HOLTEC INTERNATIONAL

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January 10, 2014

Pierre Saverot, Project Manager – Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
ATTN: USNRC Document Control Desk,
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Docket No.: 71-9325 (HI-STAR 180 Model)
TAC No.: L24753
Reference: 1. NRC Letter (Saverot) to (Hinojosa) dated December 19, 2013
2. Holtec Letter 1553036-NRC, dated September 18, 2013
3. Holtec Letter 1553034-NRC, dated May 31, 2013

Subject: Response to Request for Additional Information on HI-STAR 180 Transport Cask License Amendment Request 9325-1

Dear Mr. Saverot,

We are pleased to submit supplemental information in response to request for additional information (RAI) [1] on license amendment request (LAR) 9325-1 [3] as supplemented by [2].

Enclosures 1 and 2 contain Holtec's response to RAIs (both proprietary and non-proprietary versions). Enclosures 1 and 2 also refer to other Enclosures to this letter containing supporting documents.

Enclosures 3 and 4 contain Supplement B to Holtec Report No. HI-2073681 Revision 4 entitled "Safety Analysis Report on the HI-STAR 180 Package" (SAR) (both proprietary and non-proprietary versions). SAR Supplement B is provided as a compilation of changed SAR pages. Enclosure 5 contains one licensing drawing with proposed changes corresponding to Supplement B of the SAR.

Enclosure 6 is an affidavit prepared in accordance with 10 CFR 2.390 requesting that Enclosures marked proprietary be withheld from public disclosure due to their proprietary nature.

Please contact me at (856)797-0900 Extension 3698 if you have any questions or require any additional information.

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Sincerely,

Luis Hinojosa
Corporate Adjunct Licensing Manager
Project Manager of Licensing of Transportation Systems
Holtec International

cc: (letter only w/o enclosures)
Mark Lombard, USNRC
Tony Hsia, USNRC
Michele Sampson, USNRC
Holtec Group 1

Enclosures: (Enclosures 2, 3 and 5 contain Holtec Proprietary Information)

Enclosure 1: Response to Request for Additional Information (Holtec Non-Proprietary Information)
Enclosure 2: Response to Request for Additional Information (Holtec Proprietary Information)
Enclosure 3: HI-STAR 180 Safety Analysis Report (SAR), HI-2073681, Supplement B to Rev. 4 (Holtec Proprietary Information)
Enclosure 4: HI-STAR 180 Safety Analysis Report (SAR), HI-2073681, Supplement B to Rev. 4 (Holtec Non-Proprietary Information)
Enclosure 5: HI-STAR 180 Cask Licensing Drawing, Drawing No. 4845, Supplement B to Proposed Revision 9, Sheet 6 (Holtec Proprietary Information)
Enclosure 6: Affidavit Pursuant to 10 CFR 2.390 to Withhold Information from Public Disclosure

AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, Stefan Anton, being duly sworn, depose and state as follows:

(1) I have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is information in Enclosures 2, 3, and 5 to Holtec letter Document ID 1553037-NRC. These Enclosures contain Holtec Proprietary information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

AFFIDAVIT PURSUANT TO 10 CFR 2.390

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 4.a, and 4.b above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary

agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

STATE OF NEW JERSEY)
) ss:
COUNTY OF BURLINGTON)

Dr. Stefan Anton, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of her knowledge, information, and belief.

Executed at Marlton, New Jersey, this 9th day of January, 2014.

Stefan Anton
Holtec International

Subscribed and sworn before me this 9th day of January, 2014.

Maria C. Massi
MARIA C. MASSI

MARIA C. MASSI
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires April 26, 2015

NON-PROPRIETARY INFORMATION

Response to Request for Additional Information (2nd Round RAIs)
Holtec International
Docket No. 71-9325
HI-STAR 180 Transportation Package – LAR 9325-1

Chapter 2 – Materials Evaluation

2.1 Provide an engineering analysis to prove that friction stir welding (FSW) weld joint ductility is not critical to the "important to safety" classification of the weld joint. Provide tensile tests of the base metal and of the weld joint to demonstrate that the welding is equal to or greater than 60% of the base metal. Provide elongation tests on the base metal and the weld test coupon to demonstrate that the elongation is not exceeding 3%.

This RAI is a follow-up to RAI 2-7, dated August 29, 2013. Staff had previously asked the applicant to justify the deviations from the American Society of Mechanical Engineers (ASME) code requirements and explain the rationale for using radiographic testing in lieu of bend testing for weld soundness.

The applicant took the position that radiographic testing shall be used for weld soundness in lieu of bend testing, whereas the ASME Boiler & Pressure Vessel Code Section IX requires bend testing to assess the soundness of the weld. The ASME Section IX Code provides the qualification requirements for both weld procedures and welders, when performing welding activities for items governed by other sections of the ASME Code. Staff recognizes that Metamic-HT is not an ASME material and has unique structural characteristics, as well as thermo-physical properties, but waiving the bend test requirement of ASME Section IX is not acceptable because the purpose of the bend test is to prove weld joint ductility

This information is needed by the staff to determine compliance with 10 CFR 71.33(a)(5)(iii).

Holtec Response to RAI 2-1:

Holtec regrets that our justification to substitute Bend Testing with 100% volumetric examination (Radiography) did not resolve the issue satisfactorily for the NRC Staff. To eliminate this disconnect and bring our process in alignment with the NRC Staff's expectations, Holtec has conducted bend testing of Metamic-HT for FSW PQRs while also keeping radiography as an added requirement. Accordingly, SAR Subparagraph 1.2.1.6.1 (iv.) "Welding of Metamic-HT" has been revised to include bend testing in addition to radiography.

Since Metamic-HT is not a code material and does not have a P number, it does not have a specified radius for bend test in the Code. To overcome this lack of specificity,

Holtec has utilized QW-466.1 through Note b) (materials with 3% to 20% elongation) as a guide. In addition, the bend test is configured to insure that the welded zone's elongation (ductility) is correlated with the demand on its application under all limiting loading conditions. For this purpose, the maximum strain developed in the corner FSWs in the HI-STAR 180 fuel basket from normal and accident loadings in the SAR is obtained by perusing through all LS-DYNA package drop simulations reported in the FSAR. The maximum elongation thus determined is found to be less than 2% (HI-2063552 Rev. 5 Calculation 17, previously submitted as a supporting document under Holtec Letter 1553034-NRC Enclosures 11 & 12). Referring to the acceptance criterion for the ASME code for Level D loadings (ASME Section III, Division 1, Appendix F, F-1300), the maximum primary stress should be no greater than 70% of ultimate tensile strength of the part. Applying this criterion to the ultimate strain to establish the minimum required ductility for the weld zone yields the *required* ultimate strain to be 2.86% (2/0.7 = 2.86). The bend radius therefore should be set at such a value that the induced tensile strain from bending is at least 2.86%.

The above requirement led Holtec to employ the Guided-Bend Wrap-Around Jig, QW-466.3, with a A = 3" (approximately 4.6t radius). Using Kirchoff's beam theory, the maximum percent strain in a bent bar of thickness t at inner radius R=nt is given by (50/(n+0.5)). Therefore, using R=4.6t, the strain computes to 9.80% which is over 3 times the strain experienced by the welds under the entire array of loadings documented in the SAR. Thus, the method and parameters selected for bend test are assured to bound the maximum required strain in future cask applications. PQR 1318, summarized in Table 2-1.1 below, contains the bend test results which indicate complete compliance with the criteria articulated in the foregoing pursuant to QW-163.

(PROPRIETARY INFORMATION WITHHELD)

Furthermore, as requested, please see below a table (Table 2-1.2) summarizing the Tensile and Elongation values of Metamic HT base material tensile report "Lab Job 357 Lot 195 Metamic HT (11-25-2013)" and FSW coupons from PQR 1308. (All test reports and PQRs developed in the Metamic-HT program are archived in Holtec's documentation control system).

(PROPRIETARY INFORMATION WITHHELD)

2.2 Provide inspection acceptance criteria for FSW weld joints and the standards used as a basis for such acceptance criteria. Explain clearly the methodology used to identify atypical FSW welding defects, using volumetric or non-volumetric inspection processes reviewed and approved by NDT Level III.

This RAI is a follow-up to RAI 2-8, dated August 29, 2013. The applicant had stated that ASME Section V references the techniques and methods to conduct VT; however, the acceptance criteria are not stated in this section. Rather, ASME Section V paragraph T-980.1 states that one should follow the applicable code which, in this case, is Holtec's Standard Procedure, HSP-638, and the Quality Control Procedure, QCP 9.1, for inspection qualification, which references and follows ASNT-TC-1a.

