72-1004

TRANSNUCLEAR, INC.

March 18, 2002
NUH03-02-16

Ms. Mary Jane Ross-Lee
Spent Fuel Project Office, NMSS
U. S. Nuclear Regulatory Commission
11555 Rockville Pike M/S O13-D-13
Rockville, MD 20852

Subject: Supplemental Response to Request for Additional Information (RAI) and Submittal of Revision 2 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (TAC NO. L23343).

References:

1. Request for Additional Information Regarding Approval To Add NUHOMS® -32PT Dry Storage Canister to the Standardized NUHOMS® System (TAC NO. L23343), dated December 20, 2001.
2. Response to Request for Additional Information (RAI) and Submittal of Revision 1 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (TAC NO. L23343).

Dear Ms. Ross-Lee:

Transnuclear, Inc. (TN) herewith submits a supplemental response to Question 9-4 of the RAI (Reference 1) to provide the clarification sought by your staff in telecons on 2/28/02 and 3/06/02. The information provided in the supplemental response supercedes the corresponding information related to this issue submitted previously in Reference 2.

In addition, Revision 2 of the proprietary and non- proprietary version of Chapter M.9 affected by this supplemental response are also enclosed. Please replace the affected pages of the Revision 1 application (Reference 2) with the changed pages submitted herewith.

Should you or your staff require additional information to support review of this application, please do not hesitate to contact me at 510-744-6053.

Sincerely,

UBChopra

U. B. Chopra

Licensing Manager

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NMSS01 Public

Docket 72-1004

Enclosures:
1. Supplemental Response to Question 9-4 of the RAI.
2. Fourteen Copies of Revision 2 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (Changed Pages Only).

DOCKET NO. 72-1004

TAC NO. L23343

TN INC. SUPPLEMENTAL RESPONSE TO QUESTION 9-4 OF THE RAI

Chapter 9 Acceptance Tests and Maintenance Program

Question 9-4

Revise Chapter 9, Section M.9.1.7.3.1.3, "Borated Aluminum Acceptance Testing, Neutronic" to justify the acceptance criterion given as item "a) Individual plates may be accepted...criterion, and b) Selected plates may be re-examined..."

The concern is that statistical consideration, e.g., the assumption that every coupon is like every part of every plate (which leads to the conclusion that coupons having detected malformations can be rejected from statistical analyses), may eliminate later acceptance of any plate in the rejected lot. This comment refers to 10 CFR 72.11, 72.24 and 72.236 (c)

Response to Question 9-4

Section M.9.1.7.3.1.3 is revised to delete the acceptance criteria a), b) and c) for acceptance of individual plates from a lot that does not meet the statistical analysis. A new criterion based on the determination of an alternate minimum thickness is specified instead.

The information presented in this section has been rearranged for clarity. Also, acceptance testing for verification of uniformity of B10 distribution via radioscopy/radiography of test coupons has been added back in this section.

In response to a verbal request from the staff, Transnuclear Inc., has performed a sensitivity study to determine the effect of non uniform B10 distribution within a neutron plate on the 32PT DSC reactivity.

The B10 content in a specific area of a neutron absorber plate due to non-uniform distribution was conservatively assumed to be reduced to 45% of that credited in the rest of the plates modeled in the criticality analysis. This assumption is based on a review of the available neutron transmission test data for borated aluminum produced for the NUHOMS®-61BT DSC.

A single "chevron" (modeled as two orthogonal neutron absorber plates) in one of the four center fuel compartments in the DSC was chosen for this evaluation since it represents the most worth from a criticality point of view.

The modeled boron content in the criticality analyses presented in Section M.6 for the poison plates is 90% of the minimum specified on the design drawings and the proposed Technical Specifications. Therefore the assumed boron content in the "low boron areas" of the plate is modeled as (0.9)*(45%) or 40.5% of the minimum required to meet the requirements of the drawings and proposed technical specifications.

Table 1 lists the cases evaluated and the corresponding results. Based on the results in the Table, the effect on reactivity does not become statistically significant until at least 115.2 out of every 144 inches of the chevron is at 40.5 % of the minimum specified boron content. Even for the case with 100 % of the chevron at the lower boron content, the results demonstrate the effect on reactivity is barely statistically significant, if at all.

