application.

7135 Minstrel Way, Suite 300, Columbia, MD 21045
Phone: 410-910-5900 • Fax: 410-910-6902

If you have any questions regarding this submittal, please contact Mike Mason at 914-347-2345 or Tara Neider at 410-910-6860.

Sincerely,

Tara Neider
Senior Vice President Engineering

Revised SAR Pages:

- 2-3
- 3-iii
- 3-9, 3-9a
- 3-19
- 3-29 through 3-33
- 3-41
- Table 3-13 (deleted)
- 3.9.1-56a
- 3.9.7-1
- 3.9.8-3/4
- 3.9.8-15
- 3.9.8-20
- 3.9.10.1
- 7.4
- 8.1
- 11.8
- 11.9
- 12-31

performed in Chapters 5 and 6. The fuel assembly classes considered are listed in Table 2-1. It was determined that the Framatome 17x17 is the enveloping fuel design for the shielding, thermal and confinement source term calculation because of its total assembly weight and highest initial heavy metal loading. The bounding source term for shielding analysis is given in Table 2-3. Table 2-4 presents the thermal and radiological source terms for the Non-Fuel Assembly Hardware (NFAH).

These values are consistent with the cumulative exposures and cooling times of the fuel assemblies. The gamma spectra for the bounding fuel assembly and NFAH are presented in Chapter 5.

The shielding evaluation is performed assuming 32 fuel assemblies with the parameters (1.5kW) shown in Table 2-3. Any fuel assembly that is thermally qualified by Table 2-2 is also acceptable from a shielding perspective since only eight (8) Zone 3, (1.5 kW max), fuel assemblies are allowed in the 32PTH DSC. Minimum initial enrichments are defined for each of the zones to assure the shielding evaluation is bounding.

For criticality safety, the WE 17x17 standard assembly is the most reactive assembly type for a given enrichment. This assembly is used to determine the most reactive configuration in the DSC. Using this most reactive configuration, criticality analysis for all other fuel assembly classes is performed to determine the maximum enrichment allowed as a function of the soluble boron concentration and fixed poison plate loading. The analyses results are presented in Chapter 6.

For calculating the maximum internal pressure in the NUHOMS®-32PTH DSC, it is assumed that 1% of the fuel rods are damaged for normal conditions, up to 10% of the fuel rods are damaged for off normal conditions, and 100% of the fuel rods will be damaged following a design basis accident event. A minimum of 100% of the fill gas and 30% of the fission gases within the ruptured fuel rods are assumed to be available for release into the DSC cavity, consistent with NUREG-1536 [17].

The maximum internal pressures used in the structural analysis for the NUHOMS®-32PTH DSC are 15, 20, and 120 psig for normal, off-normal and accident conditions, respectively, during storage and transfer operations and 70 psig during storage accident conditions.

The structural integrity of the fuel cladding due to the side drop is analyzed in Section 3.5.3. The end and corner drops are not considered credible during storage and transfer. The structural integrity of the fuel cladding due to these loads will be addressed by the users under their site licenses (10CFR50).

LIST OF TABLES

LIST OF FIGURES

The top trunnions are constructed from SA-182 Type FXM-19 and the bottom trunnions are constructed from SA-182 Type 304. Both materials are stainless steel forgings. The top trunnions are designed fabricated and tested in accordance with ANSI N14.6 [8] as single failure proof lifting devices. Consequently they are designed with a factor of safety of six against the material yield strength and a factor of ten against the material ultimate strength.

D. Operational Features

The NUHOMS®-OS187H transfer cask is not considered to be operationally complex and is designed to be compatible with spent fuel pool loading/unloading methods. All operational features are readily apparent from inspection of the General Arrangement Drawings provided in Chapter 1, Section 1.5. The sequential steps to be followed for cask loading, testing, and unloading operations are provided in Chapter 8.

3.1.1.4 Discussion of NUHOMS® HD System Drop Analysis

All lifting of the TC loaded with the DSC must be made within the existing heavy loads requirements and procedures of the licensed nuclear power plant. The TC design has been reviewed under 10 CFR Part 72 and found to meet NUREG-0612 and ANSI N14.6.

The transfer cask is transported to the ISFSI in a horizontal configuration. Therefore the only credible drop accident during storage or transfer operations is a side drop. The transfer cask, canister and fuel cladding are analyzed for these credible accidents in the appendices listed below.