The staff finds the response regarding acceptance criteria for FSW weld joints, and standards used, not acceptable. HSP-638 references the applicable code as being ASME Section III, Division 1 Subsection NG 5362, 2007. FSW was not recognized by the ASME Section III until the issuance of the 2013 edition; therefore, the 2007 Code criteria cannot be used as visual inspection criteria because the welding fabrication anomalies occurring in the FSW process are unique to that process. Some of these welding fabrication anomalies are also discussed throughout HSP-638; however, in order for these anomalies to be used, Holtec needs to meet the requirements of ASME Section V, 2007 edition, and of Article 14 "Examination System Qualification for qualifying the VT and/or NDE examination procedures and NDE personnel qualifications." These examination and NDE personnel procedures shall be evaluated by Holtec's ASNT –TC 1a Tested Level III in the respective NDE disciplines. Also, the "Acceptance Standards for Visual Examination for Weld Surface Integrity" (Paragraph 5362) are for established traditional welding processes such as SMAW, GTAW, GMAW, but not for FSW. Therefore, such criteria cannot be used unless the requirements of ASME Section V, T-921.2-"Procedure Qualification" and T-992- "Performance Documentation" are completed, when required, by referencing the Code Section.

The applicant also stated that it follows its Quality Control Procedure, QCP 9.1, which references and follows ASNT-TC-1a. Staff notes that ASNT-1C-1a is only a recommended practice to qualify NDE inspection personnel to three levels of inspection based on their training experience in a specific discipline. ASNT-1C-1a shall not be used for the qualification of inspection requirements.

This information is needed by the staff to determine compliance with 10 CFR 71.33(a)(5)(iii).

Holtec Response to RAI 2-2:

We confirm that the weld inspection criteria set down in HSP-638 have been developed with full consideration of the guidance contained in ASME Section V, including the articles cited by the Staff, namely article 14 "Examination System Qualification for qualifying the VT and/or NDE examination procedures and NDE personnel qualifications", T-921.2 "Procedure Qualification" and T-992 "Performance Documentation". The provisions in HSP-638 are also informed by Holtec's current weld inspection documentation used in conventional welding (QCP-10.5H), ASME Sec. III Div. 1 NG 5362 and by the FSW weld development program executed at the Company's Orrvilon facility. During the FSW weld development program, assay of naturally occurring weld defects was further supplemented by defects forced by a deliberate departure from specified parameters. The surface condition of the FSW was correlated to the observed weld defects which along with the baseline of existing inspection documentation led to the creation of HSP-638 which has matured into a definitive governing document for the inspection criteria for FSW of Metamic HT.

The methodology of the inspection technique utilized for the inspection is taken from ASME Sec. V Article 2 and Article 9. The acceptance criteria applied is per HSP-638, the table provided below summarizes the criteria for convenience.

Qualification of inspection personnel is per HQP-9.1 for visual inspection. Qualification of the inspection procedure for VT, as stated in ASME Sec. V T-921.2 and T-922 was reviewed and approved by HMD's resident Level III inspector. A "Report of Visual

Testing Procedure and Demonstration of Adequacy" has been appended to the latest revision of HSP-638. A summary of acceptance criteria is provided in Table 2-2.1 below:

(PROPRIETARY INFORMATION WITHHELD)

2.3 Remove, from the application, all statements pertaining to the following sentence: "The concept of equivalent materials is fully developed and gained NRC acceptance in the HI-STORM FW SAR".

Staff disagrees with this statement and has always been opposed to vague wording, such as "equivalent" or "similar", in safety analysis reports (SARs). What is "equivalent" to one applicant may not be "equivalent" for another applicant. All materials must have specified characteristics in accordance with recognized Codes and Standards, particularly for "important to safety" components. Defining "equivalency" by some critical characteristics meeting or exceeding those specified for the designated material is not acceptable for staff because it does not provide the means to determine how "equivalency" will be confirmed.

The HI-STORM FW SAR was reviewed against the requirements of 10 CFR Part 72. The flexibility for evaluation of changes contained in 10 CFR 72.48 is not included in the regulatory framework for transportation, 10 CFR Part 71. Therefore, these statements could lead to an incorrect conclusion that something other than a material specified in the licensing drawings could be used. Any packaging component which does not comply with the licensing drawings referenced in the certificate is not acceptable for shipment.

This information is needed by the staff to determine compliance with 10 CFR 71.43.

Holtec Response to RAI 2-3:

To accord with the Staff's position, the notion of "Equivalent (or Equal) Material" has been removed in its entirety from the SAR Glossary and text matter. Purging of the "equivalent material " concept and similar redundant text matter from the SAR and to improve clarity has required scrubbing and relocating of certain information (such as relocation of Holtite-B critical characteristics from SAR Subsection 1.2.1.5.1 to SAR Tables 1.2.16 and 8.1.5). For convenience; the affected locations in the SAR to implement removal of "equivalent material" and clean-up to improve clarity are listed below:

- SAR Subparagraph 1.2.1.5.1 "Holtite Shielding Material" including relocation of property values to SAR Table 1.2.16 "Properties of Holtite-B for Shielding and Thermal Function" and SAR Table 8.1.5 "Properties of Holtite-B for Shielding Function"
- SAR Chapter 2, Subparagraph 2.2.1.2.2 "Holtite Neutron Shielding Material" and Table 2.2.8 "Holtite Neutron Shielding Material – Modeling Input Data" relocated to Paragraph 8.1.5.3 "Neutron Shielding Material"
- SAR Subsection 3.2.1 "Material Properties"

- SAR Table 3.2.1 "Summary of HI-STAR Packaging Materials Thermal Property References"
- SAR Table 3.2.2 "Thermal Conductivity of HI-STAR 180 Cask Materials"
- SAR Table 3.2.7 "Materials Density and Specific Heat Properties Summary"
- SAR Section 8.0 "Introduction"

Chapter 4 – Containment Evaluation

4.1 Remove all language from the application stating or indicating that each of the seals in the American Seal & Engineering "Seal option 1" seals and the Technetics "Seal option 2" can be changed without NRC approval.

The staff identified several areas throughout the application that make reference to the ability of a user to make changes to seal options 1 and 2 without NRC approval (e.g., Appendix 4A of the SAR). The seal / groove design is an important to safety component. Therefore the staff expects to review a unique design for each of the seals in the American Seal & Engineering "Seal option 1" and the Technetics "Seal option 2" based on the design drawings for the associated seal part/drawing number. The SAR, licensing drawings, and any information incorporated by reference in the licensing drawings should be written to reflect this. Any language implying that the seal designs can be changed without NRC review and approval should be removed from the application.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-1:

Appendix 4A of the SAR has been updated to remove statements that allow the user to employ a seal design that has not been reviewed and approved by the NRC through the licensing process.

4.2 Provide minimum and maximum dimensional values, or dimensions with tolerances for the following parameters in Appendix 4.A (this would also necessitate the removal of the word "Nominal" for each parameter):

a. Nominal Inner Seal Groove OD "Dg"
b. Nominal Inner Seal Seal OD "Ds"
c. Nominal Outer Seal Groove ID "Dg"
d. Nominal Outer Seal Seal ID "Ds"
e. Nominal Groove Width "W"
f. Nominal Seal Groove OD "Dg"
g. Nominal Seal OD "Ds"

The information in Appendix 4.A, "Confinement boundary seal data" should provide the location of the containment boundary components through the use of dimensions with

tolerances. This information is necessary to ensure sufficient clearance between the seal and the cavity to prevent the seal from binding and not deforming properly in the cavity.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-2:

The information on seal and groove dimensions and associated tolerances has been revised in Appendix 4.A of the SAR to accord with the seal suppliers' recommendations for the limiting dimensions for the seal and groove. Sheet 6 to proposed licensing DWG 4845 has been revised accordingly.

4.3 Provide minimum and maximum values, or values with tolerances for the nominal seal seating load in Appendix 4.A. This would also necessitate the removal of the word "Nominal" from the nominal seal seating load.

The American Seal & Engineering "Seal option 1" seal design drawings stated that the seating load was 850 lbs/in +/- 10% or 3200 lbs/in +/- 10%, depending on the seal. The Technetics "Seal option 2" seal design drawings stated that the seating load was ~942 lbs/in circumference or ~2284 lbs/in circumference, depending on the seal. The tolerance should be included for this value, or a minimum and maximum value should be given.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-3:

Appendix 4A of the SAR has been updated to include the tolerance on the seating load for all proposed seals. The tolerance is aligned with the seal suppliers' recommendations.

4.4 Revise the SAR Appendix 4A to ensure clarity that the seal manufacturer, seal part / drawing number, seal core, jacket, and lining materials, as well as specific material combinations of those materials, surface finish range, and minimum and maximum seal and groove dimensions (or dimensions with tolerances) are seal parameters that are subject to NRC approval.