Table 1 Cases Evaluated and the Results

Description	k_{KENO}	1σ	Δk±1σ
Base Case all chevrons with 90% of the specified minimum boron content.	0.9256	0.0008	-
Single chevron with center 14.4 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9265	0.0009	0.0009 ±0.0012
Single chevron with center 28.8 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9270	0.0009	0.0014 ±0.0012
Single chevron with center 43.2 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9261	0.0009	0.0005 ±0.0012
Single chevron with center 57.6 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9278	0.0010	0.0022 ±0.0013
Single chevron with center 72.0 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9266	0.0008	0.0010 ±0.0011
Single chevron with center 86.4 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9277	0.0009	0.0021 ±0.0012
Single chevron with center 100.8 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9264	0.0009	0.0008 ±0.0012
Single chevron with center 115.2 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9274	0.0009	0.0018 ±0.0012
Single chevron with center 129.6 inches out of every 144 inches with 40.5% of the specified minimum boron content.	0.9276	0.0010	0.0020 ±0.0013
Single chevron with 100 % of the plate with 40.5% of the specified minimum boron content.	0.9275	0.0008	0.0019 ±0.0011

M.9 Acceptance Tests and Maintenance Program

M.9.1 Acceptance Tests

The acceptance requirements for the NUHOMS®-32PT system are given in the FSAR except as described in the following sections. The NUHOMS®-32PT DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-32PT DSC welds and poison plates are described.

M.9.1.1 Visual Inspection

Visual examinations are performed at the fabricator's facility to ensure that the NUHOMS®-32PT system components conform to the fabrication specifications and drawings.

Visual examination of all finished absorber plates and rods are done to ensure that they are free of cracks, porosity, blisters, or foreign substances. Dimensional inspections of the plates and rods are done to ensure that their functional requirements listed in M.9.17.1 are met.

M.9.1.2 Structural Tests

The NUHOMS®-32PT DSC confinement welds are designed, fabricated, tested and inspected in accordance with ASME B&PV Code Section III, Subsection NB [9.1] with exceptions as listed in Section M.3.1. The following requirements are unique to the NUHOMS®-32PT DSC:

- The inner bottom cover weld is inspected in accordance with Article NB-5231,
- The outer bottom cover weld root and cover are penetrant tested, and
- The outer top cover plate weld root and cover are penetrant tested.

The NUHOMS®-32PT DSC basket is designed, fabricated, and inspected in accordance with ASME B&PV Code Section III, Subsection NG [9.1] with exceptions as listed in Section M.3.1. The following requirement is unique to the NUHOMS®-32PT DSC basket:

- The fuel compartment welds are inspected in accordance with Article NG-5231.

M.9.1.3 Leak Tests

The NUHOMS®-32PT DSC confinement boundary is leak tested to verify that it is leaktight in accordance with ANSI N14.5 [9.2]. The personnel performing the leak test are qualified in accordance with SNT-TC-1A [9.14].

The leak tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved.

M.9.1.4 Component Tests

No changes associated with this amendment.

M.9.1.5 Shielding Integrity Tests

No changes associated with this amendment.

M.9.1.6 Thermal Acceptance Tests

The analyses to ensure that the NUHOMS®-32PT DSCs are capable of performing their heat transfer function are presented in Section M.4.

M.9.1.7 Poison Acceptance

M.9.1.7.1 Functional Requirements of Poison Plates

The poison plates only serve as a neutron absorber for criticality control and as a heat conduction path. The NUHOMS®-32PT DSC safety analyses do not rely upon their mechanical strength. The radiation and temperature environment in the cask is not sufficiently severe to damage the aluminum matrix that retains the boron-containing particles. To assure performance of the plates' Important-to-Safety function, the only critical variables that need to be verified are thermal conductivity and B10 areal density as discussed in the following paragraphs.

M.9.1.7.2 Thermal Conductivity Testing of Poison Plates

The poison plate material shall be qualification tested to verify that the thermal conductivity equals or exceeds the values listed in Section M.4.3. Acceptance testing of the material in production may be done at only one temperature in that range to verify that the conductivity equals or exceeds the corresponding value in Section M.4.3.

Testing may be by ASTM E1225 [9.3], ASTM E1461 [9.4], or equivalent method, performed on coupons as defined in Section M.9.1.7.3.1.2.