In addition, a vertical or corner drop accident may be credible under 10CFR50 during loading onto the trailer or during transport operations governed under 10CFR71. The transfer cask and canister have been evaluated for these postulated accidents. However, the fuel cladding integrity has not been demonstrated for these accident scenarios. An additional safety review by the user is required to demonstrate fuel cladding integrity under 10CFR50 or to demonstrate that the drop accidents are not credible.

The drop analyses of the NUHOMS® HD components are performed in the following Appendices.

Appendix 3.9.1

This appendix describes the detail analysis of the canister and basket for all the loading conditions. For the drop loads, the canister is analyzed for the 75g side and end drops. The canister end closure welds are analyzed for the 22g corner drop.

The basket is analyzed for 75g the side and end drops. The basket is not analyzed for the 22g corner drop since the 75g end drop analysis bounds the 22g corner drop.

Appendix 3.9.2

This appendix describes the detail analysis of the TC for all the loading conditions. For the drop loads, the TC is analyzed for the 75g side and end drops. The results for the TC corner drop using LS-DYNA is reported in Appendix 3.9.10 (page 3.9.10-14).

Appendix 3.9.3

This appendix describes the detail analysis of the TC top cover bolt and ram cover bolt due to the 22g corner drop. The stress analysis is performed in accordance with NUREG/CR-6007.

Appendix 3.9.4

This appendix describes the detailed analysis of the TC lead slump and inner shell buckling analysis. A 75g end drop load is used for these analyses.

Appendix 3.9.8

This appendix describes the detailed structural analysis of the fuel cladding due to the following loads.

10CFR72 (Normal & Off-Normal loads):

1g down (dead weight), transfer loads (1g longitudinal, 1g transverse, and 1g vertical).

10CFR71 (Normal loads): 30g (1 foot side drop)
1 foot end drop will be addressed in the 10CFR71 application.

3.3.3 OS187H Transfer Cask Material Properties

The principal material of construction for the OS187H transfer cask is Type 304 stainless steel. The transfer cask structural, inner and outer neutron shield shells and the bottom closure assembly are constructed from SA-240 Type 304 stainless steel. The primary structural member of the top cover plate is constructed from SA-240 Type XM-19 stainless steel. Table 3-5 contains the ASME Code material properties for SA-240 Type 304 stainless steel material. ASME Code material properties for the top cover material (SA-240 Type XM-19) are given in Table 3-8.

The transfer cask top cover and ram access cover bolts are constructed from SA-540 Grade B24 Cass 1. ASME Code material properties for SA-540 Grade B24 Class 1 are given in Table 3-9.

Material properties for ASTM B-29 (Chemical Lead), which is used for the transfer cask radial gamma shield, are given in Table 3-10.

The outer radial neutron shield consists of a SA-240 Type 304 stainless steel shell that contains the neutron absorbing material (water). The top and bottom axial neutron absorber resin material is, described in Section 3.1.1.3 B. No structural credit is taken for the neutron absorber material, except for through the thickness load transmission. Material Properties for the resin are given in Table 3-11.

3.3.3.1 Radiation Effects on the Transfer Cask Materials

Gamma radiation has no significant effect on metals. The effect of fast neutron irradiation of metals is a function of the integrated fast neutron fluence, which is on the order of 1×10^{15} neutrons/cm^2 inside the cask after 50 years. Studies on fast neutron damage in stainless steel, and low alloy steels rarely evaluate damage below 10^{17} n/cm^2 because it is not significant [17]. Extrapolation of the data available down to the 10^{15} range confirms that there will be no measurable neutron damage to any of the cask metallic components.

3.3.3.2 Transfer Cask Weld Material

Welding processes, welders and welding materials used for the welding of the 32PTH DSC meet the requirements of the appropriate ASME Section III subsections and Section IX. Non-Code welds meet the provisions of Section IX of the ASME Code or AWS D1.1 [18] or D1.6 [19]. Weld metal material properties meet the requirements of Section II of the ASME Code or associated AWS requirements.

3.3.3.3 Transfer Cask Brittle Fracture

Brittle fracture is not a concern for the stainless steel components, which comprises all structural components of the cask.

Based on the evaluations, there is adequate space within the 32PTH DSC cavity for thermal and irradiation growth of the fuel assemblies and spacers.

3.5.3 Fuel Rod Integrity During Drop Scenario

The purpose of this section is to calculate Zircaloy clad fuel cladding stresses due to a transfer cask side drop.