Appendix 4A of the SAR states that the seal cross section diameter, groove depth, seating load, and spring-back are the only critical seal parameters and that all other seal properties are representative and may vary with seal manufacturer recommendations. Each seal manufacturer proposed specific seal designs to meet the reliability, sealing

requirements, life and recovery of the HI-STAR 180 seals. Specific seal materials and combinations of seal materials ensure there will be no chemical, galvanic, or other reactions. In addition, the surface finish can impact the performance of the seal. These parameters, as well as the seal and groove dimensions (see RAI 4.2), are all part of the seal / groove design which is an important to safety component not subject to change without NRC approval. The SAR should be revised to ensure that these parameters will not be changed by a future user without NRC approval.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.43(d), 71.51(a)(1) and (2).

Holtec Response to RAI 4-4:

Appendix 4A of the SAR has been revised to add the information requested in this RAI. The specification of the acceptable seals now includes "component materials", the range of acceptable surface finishes, geometric data, tolerances and supplier's model number Critical characteristics that cannot be changed without prior NRC approval have been identified in the tables.

4.5 Clarify the seal part / drawing number "TBD" for the American Seal & Engineering "Seal option 1" in Table 4.A-4 "Outer Lid Access Port Plug Seal."

Clarify if the seal part / drawing number for the American Seal & Engineering "Seal option 1" in Table 4.A-4 "Outer Lid Access Port Plug Seal" is 050415 / 050415 CAV.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-5:

We confirm that the seal/part drawing number for the American Seal & Engineering option is 050415/050415 CAV is the correct number. Appendix 4A of the SAR has been revised to reflect the correct drawing numbers.

4.6 Describe how the information below has been verified for each of the seals in the Technetics "Seal option 2."

The "Notes" section of the Technetics "Seal Option 2" states that for each seal:

1. Customer to verify that the bolting and hardware can generate the required seating load without warping or distorting.
2. Customer to verify material compatibility.

3. Customer to test and verify that seal meets all performance and safety requirements.

The SAR does not explain how these notes in the Technetics "Seal Option 2" have been verified by the customer in order for the NRC to consider approval of the seal design.

Warping or distorting of the bolting hardware could impact containment capability during normal or accident conditions. Material compatibility is necessary to ensure there are no significant chemical, galvanic, or other reactions among the packaging components, or between the packaging components and the packaging contents. The staff acknowledges that the seals are leakage rate tested to the leaktight criterion in accordance with ANSI N14.5, as described in Chapters 7 and 8 of the SAR. If there are any additional tests that are being performed to verify that the seals meet all performance and safety requirements, those tests should be described.

This information is needed by the staff to determine compliance with 10 CFR 71.43(d), 71.51(a)(1) and (2).

Holtec Response to RAI 4-6:

We hereby confirm that satisfying the three requirements stated in Technetic's literature cited above is intrinsic to all seal selections made in Holtec's cask designs. In particular, for the HI-STAR 180 joints:

1. The specified bolt preloading stress meets the ASME NB Level A stress limit and is significantly smaller than the yield strength of the bolt material. Therefore, the bolted joint can generate the required seating load without warping or distorting due to excessive bolt preloading. Moreover, bolt preloading is a controlled operation, which is required to strictly follow the relevant operation procedure to ensure that the requirements contained in the "Notes" are satisfied.

2. All cask sealing surfaces have been specified to be made of stainless steel. The seals specified in Appendix 4.A of the SAR have been qualified for compatibility of the environment attendant to their use in HI-STAR 180. This statement also applies to the aluminum jacketed seals manufactured by Technetics which have been used for multiple years in storage casks subject to continuous leakage monitoring in Europe. The operating experience for these casks has demonstrated there is no evidence of corrosive attack that can degrade seal performance.

3. Every cask is tested with the seals to ensure that the seals meet the criteria defined in chapter 8 of the SAR. There are no additional tests required to confirm the performance capability of the seals and the sealing configuration.

4.7 Address the following relative to the "useful" spring-back in association with the seal design and the ability of the closure lid seals to remain leaktight under all hypothetical accident events.

a. Define the "useful" spring-back to maintain leaktight closure lid seals in the SAR.

b. Provide justification for the numerical value of 0.01 inches for "useful" spring-back. Address how the spring-back of 0.03 inches that was used in the American Seal & Engineering "Seal option 1" design does not meet the definition of "useful" spring-back.

c. Provide clear and complete documentation in Section 2.7 of the SAR to show that, based on the structural analysis, the closure lid seals for the American Seal & Engineering "Seal option 1" and the Technetics "Seal option 2" will remain leaktight under all hypothetical accident events based on the "useful" spring-back, as well as the associated margin for these analyses.

d. Explain how the closure lid seals in the American Seal & Engineering "Seal option1" and Technetics "Seal option 2" have been designed to provide the minimum "Useful" spring-back required in Table 2.2.12 of the SAR and how this can be concluded from the design drawings provided.

"Useful" spring-back has not been defined in the SAR, although it is a required characteristic in Table 2.2.12 of the SAR. Attachment C.A to HI-2063563 (ML073100307) states, "Based on input from analysis performed by Holtec it was determined that the seal must have the capability of recovering 0.030 inches minimum without the loss of sealing capability during a transient event." This appears to meet the definition of "useful" spring-back provided in the Holtec RAI 4-4 response, therefore it appears the "useful" spring-back should be 0.030 inches. Yet in this amendment request, the wording was changed from "Spring Back at Complete Decompression" to "Minimum Useful Spring Back to maintain leaktightness" and the numerical value was changed from 0.03 inches to 0.01 inches in Table 2.2.12 of the SAR. A justification for this value, in association with the definition of "useful" spring-back, was not provided.

Section 2.7 of the SAR does not tie the numerical value for "useful" spring-back to the analysis results for each of the hypothetical accident events. Nor does it show the margin associated with each of these analysis. Holtec response to RAI 4-4, dated September 18, 2013, states that, "... in all cases, the maximum predicted spring-back in the wake of the accident event is less than the minimum "useful" spring-back of 0.010 inches, indicating that the leaktight seals are maintained," but does not provide a clear justification for that statement.

The design drawings provided for the Technetics "Seal option 2" closure lid seals do not tie the "useful" spring-back to the design of the Technetics "Seal option 2" closure lid seals. It is not clear if the design drawings provided for the American Seal & Engineering "Seal option 1" tie the "useful" spring-back or "Spring-back at complete decompression" to 0.03 inches and how that value and associated definition is conservative compared to the required value of "useful" spring-back of 0.010 inches in Table 2.2.12 of the SAR. Holtec response to RAI 4-4 states, ""useful" spring-back is the more appropriate (and conservative) measure for evaluating whether the leaktight seal is maintained following a hypothetical accident condition," but a justification for this statement was not provided.

This information is needed by the staff to determine compliance with 10 CFR 71.51(a)(2).

Holtec Response to RAI 4-7:

We agree that a clear distinction between the terms "total spring-back" and "useful spring-back" is necessary to avoid incorrect interpretation of the results. For this purpose, Figure 4-7.1 below illustrates the loading/unloading/re-loading curve for a typical O-ring gasket. The terms noted in the figure's legend are used in the explanation below to facilitate presentation.

a) The term "useful" springback is defined as the amount that the seal can unload without the leakage rate exceeding the required value. In Figure 4-7.1 below, the "useful" springback is the distance between points F and C', denoted by the letter e in the figure. In the prior submission, the term "Spring Back at Complete Decompression" was used which represents the amount that the seal diameter recovers when completely unloaded, i.e., the total springback. In the figure below, the "Spring Back at Complete Decompression" is the distance between point F and the end point (i.e., zero load point) of the unloading curve, D. This distance is denoted by the letter r in the figure.

b) The following features of the seal's loading unloading curve are germane to understanding the performance of the bolted joints in HI-STAR 180:

(i) At initial compression, upon reaching point A (lineal pressure Y0), the gasket can seal the joint to the required leakage rate level. However, additional compression is necessary to insure protection against unacceptable leakage.

(ii) The point B in the figure represents the optimum compression of the seal to insure maximum joint sealworthiness. The depth of the groove in which the gasket sits is accordingly desired to be smaller than the gasket diameter by the amount denoted by letter g. As explained in the Holtec Position Paper DS-337 (previously submitted as Enclosure 6 to Holtec letter 1553036-NRC), in the controlled compression joint utilized in HI-STAR 180, any bolt load in excess of compressing the gasket by distance denoted by letter g is taken up by the "land". This compression force serves as the initial buffer (reserve) that protects the seal from decompression under loads trying to pry the joint apart.

(iii) The gasket follows the unloading/reloading curve in Figure 4-7.1 if it were to decompress and re-compress after initial seating. The gasket responds as an elastic element (no hysteresis) during the unloading/reloading cycle.

(iv) As the gasket is made to relax during unloading, its lineal pressure, Y, drops. The pressure corresponding to point C is the minimum required pressure to meet the minimum specified leak rate.

(v) If the gasket were to continue to unload, then the lineal pressure will fall below the threshold pressure Y1, and the leak rate may begin to exceed the specified minimum. Nevertheless, the gasket will continue to load/unload along the "elastic" curve under all subsequent cycles.