M.9.1.7.3 B10 Areal Density Testing of Poison Plates

There are two poison materials qualified for the NUHOMS®-32PT DSC basket: Borated aluminum and boron carbide/aluminum metal matrix composites (MMCs), such as Boralyn®, or Metamic®, or equivalent. The B10 areal density and uniformity of the poison plates shall be verified, based on type, using approved procedures, as follows.

M.9.1.7.3.1 Borated Aluminum Using Enriched Boron, 90% B10 Credit

M.9.1.7.3.1.1 Borated Aluminum Material Description

The poison consists of *wrought* aluminum containing boron, which is isotopically enriched to 95 wt. % B10. Because of the negligibly low solubility of boron in solid aluminum, the boron appears entirely as discrete second phase particles of AlB_2 in the aluminum matrix. The matrix is limited to any 1000 series aluminum, aluminum alloy 6063, or aluminum alloy 6351 so that no boron-containing phases other than AlB_2 are formed. Titanium may also be added to form TiB_2 particles, which are finer. The effect on the properties of the matrix aluminum alloy are those typically associated with a uniform fine (1-10 micron) dispersion of an inert equiaxed second phase.

The cast ingot may be rolled, extruded, or both to the final plate dimensions.

The nominal wt. % boron is 1.5 wt. %. This wt. % boron converts to areal density of B10 as follows: (2.69 g BAl/cm^3)(1.5 wt. % B)(95 wt. % B10)(0.075 inch)(2.54 cm/inch) = 0.0073g B10/cm^2, which is intentionally 4% above the design minimum of 0.0070 g B10/cm^2.

M.9.1.7.3.1.2 Borated Aluminum Test Coupon and Lot Definitions

Sample taken from the plate material is a test coupon. Test coupons will be removed so that there is at least one coupon contiguous with each plate. These coupons will be used for neutron transmission and thermal conductivity testing. The minimum dimension of the coupon shall be as required for the acceptance test procedures.

A lot is defined as all the plates produced from a single cast ingot, or all the plates produced from a single heat.

M.9.1.7.3.1.3 Borated Aluminum Acceptance Testing, Neutronic

Effective B10 content is verified by neutron transmission testing of these coupons. The transmission through the coupons is compared with transmission through calibrated standards composed of a homogeneous boron compound without other significant poisons, for example zirconium diboride or titanium diboride. These standards are paired with aluminum shims sized to match the scattering by aluminum in the poison plates. Uniform but non-homogeneous materials such as metal matrix composites may be used for standards, provided that testing shows them to be equivalent to a homogeneous standard.

The neutron transmission testing measurements are taken using a collimated neutron beam size of approximately 1 cm^2. *The neutron transmission test procedure shall include provisions to vary the selected measurement location along the coupon length.*

The acceptance criterion for neutron transmission testing is that the B10 areal density, minus 3s based on the number of neutrons counted for that measurement, must be greater than or equal to the minimum value 0.007 g B10/cm^2.

In the event that a coupon fails the single neutron transmission measurement, the associated plate is rejected. As an alternate basis for accepting that plate, four additional measurements may be made at separate *random* locations on the plate itself, or on coupons cut from four *random locations* of the plate. For each of the additional measurements, the value of areal density less 3s based on the number of neutrons counted must be greater than or equal to the specified minimum in order to accept the plate.

If any of those four fails, the plate associated with the measurements will be rejected. However, the average of the five measurements made is to be used as a datum in the subsequent statistical analysis conducted on the lot (see below).

Macroscopic uniformity of B10 distribution is verified by *neutron radioscopy/radiography of the coupons. The acceptance criterion is that there be uniform luminance across the coupon. This inspection shall cover the entire coupon. If a coupon fails this test, the associated plate shall be rejected.*

Initial sampling of coupons for neutron transmission measurements *and radioscopy/radiography* shall be 100%. Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. A rejection during reduced inspection will require a return to 100% inspection of the lot.

In addition, a statistical analysis of the neutron transmission results *for all plates in a lot shall be performed.* This analysis shall demonstrate, *using a* one-sided tolerance *limit* factor for a *normal distribution with at least* 95% probability, *the areal density is greater than or equal to the specified minimum value of 0.007 g B10/cm^2 with* 95% confidence level.

