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BY OVERNIGHT MAIL

August 18, 2000

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Holtite-A Neutron Shielding Material

References:
1. NRC Inspection 71-0784/00201
2. USNRC Dockets 72-1008, 71,9261, and 72-1014
3. Holtec letter, K.P. Singh, to NRC, Mr. E.W. Brach, dated May 22,2000

Dear Sir:

In accordance with our commitment made in the Reference 3 letter and a phone conversation with SFPO staff on August 10, 2000, enclosed herewith is one copy of the draft revisions to the HI-STAR 100 Topical Safety Analysis Report (Holtec Report HI-941184) regarding our Holtite-A™ neutron shielding material. Deleted text is shown in strikeout and new text is shown in italic font with revision bars in the right margin. Please note that these proposed changes also apply to the analogous text in the HI-STAR 100 transportation SAR (HI-951251, Docket 71-9261) and the HI-STORM 100 FSAR (HI-2002444, Docket 72-1014). These changes will be incorporated into the next regular revisions to these documents in accordance with 10 CFR 72.48 and 10 CFR 72.248.

With this correspondence, the commitment made in the Reference 3 letter is satisfied. Please contact me at (856) 797-0900, extension 668 if you have any questions or require additional information.

Sincerely,

Brian Gutherman, P.E.
Licensing Manager

Document I.D.: HL1020-011

Enclosures: As Stated

Cc: Mr. Mike Waters, USNRC (by facsimile, w/enclosure)

NMSS01 Public

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8 total pages, including this page

STATE OF NEW JERSEY

COUNTY OF BURLINGTON

Mr. Michael P. McNamara states that he is the Vice President, Nuclear Projects of Holtec International; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth herein are true and correct to the best of his knowledge, information, and belief.

Michael P. McNamara
Vice President, Nuclear Projects
Holtec International

Sworn to and subscribed before me this 18th day of August, 2000, by Michael P. McNamara.

MARIA C. PEPE
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires April 25, 2005

Signature of Notary Public
State of New Jersey

Table 1.0.1 (continued)

TERMINOLOGY AND NOTATION

Fuel Basket means a honeycomb structural weldment with square openings which can accept a fuel assembly of the type for which it is designed.

Fuel Debris is defined as a fuel assembly with known or suspected cladding defects greater than pinhole leaks and hairline cracks such as ruptured fuel rods, severed fuel rods, or loose fuel pellets, and which cannot be handled by normal means.

Helium Retention Boundary means the enclosure formed by the overpack inner shell welded to a bottom plate and top main flange plus the bolted closure plate and port plugs with metallic seals. The helium retention boundary is an additional independent confinement boundary, however, no credit is taken for this additional barrier. The helium retention boundary maintains an inert helium atmosphere around the MPC.

HI-STAR 100 MPC means the sealed spent nuclear fuel container which consists of a honeycombed fuel basket contained in a cylindrical canister shell which is welded to a baseplate, lid with welded port cover plates, and closure ring. MPC is an acronym for multi-purpose canister. There are different MPCs with different fuel basket geometries for storing PWR or BWR fuel, but all MPCs have identical exterior dimensions. The MPC is the confinement boundary for storage conditions.

HI-STAR 100 overpack or overpack means the cask which receives and contains the sealed multi-purpose canisters containing spent nuclear fuel. It provides the retention boundary for the helium atmosphere, gamma and neutron shielding, and a set each of lifting and pocket trunnions. It is not defined as the confinement boundary for the radioactive material during storage.

HI-STAR 100 System consists of the HI-STAR 100 MPC sealed within the HI-STAR 100 overpack.

~~**Holtite™** is a trade name denoting an approved *for a family of* neutron shield materials *under development by Holtec International* for use in the HI-STAR 100 System. In this application *Currently,* Holtite-A is the only approved neutron shield material *and the terms Holtite™ and Holtite-A™ are used interchangeably throughout this TSAR.*~~

***Holtite™** is the trade name for all present and future neutron shielding materials formulated under Holtec International's R&D program dedicated to developing shielding materials for application in dry storage and transport systems. The Holtite development program is an ongoing experimentation effort to identify neutron shielding materials with enhanced shielding and temperature tolerance characteristics. Holtite-A™ is the first and only shielding material qualified under the Holtite R&D program. As such, the terms Holtite and Holtite-A may be used interchangeably throughout this TSAR.*

Table 1.0.1 (continued)

TERMINOLOGY AND NOTATION

Holtite-A™ is a *trademarked Holtec International neutron shield material.* ~~commercially available neutron shield material developed by Bisco, Inc., and currently sold under the trade name NS-4-FR. The neutron shield material is specified with a minimum B_4C loading of 1 weight percent. An equivalent neutron shield material with equivalent neutron shielding properties and composition, but not sold under the trade name NS-4-FR, may be used.~~

Important to Safety (ITS) means a function or condition required to store spent nuclear fuel safely; to prevent damage to spent nuclear fuel during handling and storage, and to provide reasonable assurance that spent nuclear fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

Independent Spent Fuel Storage Installation (ISFSI) means a facility designed, constructed, and licensed for the interim storage of spent nuclear fuel and other radioactive materials associated with spent fuel storage in accordance with 10CFR72.