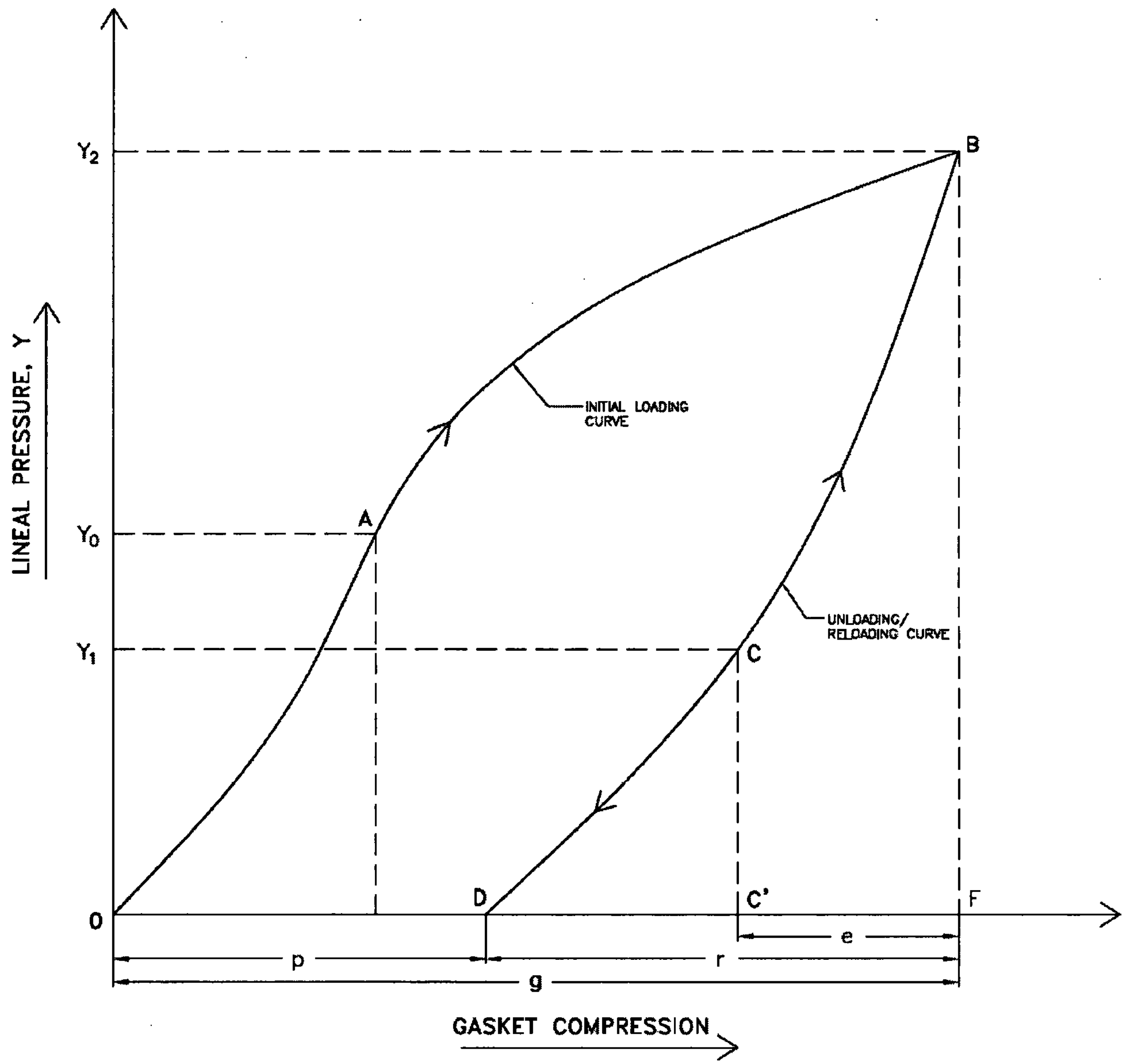
(vi) In order to maintain joint seal, it is necessary that the compression of the seal lie between points F and C'; i.e., in the useful recovery range.

(vii) The total recovery, denoted by letter r, is substantially greater than the elastic (useful) recovery, denoted by letter e.

The structural analyses reported in SAR sections 2.6 and 2.7 conclude that the seal will remains fully seated (at point B in Figure 4-7.1) after all of the analyzed Level A and Level D accidents. In other words, the seal springback at the end of the analyzed accident is *zero*. Thus none of the elastic springback available in the joint (.01 inch in the selected seal designs) is used or needed. While the American Seal & Engineering "Seal option 1" design has a *total springback of 0.03" (r = .03 inch in Figure 4-7.1)*, the evaluation of the seal performance should be based on the *useful springback, denoted by letter e.* SAR sections 2.6 and 2.7 have been revised to provide the necessary clarification.

c) SAR Section 2.7 and SAR Appendix 1.B have been revised to demonstrate that both seal options will remain leaktight under all hypothetical accident events. The revised SAR also makes it clear that the final seal springback should be checked against the 0.01" useful springback available in the system. Since the final seal springback is zero, the bolt joint has a significant safety margin against leaking (recall that the joint will remain leak-tight even if a springback equal to "e" had occurred). As a quantitative measure, the m value discussed in Subparagraph 2.6.1.3.4 of the SAR is an excellent indicator of the safety margin in the seal design.

d) The only reliable way for establishing the "useful" springback for a seal design is through product testing. Seal suppliers supply the values for "useful" springback based on testing of the seals. The "useful" springback for the American Seal and Engineering and Technetics Seals have been provided based on manufacturer's testing.



SYMBOL	DESCRIPTION
g	OPTIMAL GASKET COMPRESSION
e	USEFUL ELASTIC SPRING-BACK
p	PERMANENT GASKET DIAMETER CHANGE
r	TOTAL SPRING-BACK
Y_2	OPTIMAL LINEAL LOADING
Y_0	MINIMUM LINEAL LOADING TO PRODUCE A SEAL
Y_1	MINIMUM LINEAL LOADING ON DECOMPRESSION TO MAINTAIN A SEAL

Figure 4-7.1: Loading-Unloading Characteristics of O-Ring Seals

NON-PROPRIETARY VERSION

SAFETY ANALYSIS REPORT
on
THE HI-STAR 180 PACKAGE

(Supplement B to Revision 4)

by

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USNRC Docket No. : 71-9325
Holtec Report No. : HI-2073681
Quality Designation : Safety Significant*

NON-PROPRIETARY VERSION

* The safety designation is pursuant to Holtec International's Quality Assurance Program.

GLOSSARY AND NOTATION

GLOSSARY

AFR is an acronym for Away From Reactor.

ALARA is an acronym for As Low As Reasonably Achievable.

AL-STAR is the trademark name of the impact limiter design used in the family of HI-STAR dual-purpose casks.

Basket Shims are aluminum alloy extrusions that serve to maintain the fuel basket coaxial with the cask's storage cavity.

BWR is an acronym for Boiling Water Reactor.

Cask is a generic term used to describe a device that is engineered to hold high level waste, including spent nuclear fuel, in a safe configuration.

C.G. is an acronym for Center of Gravity.

Closure Lid is a generic term to indicate a gasketed flat cover that bolts to the top flange of the cask.

Commercial Spent Fuel (CSF) refers to nuclear fuel used to produce energy in a commercial nuclear power plant.

Containment Boundary means the enclosure formed by the cask inner shell welded to a bottom plate and top flange plus dual closure lids with seal(s) and associated penetration port closure(s) and seal(s).

Containment System means the assembly of containment components of the packaging intended to contain the radioactive material during transport.

Cooling Time (or post-irradiation decay time, PCDT) for a spent fuel assembly is the time between reactor shutdown and the time the spent fuel assembly is loaded into the cask. Cooling Time is also referred to as the "age" of the CSF.

Critical Characteristic means a feature of a component or assembly that is necessary for the component or assembly to render its intended safety function. Critical characteristics of a material are those attributes that have been identified, in the associated material specification, as necessary to render the material's intended safety function.

Criticality Safety Index (CSI) means the dimensionless number (rounded to up to the next tenth) assigned to and placed on the label of a fissile material package, to designate the degree of control of accumulation of packages containing fissile material during transportation.

Damaged Fuel Assembly is a fuel assembly with known or suspected cladding defects, as determined by a review of records, greater than pinhole leaks or hairline cracks, empty fuel rod locations that are not filled with dummy fuel rods, whose structural integrity has been impaired such that geometric rearrangement of fuel or gross failure of the cladding is expected based on engineering evaluations, or that cannot be handled by normal means. Also see fuel debris.

Damaged Fuel Container (or Canister) (DFC) means a specially designed vessel for damaged fuel or fuel debris, which may permit gaseous and liquid media to escape while minimizing dispersal of gross particulates or which may be hermetically sealed. The DFC features a lifting location, which is suitable for remote handling of a loaded or unloaded DFC.