3.5.3.1 Side Drop

The fuel rod side impact stresses are computed by treating the fuel rod as a continuous beam supported at locations of spacer grids. Continuous beam theory is used to determine the maximum bending moment in the entire beam. The maximum bending stress corresponding to the maximum bending moment in the cladding tubes is then calculated. The fuel gas internal pressure is also considered in the calculation. The cladding axial tensile stress due to the gas pressure is added to the bending stress due to the 75g drop load. The combined stresses in each cladding for different fuel assemblies are computed and tabulated in Table 3-12. It shows that among all fuel assemblies the highest axial stress is calculated to be 58,710 psi in the cladding of WE17×17OFA fuel assembly. This highest stress is lower than the yield strength of zircaloy (69,500 psi at 725 °F).

3.5.3.2 End Drop

The structural integrity of the fuel cladding due to the end drop loading condition will be evaluated by the user under the 10CFR50 site license.

3.5.3.3 Results

Side Drop

Table 3-12 summarizes the maximum bending stresses in various specified fuel cladding during the 75g side drop of their transfer cask. The maximum bending stress was calculated to be 58,710 psi in the cladding of fuel WE17x17OFA. It is less than the cladding yield strength of 69,500 psi at 725 °F. It is, therefore, concluded that the fuel cladding will not fail under the 75g side drop load.

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3.5.4 Fuel Unloading

For unloading operations, the DSC will be filled with the spend fuel pool water through the siphon port. During this filling, the DSC vent port is maintained open with effluents routed to the plant's off-gas monitoring system.

When the pool water is added to a DSC cavity containing hot fuel and basket components, some of the water will flash to steam causing internal cavity pressure to rise. The steam pressure is released through the vent port. The initial flow rate of the reflood water must be controlled such that the internal pressure in the DSC cavity does not exceed 20 psig. This is assured by monitoring the maximum internal pressure in the DSC cavity during reflood event. The reflood of the DSC is considered as a "Service Level D" event and the design pressure of the DSC is 120 psig. Therefore, there is sufficient margin in the DSC internal pressure during the reflooding event to assure that the DSC will not be over pressurized.

The maximum fuel cladding temperature during reflooding process is significantly less than the vacuum drying condition owing to the presence of water/steam in the DSC cavity. Hence, the peak cladding temperature during the reflooding operation will be less than 734°F calculated for vacuum drying procedure A in Chapter 4, Section 4.5.1 when water circulates in the annulus between the DSC and transfer cask.

To evaluate the effects of the thermal loads on the fuel cladding during reflooding operations, a conservative high fuel rod temperature of 750°F and a conservative low quench water temperature of 50°F are used. These evaluations are performed in Chapter 4, Section 4.5.2. The calculated maximum fuel cladding stress is 25,910 psi. This calculated maximum stress is much less than the claddings yield stress of 69,500 psi. Therefore, cladding integrity is maintained during reflooding operation.

3.6 Normal Conditions of Storage and Transfer

This section presents the structural analyses of the 32PTH DSC, the HSM-H and the OS187H Transfer Cask subjected to normal conditions of storage and transfer. The analyses performed evaluate these three major NUHOMS® HD System components for the design criteria described in Section 3.1.2 of this chapter.

The 32PTH DSC is subjected to both storage and transfer loading conditions, while the HSM-H is only subjected to storage loading conditions and the OS187H Transfer Cask is only subjected to transfer loading conditions.

Numerical analyses have been performed for the normal and accident conditions, as well as for the lifting loads. In general, numerical analyses have been performed for the regulatory events. These analyses are summarized in the main body of this section, and described in detail in Appendices 3.9.1 through 3.9.9.

The detailed structural analysis of the NUHOMS® HD System is included in the following appendices:

Appendix 3.9.1	32PTH DSC (Canister and Basket) Structural Analysis
Appendix 3.9.2	OS187H Transfer Cask Body Structural Analysis
Appendix 3.9.3	OS187H Transfer Cask Top Cover and RAM Access Cover Bolts Analyses
Appendix 3.9.4	OS187H Transfer Cask Lead Slump and Inner Shell Buckling Analyses
Appendix 3.9.5	OS187H Transfer Cask Trunnion Analysis
Appendix 3.9.6	OS187H Transfer Cask Shield Panel Structural Analysis
Appendix 3.9.7	OS187H Transfer Cask Impact Analysis
Appendix 3.9.8	Damaged Fuel Cladding Structural Evaluation
Appendix 3.9.9	HSM-H Structural Analysis

The structural integrity of the fuel cladding due to the end and corner drops has not been demonstrated and should be addressed by the users under their 10CFR50 programs.