Intact Fuel Assembly is defined as a fuel assembly without known or suspected cladding defects greater than pinhole leaks and hairline cracks, and which can be handled by normal means.

Maximum Reactivity means the highest possible k-effective including bias, uncertainties, and calculational statistics evaluated for the worst-case combination of fuel basket manufacturing tolerances.

MGDS is an acronym for Mined Geological Depository System.

Multi-Purpose Canister (MPC) means the sealed canister which consists of a honeycombed fuel basket for spent nuclear fuel storage, contained in a cylindrical canister shell which is welded to a baseplate, lid with welded port cover plates, and closure ring. There are different MPCs with different fuel basket geometries for storing PWR or BWR fuel, but all MPCs have identical exterior dimensions. The MPC is the confinement boundary for storage conditions. MPC is an acronym for multi-purpose canister. The MPCs used as part of the HI-STORM 100 System (Docket No. 72-1014) are identical to the HI-STAR 100 MPCs evaluated in the HI-STAR 100 storage (Docket No. 72-1008) and transport (Docket No. 71-9261) applications.

MPC Fuel Basket means the honeycombed composite cell structure utilized to maintain subcriticality of the spent nuclear fuel. The number and size of the storage cells depends on the type of spent nuclear fuel to be stored. Each MPC fuel basket has sheathing welded to the storage cell walls for retaining the Boral neutron absorber. Boral is a commercially-available thermal neutron poison material composed of boron carbide and aluminum.

Neutron Shielding means Holtite, a material used in the HI-STAR overpack to thermalize and

stipulated minimum loading. Furthermore, the surveillance, coupon testing, and material tracking processes which have so effectively controlled the quality of Boral are expected to continue to yield Boral of similar quality in the future. Nevertheless, to add another layer of insurance, only 75% ^{10}B credit of the fixed neutron absorber is assumed in the criticality analysis in compliance with Chapter 6.0, IV, 4.c of NUREG-1536, Standard Review Plan for Dry Cask Storage Systems.

1.2.1.3.2 Holtite™ Neutron Shielding

The specification of the overpack neutron shield material is predicated on functional performance criteria. These criteria are:

- Attenuation of neutron radiation and associated neutron capture to appropriate levels;
- Durability of the shielding material under normal conditions, in terms of thermal, chemical, mechanical, and radiation environments;
- Stability of the homogeneous nature of the shielding material matrix;
- Stability of the shielding material in mechanical or thermal accident conditions to the desired performance levels; and
- Predictability of the manufacturing process under adequate procedural control to yield an in-place neutron shield of desired function and uniformity.

Other aspects of a shielding material, such as ease of handling and prior nuclear industry use, are also considered, within the limitations of the main criteria. Final specification of a shield material is a result of optimizing the material properties with respect to the main criteria, along with the design of the shield system, to achieve the desired shielding results.

~~In the current submittal,~~ Currently, Holtite-A is the only approved neutron shield material which fulfills the aforementioned criteria. Holtite-A is a poured-in-place solid borated synthetic neutron-absorbing polymer. Holtite-A ~~a commercially available neutron shield material under the trade name NS-4-FR~~ is specified with a nominal B_4C loading of 1 weight percent for the HI-STAR 100 System. Appendix 1.B provides the Holtite-A material properties *germane to its function as a neutron shield.* Holtec has performed confirmatory qualification tests on Holtite-A under the company's QA program.

In the following, a brief summary of the performance characteristics and properties of Holtite-A is provided.

Density

The *nominal* specific gravity of Holtite-A is 1.68 g/cm^3 as specified in Appendix 1.B. To conservatively bound any potential weight loss at the design temperature and any inability to reach the theoretical density, the density is reduced by 4% to 1.61 g/cm^3. The density used for the

shielding analysis is conservatively assumed to be 1.61 g/cm^3 to underestimate the shielding capabilities of the neutron shield.

Hydrogen

The weight concentration of hydrogen is 6.0%. However, all shielding analyses conservatively assume 5.9% hydrogen by weight in the calculations.