DBE means Design Basis Earthquake.

DCSS is an acronym for Dry Cask Storage System.

Design Heat Load is the computed heat rejection capacity of the HI-STAR package with a specific fuel basket with CSF stored in uniform storage with the ambient at the normal temperature and the peak cladding temperature (PCT) at 400°C. The Design Heat Load is less than the thermal capacity of the system by a suitable margin that reflects the conservatism in the system thermal analysis.

Design Life is the minimum duration for which the component is engineered to perform its intended function if operated and maintained in accordance with the instructions provided by the system supplier.

Design Report is a document prepared, reviewed and QA validated in accordance with the provisions of Holtec's Quality Program. The Design Report shall demonstrate compliance with the requirements set forth in the Design Specification. A Design Report is mandatory for systems, structures, and components designated as *Important-to-Safety*. The SAR serves as the Design Report for the HI-STAR 180 package.

Design Specification is a document prepared in accordance with the quality assurance requirements of 10CFR71 Subpart H to provide a complete set of design criteria and functional requirements for a system, structure, or component, designated as *Important-to-Safety*. The SAR serves as the Design Specification for the HI-STAR 180 package.

Dose Blocker Parts means the shielding components installed outside the Containment Boundary to enable the cask to meet the dose requirements of 10CFR71 during transport.

Enclosure Vessel (or MPC Enclosure Vessel) (EV) means the pressure vessel defined by the cylindrical shell, baseplate, port cover plates, lid, closure ring, and associated welds that provides

confinement for the helium gas contained within the MPC. The EV and the fuel basket together constitute the multi-purpose canister.

Exclusive use means the sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that loading or unloading personnel have radiological training and resources appropriate for safe handling of the consignment. The consignor must issue specific instructions, in writing, for maintenance of exclusive use shipment controls, and include them with the shipping paper information provided to the carrier by the consignor.

Expanded Containment Boundary means a second barrier against leakage of radiological contents of the package engineered into the system for added safety or to meet a specific jurisdictional regulation.

Fastener Strain Limiter is a device to protect the impact limiter fastener bolts from experiencing excessive axial strain.

Fracture Toughness is a material property, which is a measure of the ability of the material to limit crack propagation under a suddenly applied load.

FSAR is an acronym for Final Safety Analysis Report.

Fuel Basket means a honeycombed cavity structure with square openings that can accept a fuel assembly of the type for which it is designed.

Fuel Debris is ruptured fuel rods, severed rods and loose fuel pellets from damaged fuel assemblies, and fuel assemblies with known or suspected defects which cannot be handled by normal means due to fuel cladding damage, including containers and structures supporting these parts.

Fuel Impact Attenuator (FIA) is the deformable metallic compression element used to close the gap between a stored fuel assembly and the closure lid to eliminate axial rattling of fuel during transport.

GTCC is an acronym for Greater Than Class C waste.

High Burnup Fuel (HBF) is a commercial spent fuel assembly with an average burnup greater than 45,000 MWD/MTU.

HI-STAR is a generic term used to denote the family of metal casks consisting of HI-STAR 60, HI-STAR 63, HI-STAR 100, HI-STAR 100Z, HI-STAR 180, HI-STAR 180D, and HI-STAR HB.

HI-STAR 180 Cask or cask means the cask that receives and contains the spent nuclear fuel. It provides the containment system boundary for radioactive materials and fulfills all requirements of 10CFR71 to merit certification as a B(U) package.

HI-STAR 180 Package consists of the HI-STAR 180 cask and fuel basket with two impact limiters installed at the extremities, a personnel barrier if required, and the licensed radioactive contents loaded for transport.

HI-STAR 180 Packaging consists of the HI-STAR 180 Package without the licensed radioactive contents loaded.

Holtite™ is the trade name for the neutron shielding materials used in the HI-STAR/HI-STORM family of casks.

Impact Limiters means a set of fully enclosed energy absorbers that are attached to the top and bottom of the cask during transport. The impact limiters are used to absorb kinetic energy resulting from normal and hypothetical accident drop conditions. The HI-STAR impact limiters are called AL-STAR.

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

Incore Grid Spacers are fuel assembly grid spacers located within the active fuel region (i.e., not including top and bottom spacers).

Inner Closure Lid means the bolted plate-like structure that forms the Containment Boundary for the cask.

LLNL is an acronym for Lawrence Livermore National Laboratory.

Leaktight (is defined in this SAR to be same as defined in ANSI N14.5-1997) means a degree of package containment that in a practical sense precludes any significant release of radioactive materials. This degree of containment is achieved by demonstration of a leakage rate less than or equal to 1×10^{-7} ref-cm^3/s of air at an upstream pressure of 1 atmosphere absolute and a downstream pressure of 0.01 atmosphere absolute or less. Reference cubic centimeter per second (ref-cm^3/s) means a volume of one cubic centimeter of dry air per second at 1 atmosphere absolute pressure (760 mm Hg) and 25°C. Finally, 1×10^{-7} ref-cm^3/s air is equal to 4.09×10^{-12} gram-moles/s of dry air or helium and is approximately equivalent to 2×10^{-7} ref-cm^3/s helium.

License Life means the duration for which the system is authorized by virtue of its certification by the U.S. NRC.

Light Water Reactor (LWR): are nuclear reactors moderated by light water. Commercial LWRs typically utilize enriched uranium and/or the so-called MOX fuel for power generation.

Lowest Service Temperature (LST) is the minimum metal temperature of a part for the specified service condition.

Maximum Normal Operating Pressure (MNOP) means the maximum pressure that would develop in the containment system in a period of 1 year under the heat condition specified in 10CFR71.71(c)(1), in the absence of venting, external cooling by an ancillary system, or operational controls during transport.

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.

Metamic™ is a trade name for an aluminum/boron carbide composite neutron absorber material qualified for use in the HI-STAR/HI-STORM fuel baskets.

Minimum Enrichment is the minimum assembly average enrichment. Natural uranium blankets are not considered in determining minimum enrichment.

Moderate Burnup Fuel (MBF) is a commercial spent fuel assembly with an average burnup less than or equal to 45,000 MWD/MTU.

Moderator Exclusion means no moderator intrusion into the cask storage cavity under hypothetical accident conditions of transport.

Multi-Purpose Canister (MPC) means the sealed canister consisting of a honeycombed fuel basket for spent nuclear fuel storage, contained in a cylindrical canister shell (the MPC Enclosure Vessel).

NDT is an acronym for Nil Ductility Transition, which is defined as the temperature at which the fracture stress in a material with a small flaw is equal to the yield stress in the same material if it had no flaws.

Neutron Absorber Material is a generic term used in this SAR to indicate any neutron absorber material qualified for use in the HI-STAR/HI-STORM fuel basket.

Neutron Shielding means a material used to thermalize and capture neutrons emanating from the radioactive spent nuclear fuel.

Neutron Sources means specially designed inserts for fuel assemblies that produce neutrons for startup of the reactor.

Non-Fuel Hardware (NFH) means high-level waste not used to produce thermal energy in the reactor. Examples of NFH are Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Devices (TPDs), Control Rod Assemblies (CRAs), Axial Power Shaping Rods (APSRs), Wet Annular Burnable Absorbers (WABAs), Rod Cluster Control Assemblies (RCCAs), Control Element Assemblies (CEAs), primary and secondary neutron source assemblies (NSAs), water displacement guide tube plugs, orifice rod assemblies, and vibration suppressor inserts.

Not-Important-to-Safety (NITS) is the term used where a function or condition is not deemed as *Important-to-Safety*. See the definition for *Important-to-Safety*.

O&M Manual is an abbreviation for operation and maintenance manual.

ORNL is an acronym for Oak Ridge National Laboratory

Outer Closure Lid means the bolted plate-like structure that forms the expanded Containment Boundary for the cask.

Overpack is an alternative term used to denote a cask that contains a basket with a separate enclosure vessel.

Planar-Average Initial Enrichment is the average of the distributed fuel rod initial enrichments within a given axial plane of the assembly lattice.

Post-Core Decay Time (PCDT) is synonymous with cooling time.

PWR is an acronym for Pressurized Water Reactor.

Reactivity is used synonymously with effective neutron multiplication factor or k-effective.

Regionalized Fuel Loading is a term used to describe an optional fuel loading strategy used in lieu of uniform fuel loading. Regionalized fuel loading allows higher heat emitting fuel assemblies to be stored in certain fuel storage locations provided lower heat emitting fuel assemblies are stored in other fuel storage locations.

SAR is an acronym for Safety Analysis Report.

Service Life means the duration for which the component is reasonably expected to perform its intended function, if operated and maintained in accordance with the provisions of this SAR. Service Life may be much longer than the Design Life because of the conservatism inherent in the codes, standards, and procedures used to design, fabricate, operate, and maintain the component.

Short-term Operations means those normal operational evolutions necessary to support fuel loading or fuel unloading operations.