3.6.1 32PTH DSC Normal Conditions Structural Analysis

Details of the structural analysis of the 32PTH DSC are provided on Appendix 3.9.1. The Fuel Basket and Canister are analyzed independently. The Fuel Basket is analyzed in Appendix 3.9.1, Section 3.9.1.2, while the Canister is analyzed in Appendix 3.9.1, Section 3.9.1.3. Three separate finite element models are constructed for the structural evaluation of the fuel basket while four finite element models are used for the structural evaluation of the canister shell.

3.7 Off Normal and Hypothetical Accident Conditions

This section presents the structural analyses of the 32PTH DSC, the HSM-H and the OS187H Transfer Cask subjected to off normal and hypothetical accident conditions of storage and transfer. The analyses are summarized in Sections 3.7.1, 3.7.2 and 3.7.3 of this chapter and are evaluated against the design criteria described in Section 3.1.2 of this chapter.

The 32PTH DSC is subjected to both storage and transfer loading conditions, while the HSM-H is only subjected to storage loading conditions and the OS187H Transfer Cask is only subjected to transfer loading conditions.

The structural integrity of the fuel cladding due to end and corner drops has not been demonstrated and should be addressed by the users under their 10CFR50 programs.

3.7.1 32PTH DSC Off Normal and Accident Conditions Structural Analysis

Details of the structural analysis of the 32PTH DSC are provided in Appendix 3.9.1. The Fuel Basket and Canister are analyzed independently. The Fuel Basket is analyzed in Appendix 3.9.1, Section 3.9.1.2, while the Canister is analyzed in Section 3.9.1.3. Three separate finite element models are constructed for the structural evaluation of the fuel basket, while four finite element models are used for the structural evaluation of the canister shell.

3.7.1.1 32PTH DSC Fuel Basket Off Normal and Accident Condition Structural Analysis

3.7.1.1.1 32PTH Fuel Basket Off Normal and Accident Condition Stress Analysis

The fuel basket stress analyses are performed for off normal and accident condition loads during fuel transfer and storage. The detailed stress analysis is presented in Appendix 3.9.1, Section 3.9.1.2.3 (page 3.9.1-7). A summary of the fuel basket load cases is provided in Section 3.9.1.2.2 (page 3.9.1-5).

The basket stress analyses are performed using a finite element method for the transfer side drop impact loads, as well as, storage seismic loads, and both transfer and storage thermal load cases. A 3-dimensional cross-section finite element model is utilized to evaluate the effect of transverse inertial loads on the fuel basket. The finite element model is described in detail in Appendix 3.9.1, Section 3.9.1.2.3.A (page 3.9.1-7). Analytical calculations are used for the axisymmetric transfer end drop load case.

The mechanical properties of structural materials used in the basket, rail and canister are shown in the Appendix 3.9.1, Tables 3.9.1-1 and 3.9.1-2 as a function of temperature. All structural components of the fuel basket and support rails are constructed from SA-240, Type 304 stainless steel, with properties taken from AMSE B&PV Code [10].

Nonlinear elastic stress analyses are conducted for computing the elastic stresses in the fuel basket model. The nonlinearity of analysis results from the gaps in the model. In general, for each load case, the maximum total load is applied in small steps. The ANSYS automatic time

Table 3-13

Table Deleted

The weld stresses at outer top cover and inner top cover plates are summarized and compared with code allowables in the following table.

Summary of Weld Shear Stresses and Allowables

Weld	Load	Stress Type	Maximum Stress (ksi)	Allowable (ksi)	Factor of Safety
Between Outer Top Cover and Shell	75g Side Drop + 30 psig Internal Pressure	Shear	13.78	18.64	1.35
	75g Side Drop +15 psig External Pressure	Shear	13.68	18.64	1.36
Between Inner Top Cover and Shell	75g Side Drop + 30 psig Internal	Shear	13.30	17.4	1.31
	75g Side Drop +15 psig External Pressure	Shear	13.38	17.4	1.30

The canister corner drop load case is analyzed as follows.