Boron Carbide

Boron carbide dispersed within Holtite-A in finely dispersed powder form is present in 1% (nominal) weight concentration. Holtite-A may be specified with a B_4C content of up to 6.5 weight percent. For the HI-STAR 100 System, Holtite-A is specified with a minimum B_4C weight percent of 1%.

Design Temperature

The design temperature of Holtite-A is set at 300EF. The maximum spatial temperature of Holtite-A under all normal operating conditions must be demonstrated to be below this design temperature.

Thermal Conductivity

It is evident from Figure 1.2.9 that Holtite-A is directly in the path of heat transmission from the inside of the overpack to its outside surface. For conservatism, however, the design basis thermal conductivity of Holtite-A under heat rejection conditions is set equal to zero. The reverse condition occurs under a postulated fire event when the thermal conductivity of Holtite-A aids in the influx of heat to the stored fuel in the fuel basket. The thermal conductivity of Holtite-A is conservatively set at 1 Btu/hr-ft-EF for all fire event evaluations.

The Holtite-A neutron shielding material is stable below the design temperature for long-term use and provides excellent shielding properties for neutrons. ~~Technical papers provided in Appendix 1.B validate the neutron shield material's long-term stability within the design temperature and the material's ability to resist the effects of a fire accident. Holtite-A has been utilized in similar applications and has been licensed for use in a transportation cask under Docket No. 71-9235.~~

1.2.1.3.3 Gamma Shielding Material

For gamma shielding, HI-STAR 100 utilizes carbon steel in plate stock form. Instead of utilizing a thick forging, the gamma shield design in the HI-STAR 100 overpack borrows from the concept of layered vessels from the field of ultra-high pressure vessel technology. The shielding is made from successive layers of plate stock. The fabrication of the shell begins by rolling the inner shell plate and making the longitudinal weld seam. Each layer of the intermediate shells are constructed from two halves. The two halves of the shell shall be precision sheared, bevelled, and rolled to the

APPENDIX 1.B: HOLTITE-*A* ™ MATERIAL DATA
(Total of 20 Pages Including This Page)

The information provided in this appendix describes the neutron absorber material, Holtite-A ~~(also known commercially as NS-4-FR)~~ for the purpose of confirming its suitability for use as a neutron shield material in spent fuel storage casks. *Holtite-A is one of the family of Holtite neutron shield materials denoted by the generic name Holtite™. It is currently the only neutron shield material approved for installation in the HI-STAR 100 cask. It is chemically identical to NS-4-FR* which was originally developed by Bisco Inc. and used for many years as a shield material with B_4C or Pb added.

~~NS-4-FR~~ *Holtite-A* contains aluminum hydroxide ($Al(OH)_3$) in an epoxy resin binder. Aluminum hydroxide is also known by the industrial trade name of aluminum tri-hydrate or ATH. ATH is often used commercially as a fire-retardant. ~~hence the "FR" designation in NS-4-FR. NS-4-FR~~ *Holtite-A* contains approximately 62% ATH supported in a typical 2-part epoxy resin as a binder. Holtite-A ~~the Holtec International version of NS-4-FR,~~ contains 1% (nominal) by weight B_4C, a chemically inert material added to enhance the neutron absorption property. Pertinent properties of Holtite-A are listed in Table 1.B.1.

The essential properties of Holtite-A are:

1. the hydrogen density (needed to thermalize neutrons),
2. thermal stability of the hydrogen density, and
3. the uniformity in distribution of B_4C needed to absorb the thermalized neutrons.

ATH and the resin binder contain nearly the same hydrogen density so that the hydrogen density of the mixture is not sensitive to the proportion of ATH and resin in the ~~NS-4-FR~~ *Holtite-A* mixture. B_4C is added ~~(1% in Holtite-A)~~ as a finely divided powder and does not settle out during the resin curing process. Once the resin is cured (polymerized), the ATH and B_4C are physically retained in the hardened resin. ~~Analysis~~ *Qualification testing* for B_4C throughout a column of Holtite-A has confirmed ~~(Holtec International qualification tests)~~ that the B_4C is uniformly distributed with no evidence of settling or non-uniformity. Furthermore, an excess of B_4C is specified in *the* Holtite-A *mixing and pouring procedure* as a precaution to assure that the B_4C concentration is always adequate throughout the mixture.