Single Failure Proof means that the handling system is designed so that a single failure will not result in the loss of the capability of the system to safely retain the load. Single Failure Proof means that the handling system is designed so that all directly loaded tension and compression members are engineered to satisfy the enhanced safety criteria of Paragraphs 5.1.6(1)(a) and (b) of NUREG-0612.

SNF is an acronym for Spent Nuclear Fuel (also referred to as CSF in this SAR).

STP is Standard Temperature (298°K) and Pressure (1 atm) conditions.

SSC is an acronym for Structures, Systems and Components.

Surface Contaminated Object (SCO) means a solid object that is not itself classed as radioactive material, but which has radioactive material distributed on any of its surfaces. See 10CFR71.4 for surface activity limits and additional requirements.

Transport Index (TI) means the dimensionless number (rounded up to the next tenth) placed on the label of a package, to designate the degree of control to be exercised by the carrier during transportation. The transport index is determined as the number determined by multiplying the maximum radiation level in millisievert per hour at one meter (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one meter (3.3 ft)).

Transport Package consists of a HI-STAR Package with a set of support saddles, a personnel barrier and licensed radioactive contents loaded for transport. It excludes all lifting devices, tie-downs, longitudinal stops, rigging, transporters, welding machines, and auxiliary equipment (such as the drying and helium backfill system) used during fuel loading operations and preparation for off-site transportation.

Transport Packaging consists of a Transport Package without licensed radioactive contents loaded.

Uniform Fuel Loading is a fuel loading strategy where any authorized fuel assembly may be stored in any fuel storage location, subject to other restrictions in the CoC, such as those applicable to non-fuel hardware, and damaged fuel containers.

Undamaged 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. Fuel assemblies without fuel rods in fuel rod locations shall not be classified as Undamaged Fuel Assemblies unless dummy fuel rods are used to displace an amount of water greater than or equal to that displaced by the original fuel rod(s).

Water Tight is defined as a degree of leaktightness that in a practical sense precludes any significant intrusion of water through all water exclusion barriers. This degree of leaktightness

ranges from 1 x 10^{-2} std cm^3/s air to 1 x 10^{-4} std cm^3/s air in accordance with ASTM E1003-05 "Standard Test Method for Hydrostatic Leak Testing".

ZPA is an acronym for Zero Period Acceleration.

ZR means any zirconium-based fuel cladding material authorized for use in a commercial nuclear power plant reactor. Any reference to Zircaloy fuel cladding in this SAR applies to any zirconium-based fuel cladding material.

NOTATION

α Mean Coefficient of thermal expansion, cm/cm-°C x 10^{-6} (in/in-°F x 10^{-6})

d_{max}: Maximum predicted crush of the impact limiters in a package free drop event.

e: Elongation in percent (i.e., maximum tensile strain expressed in percentage at which the ASME Code test specimen will fail)

E Young's Modulus, MPa x 10^4 (psi x 10^6)

f: Factor-of-Safety (dimensionless)

m: Metric for bolted joint leakage (Table 2.6.1)

P_b Primary bending stress intensity

P_e Expansion stress

$P_L + P_b$ Either primary or local membrane plus primary bending

P_L Local membrane stress intensity

P_m Primary membrane stress intensity

Q Secondary stress

S_u Ultimate Stress, MPa (ksi)

S_y Yield Stress, MPa (ksi)

S_m Stress intensity values per ASME Code

T_c: Allowable fuel cladding temperature

T_p: Peak computed fuel cladding temperature

α_{max}: Maximum value measured or computed deceleration from a package drop event. α_{max} can be parallel or lateral to the centerline of the cask.

β: Weight percent of boron carbide in the neutron shield

β_{max}: The value of maximum deceleration selected to bound all values of α_{max} for a package drop event. Values for β_{max} in axial and lateral directions are selected

from the population of drop scenarios for a particular regulatory drop event (such as §71.73, free drop).

Γ: Total gasket spring back in the unloading cycle

Δ: Initial inter-part gap immediately before impact (Section 2.7)

δ: Lateral (global) deflection of the basket panel

δ_g: Maximum permissible gasket relaxation to maintain leak tightness

δ_{max}: Maximum value of δ

$\in$: Charpy lateral expansion at -28.9 °C (-20°F)

ξ: Weight percent of hydrogen in the neutron shield material

ρ: Density

φ: Coefficient of thermal expansion (average between ambient and the temperature of interest)

ψ: Thermal conductivity

θ Orientation of free drop (see Section 2.7.1)

CHAPTER 1: GENERAL INFORMATION

1.0 OVERVIEW

This Safety Analysis Report (SAR)* for the HI-STAR 180 Package is a compilation of information and analyses in the format suggested in Reg. Guide 7.9 [1.0.1] to support a United States Nuclear Regulatory Commission (USNRC) licensing review for certification as a spent nuclear fuel transportation package pursuant to the provisions of 10CFR71 Subpart D [1.0.2] and 49CFR173 [1.0.3]. To ensure completeness of information and to facilitate locating key information in this SAR, a Reg. Guide 7.9 Compliance Matrix is provided in Appendix 1.A.

HI-STAR 180 is the model name of a transport cask engineered to serve as a type B(U)F-96 packaging for transporting radioactive material (including commercial spent fuel (CSF), reactor-related GTCC waste, and high level waste) under exclusive use shipment pursuant to 10CFR71.47. This SAR considers only CSF as the package contents.

The HI-STAR 180 Cask containment system is engineered to parallel the anatomical design and construction of the containment system of HI-STAR 100 Package certified for transport under Docket No. 71-9261 [1.0.4] and for storage under Docket No. 72-1008 [1.0.5]. More specifically, the containment system materials of construction, welding joint details, NDE requirements, seal joint type, and Code of construction for the HI-STAR 180 Packaging, are identical to those of the HI-STAR 100 Packaging (certified by the USNRC and deployed at nuclear plants since the late 1990s).

[PROPRIETARY TEXT REMOVED]
[PROPRIETARY TEXT REMOVED]
Finally, the design embodiment, construction, and materials for the HI-STAR 180 Package impact limiters are identical to those used in the HI-STAR 100 Package (Docket No. 71-9261) [1.0.4] and are fully described in this SAR.

Figures 1.0.1 and 1.0.2 provide pictorials of the exterior of the HI-STAR 180 Cask and HI-STAR 180 Packaging, respectively. The drawing package in Section 1.3 details the important-to-safety features considered in the packaging evaluation and also includes certain details on non-important-to-safety features. For the reader's convenience and clarity, additional pictorials of the cask and packaging components are provided throughout this SAR.

Package Design Control: The design information presented in this SAR is subject to validation, safety compliance and configuration control in accordance with Holtec's NRC approved quality assurance (QA) program which comports with the provisions of 10CFR71.107. Chapters 7 and 8 and the licensing drawing package contain conditions to the CoC, and as such, they can be modified only through an NRC licensing action. The other chapters contain substantiating information to support the safety case and unless otherwise noted, the information can be amended subject to the stipulations of 71.107(c).

* See Glossary for definition and abbreviation of terms used throughout this SAR.

The HI-STAR 180 Package is equipped with appropriate shielding to minimize personnel exposure. The HI-STAR 180 Packaging (with or without the personnel barrier) ensures the external radiation standards of 10CFR71.47 under exclusive shipment are met when loaded with design basis fuel. The drawing package in Section 1.3 provides information on the configuration of neutron and gamma shielding features.

The initial attenuation of gamma and neutron radiation emitted by the radioactive spent fuel is provided by the fuel basket and the fuel basket shims. However, most of the shielding in the transport package is contained in the body of the cask and consists of neutron shielding (by steel and Holtite) and gamma shielding (by steel in radial direction, and by steel and lead in axial directions). [PROPRIETARY TEXT REMOVED]The arrangement of the shielding materials shown in the licensing drawings reflects the design optimization carried out for the HI-STAR 180 cask.

[PROPRIETARY TEXT REMOVED]

1.2.1.5.1 Holtite™ Neutron Shielding Material

(a) Qualification of the Holtite™ Neutron Shielding Material

The shielding against neutron radiation in HI-STAR 180 Packaging is provided by Holtite-B. Holtite™ is a hydrogen rich, radiation resistant, polymeric material impregnated with boron carbide. Holtite-A is the predecessor of Holtite-B which was developed by Holtec International in the early 90s as a part of the company's HI-STAR 100 design development program.
Holtite-A was subjected to extensive studies of its critical characteristics (viz., radiation resistance, physical stability at service temperature and homogeneity) during its evaluation and validation program [1.2.4, 1.2.5], which led to its regulatory approval in the HI-STAR 100 Docket (71-9261) and subsequent use in the manufactured HI-STAR 100 overpacks. Holtite-B is an improved version of Holtite-A in respect of its stability at higher temperatures.