- Finite Element Model

The 3D canister finite element model as described in Appendix 3.9.1, Section 3.9.1.3.2, page 3.9.1-40) is used for calculating the canister corner drop. The finite element model is shown on Figure 3.9.1-27.

- Loading and Boundary Conditions

The transfer cask cavity length is 186.6" and the canister length is 185.75". The gap between the inside surface of the transfer cask lid and outer surface of the canister outer top cover is 0.85". For storage the end drop is not a creditable event. The transfer cask is transferred in a horizontal position held by the transfer trailer. During the rotation of the transfer cask from vertical to horizontal, the cask could slide into the ground and incur a corner drop if a non-single failure proof crane is used. The only possible corner drop is impact to the bottom end of the transfer cask. However, for weld shear stress calculation it is conservatively assumed that the internal weight (basket + fuel assemblies) will impact the inner surface of the canister inner top cover without any support from transfer cask lid.

The maximum axial G load calculated from LS-DYNA as described in Appendix 3.9.11 is 21g (Appendix 3.9.11, Section 3.9.11.6). For conservatism an axial g load of 22g is used for the analysis.

3.9.7 OS187H TRANSFER CASK IMPACT ANALYSIS

3.9.7.1 Introduction

The purpose of this appendix is to present the evaluation of the peak decelerations of NUHOMS® OS187H Transfer Cask during impact, subsequent to the hypothetical accident drop onto the concrete pad/soil system during transfer operations. The hypothetical accident condition drop consists of 80 inch end drop, side drop and center of gravity (C.G.) over corner drop. The 80 inch end drop and CG over corner drop are not credible events under 10CFR72 storage and transfer operations. However, this analysis is included to support credible accidents under 10CFR50. The fuel cladding integrity has not been demonstrated for these accident scenarios. An additional safety review by the user is required to demonstrate fuel cladding integrity under 10CFR50.

For the impact analysis, the transfer cask is assumed rigid as compared to the flexibility of the concrete slab/soil system. The methodology described in Reference 1 is used in this evaluation.

The cask is approximated by a cylinder 197.07 inches long and 81.7 inches in diameter. The effect of the outer shield shell, which is very thin relative to the main structural body of the transfer cask, is neglected. Also, small variations around top cover and cylinder are neglected. The stiffness variation due to the neglected items of the transfer cask is negligible.

The OS187H Transfer Cask is assumed to impact a 36 inch thick concrete pad, with #11 rebar on 12" spacing, at top and bottom of the pad, and 2" coverage.

3.9.7.2 Material Properties

The following material properties, taken from Reference 1, are assumed to model the design basis concrete pad and soil foundation.

E_c = Concrete elastic modulus = 3.6×10^6 psi.
σ_u = Ultimate concrete strength = 4,000 psi.
E_s = Sub-soil modulus = 60,000 psi. (higher value gives higher g load)
S_y = Rebar yield strength = 60,000 psi.
ν_c = Poisson's ratio of concrete = 0.17
ν_s = Poisson's ratio of soil = 0.49

3.9.8.3 Loads

3.9.8.3.1 Part 72 Normal and Off-normal Condition Loads

The damaged fuel inside the DSC is subjected to following normal and off normal condition Part 72 loads:

- Dead Weight
- Internal Pressure
- Thermal
- Transfer Load (Inertia Loads associated with moving the DSC from the fuel loading area to the ISFSI site), which consists of 1g in the longitudinal, 1g in the transverse and 1g in the vertical direction.
- HSM Loading/Unloading (Normal loads associated with inserting the DSC into and retrieving the DSC from the HSM)
- Jammed Canister Load (Off normal loads associated with jamming the DSC during DSC insertion into the HSM)

The stresses due to the dead weight are insignificant. No internal pressure is assumed for the damaged fuel. The cladding is assumed to be able to expand due to thermal loads and thus no thermal-induced stresses are considered. However, the temperature of the cladding is considered for selection of allowable stresses at temperature. Therefore, the structural integrity of the damaged fuel is evaluated in this appendix only for the Transfer/Handling loads (DSC Loading/transfer to ISFSI, HSM Loading/Unloading, and Jammed Canister Load conditions).

3.9.8.3.2 Part 71 Normal Condition Loads

The structural integrity of the fuel cladding for the normal condition Part 71 load is evaluated only for the one-foot side drop condition in this application. The one-foot end drop and vibratory loads will be addressed in the 10CFR71 application.