Th*is statistical* analysis shall be based on full data set for the lot, except that any data from materials which are rejected based on physical examination of the materials may be eliminated from the statistical analysis. For example, a rejection based on dimensional or surface finish inspection is ground for excluding the datum associated with that plate. Failure to meet the acceptance criterion of this statistical analysis shall result in rejection of the entire lot. Individual pieces in that lot may be accepted based on the determination of an alternate minimum thickness as follows:

All areal densities determined by neutron transmission for that lot may be converted to volume density by dividing by the thickness of the corresponding coupon. *The thickness shall be measured at the same location as the neutron transmission test, or shall be an equal or larger value.* The one sided lower tolerance limit of volume density with 95% probability and 95% confidence may then be determined. Finally, the minimum specified value of B10 areal density may be divided by the 95/95 lower tolerance limit of B10 volume density to arrive at a minimum plate thickness. Then, all plates which have any location (other than local pits) thinner than this minimum shall be rejected, and those equal to or thicker may be accepted.

M.9.1.7.3.1.4 Justification for Acceptance Test Requirements, Borated Aluminum

According to NUREG/CR-5661 [9.5]:

> "Limiting added poison material credit to 75% without comprehensive tests is based on concerns for potential 'streaming' of neutrons due to nonuniformities. It has been shown that boron carbide granules embedded in aluminum permit channeling of a beam of neutrons between the grains and reduce the effectiveness for neutron absorption."

Furthermore:

"A percentage of poison material greater than 75% may be considered in the analysis only if comprehensive tests, capable of verifying the presence *and uniformity* of the poison, are implemented." [emphasis added]

The calculations in Section M.6 use boron areal densities that are 90% of the minimum value of 0.007 g B10/cm^2. This is justified by the following considerations:

a) The coupons for neutronic inspection are removed contiguous to every finished plate. As such, they are taken from locations that are representative of the finished product.

b) Statistical analysis of the neutron transmission results on the coupons demonstrates that at any location in the plates, the B10 areal density will meet or exceed the specified minimum with 95% confidence and 95% probability.

c) *Neutron radioscopy/radiography across the entire coupon will detect macroscopic non-uniformities in the B10 distribution which could be introduced by the fabrication process.* The use of neutron transmission *and neutron radioscopy/radiography of* the coupons, satisfies the "and uniformity" requirement emphasized in NUREG/CR-5661 on both the microscopic and macroscopic scales.

d) The recommendations of NUREG/CR-5661 are based upon testing of a poison with boron carbide particles averaging 85 microns. The boride particles in the borated aluminum are much finer (5-10 microns). Both the manufacturing process and the neutron radioscopy assure that they are uniformly distributed. For a given degree of uniformity, fine particles will be less subject to neutron streaming than coarse particles. Furthermore, because the material reviewed in the NUREG was a sandwich panel, the thickness of the boron carbide containing center could not be directly verified by thickness measurement. The alloy specified here is uniform throughout its thickness.

<u>M.9.1.7.3.2 Metal Matrix Composites (MMCs) Boralyn®, Metamic®, or Equivalent; 90% B10 credit</u>

<u>M.9.1.7.3.2.1 MMC Material Description</u>

The MMC poison plates (Boralyn®, Metamic®, or Equivalent) consist of a composite of aluminum with boron carbide particulate reinforcement. The material is formed into a billet by powder metallurgical processes and either extruded, rolled, or both to final dimensions. The finished product has near-theoretical density and metallurgical bonding of the aluminum matrix particles. It is "uniform" blend of powder particles from face to face, i.e.; it is not a "sandwich" panel.

The nominal volume % boron carbide is 10.7 volume %. This volume % boron carbide corresponds to a B10 areal density of 0.107(2.52 g/cm^3 B_4C)(0.782 gB/gB_4C)(0.185 g B10/gB)(0.075 in)(2.54 cm/in) =0.0074 g B10/cm^2, which is intentionally 6% above the design and specification minimum of 0.007 g B10/cm^2.

The maximum areal density that will be permitted for use in Boralyn® corresponds to a maximum 15 volume % B_4C composition for which Boralyn® was originally qualified. This corresponds to a maximum B10 areal density for Boralyn® of (15.0 volume % B_4C)/(10.7 volume % B_4C)*0.0074 gB10/cm^2 = 0.0104 g B10/cm^2.

Similarly, the maximum areal density that will be permitted for use in Metamic® corresponds to a maximum 40.0 volume % B_4C composition for which Metamic® was originally qualified. This corresponds to a maximum B10 areal density for Metamic® of (40.0 volume % B_4C)/(10.7 volume % B_4C)*0.0074 gB10/cm^2 = 0.0277 g B10/cm^2.