Like Holtite-A, Holtite-B is a relatively poor conductor of heat and possesses limited gama attenuation capability. Its main function is to provide neutron shielding which is enabled by a hydrogen rich polymeric matrix and spatially distributed particles of Boron Carbide. [PROPRIETARY TEXT REMOVED] Holtite-B has been subjected to the same battery of tests to establish its radiation resistance, physical stability at service temperature and homogeneity as Holtite-A [1.2.17]. In contrast to Holtite-A which is qualified to operate under 149°C (300°F) temperature, Holtite-B is capable of operating at 204°C (400°F) in sustained use without a significant weight loss.

In this SAR, the terms Holtite-B and Holtite are used interchangeably.

(b) Critical Characteristics of the Holtite Neutron Shielding Material

(i) Critical Characteristics for Shielding Function

Holtite Density
[PROPRIETARY TEXT REMOVED]

(ii) Critical Characteristics for Thermal Function

The thermal conductivity of Holtite-B is utilized in the thermal analysis of the package in Chapter 3 and therefore it is a critical characteristic. Table 1.2.16 provides the minimum acceptable effective conductivity of Holtite-B including the contribution of conductivity enhancers.

1.2.1.6 Criticality Control Features

Criticality control in the HI-STAR 180 Packaging is provided by the coplanar grid work of the Fuel Basket honeycomb, made entirely of the Metamic™-HT extruded borated metal matrix composite plates. Metamic-HT is the neutron absorber in the HI-STAR 180 Packaging. Thus the neutron absorber is not attached to the cell walls by a mechanical means that may be vulnerable to detachment. Hence, the locational fixity of the neutron absorber is guaranteed.

There are no moderators in the HI-STAR 180 Packaging. The fuel basket flux trap design features described in subsection 1.2.1.1 above and illustrated in the licensing drawings are the criticality control features in the HI-STAR 180 fuel basket.

[PROPRIETARY TEXT REMOVED]

1.2.1.6.1 Qualification of Metamic-HT

Metamic-HT is a composite of nano-particles of aluminum oxide (alumina) and finely ground boron carbide particles dispersed in the metal matrix of pure aluminum produced by an extrusion process that ensures a high level of isotropy. Metamic-HT is the constituent material of the HI-STAR 180 fuel baskets. Metamic-HT neutron absorber is a successor to the Metamic (classic) product widely used in dry storage fuel baskets [1.2.7] and spent fuel storage racks [1.2.8, 1.2.9]. Metamic-HT is engineered to possess the necessary mechanical characteristics for structural application in spent nuclear fuel casks. [PROPRIETARY TEXT REMOVED]
[PROPRIEATRY TEXT REMOVED]
[PROPRIETARY TEXT REMOVED]

[PROPRIETARY TEXT REMOVED]

Table 1.2.16: Properties of Holtite-B for Shielding and Thermal Function

Property (Note 1)	Property Value
Minimum Bulk Density, g/cm^3	See Table 8.1.5
Minimum Hydrogen Areal Density, g/cm^2 (for the combined thickness of the two rows of shield cylinder "sector pockets")	See Table 8.1.5
Nominal Boron Carbide Content, wt%	See Table 8.1.5
Minimum Effective Thermal Conductivity, W/m-K (Btu/ft-hr-°F) (including contribution from conductivity enhancers)	0.4 (0.23) at design temperature
Design Temperature, °C (°F)	204 (400)

Note 1: All properties are critical characteristics.

APPENDIX 1.B: [THIS APPENDIX IS PROPRIETARY IN ITS ENTIRETY]

[PROPRIETARY TEXT REMOVED]

2.2.1.2 Nonstructural Materials

2.2.1.2.1 Monolithic Shield Cylinder

The monolithic shield cylinder is not in the primary load path of the HI-STAR 180 cask during a lifting operation since it has no connection to the upper trunnions. The monolithic shield cylinders do, however, girdle the containment shell and thus may act in concert with the containment shell during Hypothetical Accident Conditions of Transport. Necessary structural properties for the monolithic shield, for analysis purposes, are the yield and ultimate strength; a representative set of properties is tabulated in Table 2.2.7, and *critical characteristics* are provided in Table 2.1.16.

2.2.1.2.2 Holtite Neutron Shielding Material

The non-structural properties of the neutron shielding material are provided in Section 1.2. Holtite B does not serve a structural function in the HI-STAR 180D package; however, since the Holtite is included in the structural analysis model, the mechanical properties used as input to the analysis model are listed in Table 2.2.8.

2.2.1.2.3 Fuel Basket Supports

The fuel basket supports (basket shims), made of an aluminum alloy 2219-T8511, provide the heat transfer bridge between the basket and the cask inside surface, and serve to position the fuel basket. Representative mechanical properties for the basket supports are tabulated in Table 2.2.9.

[PROPRIETARY TEXT REMOVED]

2.2.1.2.4 Cask Coating

The HI-STAR 180 cask exterior steel surfaces are coated with Carboguard® 890 (see www.carboline.com for product data sheet) or equivalent surface preservative. Carboguard ® 890 and equivalent surface preservatives have provided years of proven performance on HI-STAR 100 casks. In addition, exterior surfaces of the cask are easily inspected and recoated as necessary. For cask coatings, alternate surface preservatives are determined equivalent per the recommendation of a coating manufacturer and with Holtec approval. Carboguard 890 is the product name at the time of this SAR writing. Chemically identical products with different names are permitted. Other coatings that can be shown to have had proven performance in similar applications and environments are permitted.

2.2.1.2.5 Cask Liner

A cask liner is required to protect containment boundary steel components against increased corrosion from submersions into the spent fuel pools. The HI-STAR 180 cask cavity and inter-lid

Table 2.2.8: [PROPRIETARY TABLE REMOVED]

Table 2.2.9: Basket Shims - Mechanical Properties

Aluminum Alloy (B221 2219-T8511)					
Temp. °C (°F)	S_y	S_u	E	α	% Elongation
25 (75)	290 (42)	400 (58)	7.2 (10.5)	–	5
150 (300)	243 (35)	307 (44)	6.8 (9.5)	23.9 (13.3)	6.4
204 (400)	188 (27)	231 (34)	6.3 (9.1)	24.5 (13.6)	8.2
230 (450)	171 (25)	209 (30)	6.1 (8.8)	24.8 (13.8)	8.6
260 (500)	154 (22)	182 (26)	5.9 (8.5)	25.0 (13.9)	8.6
290 (550)	98 (14)	116 (17)	5.5 (8.0)	25.4 (14.1)	10.5

Definitions:

S_y = Yield Stress, MPa (ksi)
α = Mean Coefficient of thermal expansion, cm/cm-°C x 10^{-6} (in/in-°F x 10^{-6})
S_u = Ultimate Stress, MPa (ksi)
E = Young's Modulus, MPa x 10^4 (psi x 10^6)

Notes:

1. Source for E values is "Properties of Aluminum Alloys", page 82 [2.2.7] (properties listed in the table above are not affected by time at temperature).
2. Source for S_y, S_u, and % Elongation values at room temperature is ASTM Specification B221M [2.2.9]. Values at elevated temperatures are obtained by scaling the room temperature values using the data from [2.2.7].
3. Source for α is Table TE-2 of [2.1.6] (values listed in TE-2 are also considered representative of Aluminum Alloy (2219-T8511) (UNS No. A92219)).

the closure lid bolts, necessary to insure continued sealing subsequent to the drop events, will preclude relative rotations at the joint under the internal pressure (see Table 2.2.12). The analysis considers the combined effects of the design internal pressure in Table 2.1.1, the operating temperature distribution (Table 2.6.2), and a hypothetical FIA load on the inner closure lid and the containment baseplate (see Subsection 2.6.1.2). Figure 2.6.3 shows the axi-symmetric finite element model, and Figure 2.6.4 shows the graphical results, both reproduced from [2.1.12].

For Load Combination N2, a dynamic finite element model implemented in LS-DYNA [2.5.3] is used to determine the peak deceleration of the cask. Then a static stress analysis is performed in ANSYS based on the bounding cask deceleration β_{max}.

Results are evaluated against Level A stress intensity limits for locations in the containment shell, and in the baseplate, which together with the closure lids, make up the containment boundary [2.5.3]. The bolted connection of the lids to the closure flange is not modeled for Load Combination N1, as this solution is not meant to evaluate the sealing performance of the gaskets.

The key results for Load Combinations N1 and N2 are summarized wherein the minimum safety factor for different components of the cask for each of the load combinations is presented. All safety factors are conservatively computed using allowable stresses based on the maximum normal operating temperatures (see Tables 2.1.1 and Table 2.6.2, for component temperatures, and Table 2.1.6 for allowable stress intensity).

2.6.1.4.2 Result Summary for Normal Heat Condition for Transport

- Maximum Cask Deceleration from Load Combination N2

Table 2.6.4 lists the maximum cask deceleration calculated for the 0.3-meter side drop using the LS-DYNA model. Table 2.6.4 also defines the bounding value for β_{max}, which is used as input for the static stress analysis.