~~NS-4-FR material has been extensively tested for thermal stability, as indicated in the following documents (copies of these documents are attached):~~

- ~~Letter dated 4/20/87 from Mr. Larry Dietrick, Bisco Products to Mr. Tod Lesser, NAC International, "Weight loss of NS-4-FR under extreme temperature conditions"~~
- ~~"Experimental Studies On Long-Term Thermal Degradation of Enclosed Neutron Shielding Resin", Asano, Ryoji and Nagao Niomura~~
- ~~"Thermal Testing of Solid Neutron Shielding Materials", Boonstra, Richard H.~~

~~The specific gravity specified in Table 1.B.1 does not include an allowance for weight loss. The specific gravity specified in Chapter 1 includes a 4% reduction to conservatively account for potential weight loss at the design temperature of 300°F. However, the BISCO letter dated 4/20/87 provides information stating that samples had been exposed to a continuous temperature of 338°F for 146 days and a maximum of 3.15% weight loss had been experienced. Thus, there is a substantial level of conservatism in the Holtec allowance for weight loss.~~

The specific gravity specified in Table 1.B.1 does not include an allowance for weight loss. The specific gravity assumed in the shielding analysis includes a 4% reduction to conservatively account for potential weight loss at the design temperature of 300°F or an inability to reach theoretical density. Tests on the stability of Holtite-A were ~~also~~ performed by Holtec International. *The results of the tests are summarized in Holtec Reports HI-2002396, "Holtite-A Development History and Thermal Performance Data" and HI-2002420, "Results of Pre- and Post-Irradiation Test Measurements." The information provided in these reports demonstrates that Holtite-A™ possesses the necessary thermal and radiation stability characteristics to function as a reliable shielding material in the HI-STAR 100 overpack.*

~~The paper entitled "Experimental Studies on Long-Term Thermal Degradation of Enclosed Neutron Shielding Resin" provides information which corroborates the information provided in the BISCO letter dated 4/20/87. The paper suggests that enclosures of the NS-4-FR material can further decrease the percent weight reduction at elevated temperatures.~~ The ~~NS-4-FR~~ *Holtite-A* is encapsulated in the HI-STAR 100 overpack and, therefore, should experience a very small weight reduction during the design life of the HI-STAR 100 System. ~~It should be noted that the shielding analysis conservatively assumes 4% loss in density.~~

~~The paper entitled "Thermal Testing of Solid Neutron Shielding Materials" provides information regarding NS-4-FR material stability during a fire accident. Results of the study suggests that NS-4-FR could withstand a fire accident with minimal damage. This data is provided for information only, as the post-accident shielding analysis very conservatively assumes complete degradation of the Holtite-A neutron shield and replaces the neutron shield with a void.~~

The data and test results ~~presented here~~ confirm that *Holtite-A remains stable under design thermal and radiation conditions, the material properties meet or exceed that assumed in the shielding analysis, and the B_4C remains uniformly distributed with no evidence of settling or non-uniformity.*

~~1. Holtite-A with 1% B_4C is thermally stable, has the same thermal stability and characteristics as the previously approved NS-4-FR material;~~

~~2. The hydrogen density meets or exceeds minimum NS-4-FR specifications (measured at 0.105 gH_2/cc compared to the NS-4-FR specification of 0.096 gH_2/cc), and~~

~~3. The B_4C is uniformly distributed, with no evidence of settling or non-uniformity.~~

Based on the information described above, Holtite-A meets all of the requirements for an acceptable neutron shield material. ~~in the manner of NS-4-FR, which was licensed previously in Docket No. 71-9235 (NAC-STC).~~

Table 1.B.1

REFERENCE PROPERTIES OF HOLTITE-A NEUTRON SHIELD *MATERIAL*

PHYSICAL PROPERTIES ~~(Reference: NAC International Brochure)~~	
% ATH	62 *nominal* ~~maximum (confirmed by Holtec in independent analyses)~~
Specific Gravity	1.68 g/cc nominal
~~Thermal Conductivity~~	~~0.373 Btu/hr/ft-°F~~
Max. Continuous Operating Temperature	300°F
~~Specific Heat~~†	~~0.39 Btu/lb-°F~~
Hydrogen Density	0.096 g/cc minimum ~~(confirmed by Holtec in independent analyses)~~
Radiation Resistance	Excellent
~~Ultimate Tensile Strength~~	~~4,250 psi~~
~~Tensile elongation~~	~~0.65%~~
~~Ultimate Compression Strength~~	~~10,500 psi~~
~~Compression Yield Strength~~	~~8,780 psi~~
~~Compression Modulus~~	~~561,000 psi~~
CHEMICAL PROPERTIES (Nominal)	
wt% Aluminum	21.5 ~~(confirmed by Holtec)~~
wt% Hydrogen	6.0 ~~(confirmed by Holtec)~~
wt% Carbon	27.7
wt% Oxygen	42.8
wt% Nitrogen	2.0
wt% B_4C	~~up to 6.5 (Holtite-A uses 1% B_4C)~~ *1.0*

~~† BISCO Products Data from Docket M-55, NAC-STC TSAR.~~