Note that for the normal and accident off-site transport drops, the impact limiters are attached at both ends of the horizontal loaded cask.

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3.9.8.10 One Foot End Drop Damaged Fuel Evaluation

The structural integrity of the fuel cladding due to the one-foot end drop loading condition will be analyzed in the 10CFR71 application.

3.9.8.12 Conclusions

The maximum computed stresses in the fuel rods and their ratios to the irradiated yield stress of the cladding material are summarized in Table 3.9.8-6. From Table 3.9.8-6, it can be concluded that stresses for all load cases considered are significantly less than the yield stress of the Zircaloy cladding material (computed stresses are 4% to 49% of the yield stress).

It is important to note that, the stresses in the fuel rods for all analyzed normal and off normal load cases are compressive stresses (less than the critical buckling stress), except for the 1-foot transport condition side drop load.

For the 1-foot side drop it is demonstrated by using fracture mechanics procedures (by comparing computed stress intensity factors to critical crack initiation fracture toughness in Table 3.9.8-7), that the damaged fuel rods will maintain their structural integrity.

This calculation demonstrates that the fuel cladding in the NUHOMS® 32PTH DSC will retain its structural integrity when subjected to normal condition of storage and on site transfer loads. The fuel cladding will also maintain its integrity when subjected to a one-foot side drop during offsite transport. The fuel cladding integrity during the one-foot end drop and transport vibratory loads will be demonstrated in the 10CFR71 application. Therefore, the retrievability of the fuel assembly is assured when subjected to storage and transfer normal and off normal loads.

APPENDIX 3.9.10

OS187H TRANSFER CASK DYNAMIC IMPACT ANALYSIS

3.9.10.1 Introduction

The purpose of this calculation is to determine the rigid body accelerations for the NUHOMS®-OS187H Transfer Cask during the hypothetical accident condition 80 inch free drop during fuel transfer. The drop orientations analyzed in this appendix are 80 inch side drop (10CFR72) and 80 inch corner drop (10CFR50).

The rigid body transfer cask accelerations are predicted numerically by the LS-DYNA 3D explicit nonlinear dynamic analysis finite element solver, Version 970 [1]. The methodology used in performing this analysis is based on work conducted at the Lawrence Livermore National Laboratory, where an analysis methodology is developed and validated through comparisons with test data [2][3]. Validation of the dynamic impact analyses presented herein is achieved through comparison of a previous TN-32 Dry Storage Cask Tipover Analysis with a similar analysis performed by Lawrence Livermore National Labs (LLNL). The results of these analyses are used as input to the detailed static analyses for the cask body presented in Appendix 3.9.2.

The results of these analyses are also used as input to the static analyses of the cask internal basket and canister structures (presented in Appendix 3.9.1) by including dynamic application factors (See Appendix 3.9.11).

3.9.10.2 Analysis Software

The LS-DYNA [1] finite element program was used for the analyses presented in this Appendix. Model generation was performed using the ANSYS [4] finite element program. Data filtering was performed using the LS-PREPOST software supplied with LS-DYNA.

LS-DYNA is a general purpose, explicit finite element program used to model the nonlinear dynamic response of three-dimensional models. Applications of LS-DYNA include crash worthiness, sheet metal forming, high velocity impact, explosive phenomena, drop tests, etc.

ANSYS is a general purpose program capable of solving structural, mechanical, electrical, electromagnetic, electronic, thermal, fluid, and biomedical problems. It has extensive preprocessing (model generation), solution, postprocessing, and graphics capabilities.

7.3 Confinement Requirements for Hypothetical Accident Conditions

7.3.1 Fission Gas Products

The 32PTH DSC confinement boundary is designed to prevent the leakage of radioactive materials. The analyses presented in Chapters 3 and 11 demonstrate that the confinement boundary is not compromised following hypothetical accident conditions. Therefore, estimating the maximum quantity of fission gas products is not necessary in accordance with ISG-5[3].

7.3.2 Release of Contents

The 32PTH DSC confinement boundary is designed to prevent the leakage of radioactive materials. The analyses presented in Chapters 3 and 11 demonstrate that the confinement boundary is not compromised following hypothetical accident conditions. End and corner drops are not considered credible events during storage and transfer. However, the DSC and transfer cask have been evaluated for these drops to support evaluations required for postulated events under 10CFR50 and 10CFR71. The cladding integrity must be demonstrated by the user for 10CFR50 postulated end drops and will be evaluated in the 10CFR71 transport safety analysis report for hypothetical accidents during transports. Therefore, confinement analyses for the release of radioactive materials are not necessary in accordance with ISG-5 [3].