Typical MMC processing steps consist of:

- blending of boron carbide powder with aluminum alloy powder,
- billet formed by vacuum hot pressing (Boralyn®) or cold isostatic pressing followed by vacuum sintering (Metamic®),
- billet extruded to intermediate or to final size,
- hot roll, cold roll and flatten as required, and
- anneal (optional).

M.9.1.7.3.2.2 MMC Qualification Test Program

The process specifications for the Boralyn® or Metamic® have been subjected to qualification testing to demonstrate that the process results in a material that:

- has a uniform distribution of boron carbide particles in an aluminum alloy with few or none of the following: voids, oxide-coated aluminum particles, B_4C fracturing, or B_4C/aluminum reaction products,
- meets the requirements for B10 areal density and thermal conductivity, and
- will be capable of performing its Important-to-Safety functions under the thermal and radiological environment of the NUHOMS®-32PT DSC over its 40-year lifetime.

These qualification programs consisted of:

1. Fast neutron irradiation of the material to a fluence of about $8x10^{15}$ n/cm^2 or more, with dimensional measurements, transmission electron microscopic (TEM) examination, and /or mechanical testing to evaluate differences in the as-produced and irradiated conditions.

2. Exposure to temperatures in the range of 700°F or greater for periods of 30 days or more, again with dimensional measurements, transmission electron microscopic (TEM) examination, and /or mechanical testing to evaluate differences in the as-produced and irradiated conditions.

3. Evaluation of corrosion or hydrogen generation rates.

4. Verification of uniformity of B10 distribution by neutron radioscopy or by statistical analysis of neutron transmission measurements *together with quantitative metallography.*

The results of these qualification test programs have been previously presented to the NRC in the license applications for the TN-68 dry storage cask [9.12], the NUHOMS® 61BT DSC (Appendix K), and the NUHOMS® MP-197 transport packaging [9.13].

The qualification testing described above demonstrated, as would be expected from the properties of aluminum and boron carbide alone, that the materials suffer insignificant damage from the levels of radiation and temperature experienced in dry storage or transport of irradiated fuel. These materials also demonstrate corrosion characteristics very similar to the aluminum matrix.

Boralyn® qualification testing was performed on a 15 volume % boron carbide / 1000 series aluminum composite, and Metamic® qualification testing was performed on 15, 31 and 40 volume % boron carbide / 6000 series aluminum composites. The boron carbide content of material produced for the NUHOMS®-32PT DSC will not exceed the volume percent subjected to qualification testing for that material, unless it is subjected to additional testing as described in the following sections.

The production of MMC plates for use in the NUHOMS®-32PT DSC is consistent with the process used to produce the qualification test material. Processing changes may be incorporated into the production process, only if they are reviewed and approved by the holder of an NRC-approved QA plan who is supervising fabrication, in accordance with the following criteria:

Major processing changes, such as billet formation by processes other than hot vacuum pressing or CIP/vacuum sintering, or direct rolling of the billet (elimination of extrusion) shall be subject to a complete program of qualification testing including the four areas of radiation exposure, thermal exposure, hydrogen generation / corrosion, and B10 uniformity described above for the original Boralyn® and Metamic® qualification programs. Other examples of major changes which require qualification testing are:

- B_4C content of > 15 volume % for Boralyn® or equivalent, or
- B_4C content of > 40 volume % for Metamic® or equivalent, or
- Product theoretical density < 98%, or
- *More than 5 %* of B_4C powder $\geq$ 40 microns, *and more than 20 % of B_4C powder $\geq$ 25 microns.*

Minor processing changes that do not have an adverse effect on *the particle bonding,* microstructure or uniformity of the B_4C *particle* distribution may be accepted by engineering review without testing. Examples of such changes include reduction of B_4C content in the MMC, increased billet forming pressure, and changes in mechanical processing variables such as extrusion speed. Changes that have an uncertain or a small adverse effect on the microstructure shall be subjected to limited additional testing such as microscopic metallurgical examination in the as-built condition of the plates. Examples of such changes are increased billet forming temperature and small increases in the B_4C content (within the maximum limits listed above).

The basis for acceptance shall be that the changes do not have an adverse effect on *either* the *durability or neutron absorption effectiveness of the material. These characteristics are* *determined by the bonding and* uniformity of the *B_4C particle* distribution. The evaluation may consist of an engineering review, or it may consist of additional testing.