8 OPERATING PROCEDURES

This chapter outlines a sequence of operations to be incorporated into procedures for preparation of the NUHOMS® HD System DSC, loading of fuel, closure of the DSC, transport to the ISFSI, transfer into the HSM-H-H, monitoring operations, and retrieval and unloading. Operations are presented in their anticipated approximate performance sequence. Alternate sequencing that achieves the same purpose is acceptable. Temporary shielding may be used throughout as appropriate to maintain doses as low as reasonable achievable (ALARA). All lifts of the DSC in the TC shall be made in accordance with the existing heavy load requirements and procedures of the licensed nuclear power plant.

8.1 Procedures for Loading the DSC and Transfer to the HSM-H-H

8.1.1 Narrative Description

The following steps describe the recommended generic operating procedures for the NUHOMS® System. A list of major equipment used during loading and unloading operations is provided in Table 8-1. A pictorial representation of key phases of this process is provided in Figure 8-1.

8.1.1.1 Transfer Cask and DSC Preparation

1. Verify by plant records or other means that candidate fuel assemblies meet the physical, thermal and radiological criteria specified in the Technical Specifications.
2. Clean or decontaminate the transfer cask as necessary to meet licensee pool and ALARA requirements, and to minimize transfer of contamination from the cask cavity to the DSC exterior.
3. Examine the transfer cask cavity for any physical damage.
4. Verify specified lubrication of the transfer cask rails.
5. Examine the DSC for any physical damage and for cleanliness. Verify that bottom fuel spacers or damaged fuel bottom end caps, if required, are present in all fuel compartments. Remove damaged fuel top end caps if they are in place. Record the DSC serial number which is located on the grappling ring. Verify the basket type by identifying the last character in the serial number.
6. Install lifting rods and eyes into the four threaded sockets in the bottom of the DSC cavity. Verify specified thread engagement.
7. Lift the DSC into the cask cavity and rotate the DSC to match the transfer cask alignment marks.
8. Remove the lifting rods and eyes.
9. Fill the transfer cask/DSC annulus with clean water.
10. Seal the top of the annulus, using for example an inflatable seal.
11. A tank filled with clean water, and kept above the pool surface may be connected to the top vent port of the transfer cask via a hose to provide a

11.3.1 Cask Drop

Cause of Accident

As described in Chapter 8, handling operations involving hoisting and movement of the on-site transfer cask and 32PTH DSC are typically performed inside the plant's fuel handling building. These include utilizing the crane for placement of the empty 32PTH DSC into the transfer cask cavity, lifting the transfer cask/32PTH DSC into and out of the plant's spent fuel pool, and placement of the transfer cask/32PTH DSC onto the transport skid/trailer. An analysis of the plant's lifting devices used for these operations, including the crane and lifting yoke, is needed to address a postulated drop accident for the transfer cask and its contents. The postulated drop accident scenarios addressed in the plant's 10CFR 50 licensing basis are plant specific and should be addressed by the licensee.

Once the transfer cask is loaded onto the transport skid/trailer and secured, it is pulled to the HSM-H site by a tractor vehicle. A predetermined route is chosen to minimize the potential hazards that could occur during transport. This movement is performed at very low speeds. System operating procedures and technical specification limits defining the safeguards to be provided ensure that the system design margins are not compromised. As a result, it is highly unlikely that any plausible incidents leading to a transfer cask drop accident could occur. Similarly, at the ISFSI site, the transport skid/trailer is backed-up to, and aligned with, the HSM-H using hydraulic positioning equipment. The transfer cask is then docked with, and secured to, the HSM-H access opening. The loaded 32PTH DSC is transferred to or from the HSM-H using a hydraulic ram system. The hold down mechanisms that secure the transfer cask to the transport skid/trailer remain in place at all times during the 32PTH DSC transport. As a result, there is no reasonable way during these operations for a cask drop accident to occur.

Lifts of the transfer cask loaded with the dry storage canister are made within the existing heavy loads requirements and procedures of the licensed nuclear power plant. The transfer cask design meets requirements of NUREG-0612 and ANSI N14.6.

The transfer cask is transported to the ISFSI in a horizontal configuration. Therefore the only credible drop accident during storage or transfer operation is a side drop.