M.9.1.7.3.2.3 MMC Test Coupon and Lot Definitions

Coupon removal for MMC's is the same as for borated aluminum. A lot shall be defined as all plates made from a single billet, or from a group of billets, all processed from the same batch of blended powder, and compacted into billets during a single production campaign.

M.9.1.7.3.2.4 MMC Acceptance Testing, Neutronic

The acceptance criteria for neutron transmission testing of MMC plates and the alternate acceptance criteria in the event that a MMC coupon fails an acceptance criteria are the same as those discussed in Section M.9.1.7.3.1.3.

M.9.1.7.3.3 Justification for Acceptance Test Requirements, MMCs

The justification for the test requirements and 90% B10 credit for MMCs *is* the same as those for borated aluminum, except that the boron carbide particles in a MMC are typically in the range of 1-25 microns.

M.9.1.7.4 B_4C Linear Density Testing for Poison Rod Assemblies (PRAs)

The PRAs are shown in Figure M.1-2, and additional physical requirements are listed in Table M.2-4. The B_4C poison is inserted into the stainless steel tubes shown in Figure M.1-2. Table M.2-4 specifies the minimum B_4C content per unit length in the axial direction of the rods for the various PRA designs. The minimum B_4C content per unit length is consistent with the criticality analysis (Section M.6) with an additional 25% margin.

Pellets or powder representing each powder lot shall be tested per ASTM C751 [9.6] or ASTM C750 (Type 2) [9.7] (or equivalent). Density and diameter shall be measured to verify conformance to the specification requirements.

Deviations from the specified dimensions or density may be accepted, so long as the resulting minimum B_4C mass per unit length is maintained.

Justification for Durability of B_4C Pellets:

B_4C is essentially inert and will not be attacked even by hot hydrofluoric or nitric acids[9.8]. It is insoluble in water [9.9], resistant to steam at temperatures of 200 to 300°C [9.10] and has a melting point of 2450°C [9.10]. Mechanically, B_4C is extremely hard (Mohs hardness of 9.3 vs. 10 for diamond) and is used in abrasion- and wear-resistant applications and in bullet-proof tiles. It has a compressive strength of 398,000 psi In the PRAs, the B_4C pellets are sealed within stainless steel. With this configuration there is nothing that could cause the material to degrade. In the unlikely event that a pellet were to crack or break, the total mass would be confined by the steel to the same dimensions.

The irradiation-induced swelling is due to neutron capture by the ^{10}B isotope. Using data from [9.11] and by determining the neutron absorption in the B_4C (^{10}B capture) from the shielding analyses, the swelling is determined to be negligible ~ 0.00002%. Finally, according to [9.11], the first intergranular cracks do not start to appear until fluences are 5.5 orders of magnitude greater than those calculated for 50 year operation.

M.9.2 Maintenance Program

NUHOMS®-32PT system is a totally passive system and therefore requires little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-32PT system maintenance tasks are performed in accordance with the FSAR.

M.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 1998 Edition including 1999 addenda.

9.2 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.3 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique."

9.4 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method."

9.5 NUREG/CR-5661, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," 1997.

9.6 ASTM C751, "Standard Specification for Nuclear-Grade Boron Carbide Pellets."

9.7 ASTM C750, "Standard Specification for Nuclear-Grade Boron Carbide Powder."

9.8 The Merck Index, *9th edition, Merck & Co., 1976.*

9.9 *Grant (ed.),* Hackh's Chemical Dictionary, *4th edition, McGraw-Hill, 1969.*

9.10 *Lipp, A., "Boron Carbide: Production, Properties, Application," Reprint from* Technische Rundschau, *Nos. 14, 28, 33 (1995) and 7 (1966).*

9.11 *Stoto, T. et al., "Swelling and Microcracking of Boron Carbide Subjected to Fast Neutron Irradiations,"* Journal of Applied Physics, *Vol. 68, No.7, October 1, 1990, pp. 3198-3206.*

9.12 Transnuclear Inc., TN-68 Dry Storage Cask, Final Safety Analysis Report, Revision 0, Hawthorne, NY, 2000 (Docket No. 72-1027).

9.13 Transnuclear Inc., NUHOMS® - MP197 Transportation Packaging, Safety Analysis Report (Docket No. 71-9302).

9.14 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.