The transfer cask and dry storage canister are evaluated for a postulated end and corner drop to demonstrate structural integrity during transport and plant handling. However the fuel cladding structural integrity has not been demonstrated for these scenarios. Therefore, the user is required to demonstrate fuel cladding structural integrity under 10CFR50 postulated drop accidents or demonstrate that the drop accidents are not credible.

Accident Analysis

The stress analyses are performed in Chapter 3, Appendix 3.9.1 for 32PTH DSC and Appendix 3.9.2 for the Transfer Cask.

Components	SAR Sections
Basket	Appendix 3.9.1, Section 3.9.1.2.3 (pages 3.9.1-15 to 19)
Canister	Appendix 3.9.1, Load Cases 6 through 17, (pages 3.9.1-46 to 50)
Transfer Cask	Appendix 3.9.2, Load Cases 7 through 9 (pages 3.9.2-24 to 25)
Fuel Cladding	Section 3.5.3, Appendix 3.9.8

Accident Dose Calculation

Based on analysis results presented in Appendix 3.9.1 and Appendix 3.9.2, the accidental transfer cask drop scenarios do not breach the transfer cask/32PTH DSC confinement boundaries. The function of transfer cask lead shielding is not compromised by these drops. The transfer cask neutron shield, however, may be damaged in an accidental drop.

The transfer cask surface dose rate, with the neutron shield intact for the 32PTH DSC in the transfer cask is calculated in Chapter 5 of this SAR as 384 mrem/hr gamma and 125 mrem/hr neutron.

The dose rate at the transfer cask surface due to the loss of the neutron shield is also calculated; the peak dose is 400 mrem/hr gamma and 6049 mrem/hr neutron.

Corrective Actions

The DSC will be inspected for damage, and the DSC opened and the fuel removed for inspection, as necessary. Removal of the transfer cask top cover plate may require cutting of the bolts in the event of a corner drop onto the top end. These operations will take place in the plant fuel building decontamination area and spent fuel pool after recovery of the transfer cask. Following recovery of the transfer cask and unloading of the DSC, the transfer cask will be inspected, repaired and tested as appropriate prior to reuse.

For recovery of the cask and contents, it may be necessary to develop a special sling/lifting apparatus to move the transfer cask from the drop site to the fuel pool. This may require several weeks of planning to ensure all steps are correctly organized. During this time, lead blankets may be added to the transfer cask to minimize on-site exposure to site operations personnel. The transfer cask would be roped off to ensure the safety of the site personnel.

12.5.3 Lifting Controls

12.5.3.1 Transfer Cask Lifting Heights

The lifting height of a loaded transfer cask (TC)/32PTH DSC, is limited as a function of location, as follows:

a) The maximum lift height and handling height for all TRANSFER OPERATIONS where the TC/32PTH is in the horizontal position on the trailer shall be 80 inches.

b) The maximum lift height of the transfer cask/32PTH DSC shall be restricted by site (10CFR50) limits for all handling operations except those listed in 12.5.3.1a above. An evaluation of the fuel cladding structural integrity shall be performed for all credible drops under the user's 10CFR50 heavy loads program.

These restrictions ensure that any 32PTH DSC drop as a function of location is within the bounds of the accident analysis.

12.5.3.2 Cask Drop

Inspection Requirement

The 32PTH DSC will be inspected for damage after any transfer cask drop of fifteen inches or greater.

Background

TC/32PTH DSC handling and loading activities are controlled under the 10CFR 50 license until a loaded TC/32PTH DSC is placed on the trailer, at which time fuel handling activities are controlled under the 10CFR 72 license. Although the probability of dropping a loaded TC/32PTH DSC while in route from the Fuel Handling Building to the ISFSI is small, the potential exists to drop the cask 15 inches or more.

Safety Analysis

The analysis of bounding drop scenarios shows that the transfer cask will maintain the structural integrity of the 32PTH DSC confinement boundary from an analyzed side drop height of 80 inches. The 80-inch drop height envelopes the maximum vertical height of the transfer cask when secured to the transfer trailer while en route to the ISFSI.

Although analyses performed for cask drop accidents at various orientations indicate much greater resistance to damage, requiring the inspection of the DSC after a drop of 15 inches or greater ensures that:

1. The DSC will continue to provide confinement
2. The transfer cask can continue to perform its design function regarding DSC transfer and shielding.