- Stress Intensity Results from Overall Finite Element Analysis of the Cask

Table 2.6.5 is a summary table that includes primary and primary plus secondary stress intensity safety factors (per Table 2.1.2) for Load Combination N1 associated with the Normal (Heat) Conditions of Transport. Table 2.6.6 provides similar results for Load Combination N2. The tabular results demonstrate that all safety factors exceed 1.0 at the key locations for each component of the containment boundary.

- Status of Lid Bolts and Seals

[PROPRIETARY TEXT REMOVED]

The [PROPRIETARY TEXT REMOVED]closure lid port cover seals are analyzed using classical methods to demonstrate that the torque requirement for the [PROPRIETARY TEXT

The remaining design objectives, namely, limiting of the maximum rigid body deceleration under the 9-meter drop event and preventing contact of the cask with the unyielding surface, are demonstrated by the Classical Dynamics Method and the LS-DYNA [2.5.3] finite element code, as discussed earlier. LS-DYNA has been benchmarked extensively by others [2.7.5, 2.7.6] and by Holtec using the test data from the static tests of the crush material and, more importantly, from the quarter-scale model 9-meter drop experiments carried out at the Oak Ridge National Laboratory in support of HI-STAR 100 Part 71 certification in the late 90s [2.7.4] (see Appendix 2.B). The Classical Dynamics Method has also been benchmarked against the HI-STAR 100 ¼-scale drop tests [2.6.5]. As discussed in Appendix 2.B, the LS-DYNA simulation model for the family of AI-STAR impact limiters is a credible and reliable vehicle for determining the HI-STAR 180 Package's impact performance *with respect to the extent of crush and the peak g-load.* LS-DYNA has been used by Holtec International in a wide variety of impact scenarios in dry storage projects [2.7.10].

Regulatory Guide 7.9 calls for evaluation of the response of the containment component in terms of stress intensity, and includes investigation of structural stability as well as the consequences of the combined effects of temperature gradients, pressure, and other loads. The work effort to fulfill the above Reg. Guide 7.9 recommendation is carried out using the static analysis approach, as discussed in the foregoing.

[PROPRIETARY TEXT REMOVED]

[PROPRIETARY TEXT REMOVED]

[PROPRIETARY TEXT REMOVED] [PROPRIETARY TEXT REMOVED][PROPRIETARY TEXT REMOVED]

The previously described key attributes implemented in the HI-STAR 180 LS-DYNA model take advantage of the state-of-art numerical analysis capability of the finite element code for simulating transient, nonlinear impact events. With good accuracy demonstrated in the benchmarking effort (Appendix 2.B) as well in the analysis independently performed by the NRC/PNNL investigators [2.7.5], the previously described HI-STAR 180 finite element model is deemed to be able to predict the impact performance of the package under various accidental drop conditions with reliable accuracy.

[PROPRIETARY TEXT REMOVED]

[PROPRIETARY TEXT REMOVED][PROPRIETARY TEXT REMOVED][PROPRIETARY TEXT REMOVED]

2.7.1.2 Simulation of Drop Events

As discussed before, the free drop of the package from 9 meters onto an essentially unyielding surface is simulated for a number of orientations using LS-DYNA and the Classical Dynamics Method. The peak g-loads from each drop simulation, α_{max}, in both axial and lateral direction (to the cask's axis) are compared between the two approaches. The largest axial and lateral decelerations from both approaches, denoted hereafter as β_{max}, are then used to determine the regulatory compliance of the package using the so-called "static analysis" explained previously, with additional

3.2 MATERIAL PROPERTIES AND COMPONENT SPECIFICATIONS

3.2.1 Material Properties

Materials present in the HI-STAR 180 Packaging include structural steels, aluminum, lead, insulation, neutron shielding material (Holtite-B), neutron absorber (Metamic-HT), impact limiter crush material and helium. In Table 3.2.1, a summary of references used to obtain cask material properties for performing all thermal analyses is presented.

Thermal conductivity data of cask structural steels, neutron shielding materials, impact limiters, lead, insulation and helium are provided in Table 3.2.2. Thermal conductivities of fuel, aluminum basket shims and fuel basket (Metamic-HT) are provided in Tables 3.2.3, 3.2.4 and 3.2.5.

Surface emissivity data for key materials of construction are provided in Table 3.2.6. [PROPRIETARY TEXT REMOVED]A theoretical bounding solar absorbtivity coefficient is applied to all exposed cask surfaces.

In Table 3.2.7, the specific heat and density data of cask materials is presented. These properties are also used in performing transient (hypothetical fire accident condition) analyses. The viscosity of helium is presented in Table 3.2.8.

The HI-STAR 180 Package exposed surfaces heat transfer coefficient is calculated by accounting for both natural convection heat transfer and radiation. Natural convection from a heated horizontal cylinder depends upon the product of the Grashof (Gr) and Prandtl (Pr) numbers. Following the approach developed by Jakob and Hawkins [3.2.8], GrPr is expressed as $L^3 \Delta T\ Z$, where L is the diameter of the cask, ΔT is the cask surface-to-ambient temperature differential and Z is a parameter which is a function of air properties evaluated at the average film temperature. The temperature dependence of Z for air is provided in Table 3.2.9.

The long-term thermal stability and radiation resistance of Holtite-B has been confirmed through qualification testing and is archived in Reference [1.2.17]. The qualification test conditions exceed the Holtite-B thermal and radiation environment (gamma and neutron fluence) in the HI-STAR 180 cask. The Holtite-B thermal stability test temperature, is the same as the design temperature reported in Table 1.2.16is above the maximum operating temperature of Holtite-B (See Table 3.1.1). The Holtite-B radiation test exposures exceed the HI-STAR 180 5-year licensed life fluence under transport by a large factor (See Table 3.2.13). The qualification testing confirms that Holtite-B does not degrade at elevated temperatures and Holtite-B is unaffected by high neutron fluence and megarad gamma doses. Qualification testing shows cumulative weight loss is limited to 5 wt% for a minimum service life of 40 years.

3.2.2 Component Specifications

The HI-STAR 180 Package materials and components which are required to be maintained below maximum pressure and temperature limits for safe operation, to ensure their intended functions, are summarized in Chapter 2 (Table 2.1.1) and Chapter 3 (Tables 3.2.10, 3.2.11 and 3.2.12). These

Table 3.2.1: Summary of HI-STAR Packaging Materials Thermal Property References

Material	Emissivity	Conductivity	Density	Heat Capacity
Helium	NA	Handbook [3.2.2]	Ideal Gas Law	Handbook [3.2.2]
Zircaloy Cladding	EPRI [3.2.3]	NUREG [3.2.6]	Rust [3.2.4]	Rust [3.2.4]
UO_2	Not Used	NUREG [3.2.6]	Rust [3.2.4]	Rust [3.2.4]
Carbon Steel	Kern [3.2.5]	ASME [3.2.7]	Marks [3.2.1]	Marks [3.2.1]
Aluminum Basket Shims	Test Data [1.2.27]	ASM [3.2.14]	ASM [3.2.14]	ASM [3.2.14]
Holtite-B	Not Used	Conservative lowerbound properties Table 1.2.16		Polymer Handbook [3.2.15]
Metamic-HT	Test Data [1.2.27]	Test Data [1.2.27]	Test Data [1.2.27]	Test Data [1.2.27]
Impact Limiter Crush Material	NA	Note 1	Table 2.2.10	ASME [3.2.7]
Air	NA	Incropera [3.2.11]	Ideal Gas Law	Incropera [3.2.11]
Lead	NA	Handbook [3.2.2]	Handbook [3.2.2]	Handbook [3.2.2]
Insulation	Table 2.2.10			
Note 1: Nominal values of thermal conductivity are specified in Table 3.2.2.				

Table 3.2.2: Thermal Conductivity of HI-STAR 180 Cask Materials

Material	@ 93.3°C (200°F) W/m-°K (Btu/ft-hr-°F)	@ 232.2°C (450°F) W/m-°K (Btu/ft-hr-°F)	@ 371.1°C (700°F) W/m-°K (Btu/ft-hr-°F)
Helium	0.1686 (0.0976)	0.2227 (0.1289)	0.2722 (0.1575)
Carbon Steel	47.7 (27.6)	45.5 (26.3)	41.5 (24)
Cryogenic Steel	41.1 (23.8)	41.0 (23.7)	38.5 (22.3)
Impact Limiters[1]	[PROPRIETARY TEXT REMOVED]		
[PROPRIETARY TEXT REMOVED]	[PROPRIETARY TEXT REMOVED]		
[PROPRIETARY TEXT REMOVED]	[PROPRIETARY TEXT REMOVED]		
Lead	30 (17.3)		
Air	0.03 W/m-°K@350°K 0.0373 W/m-°K@450°K 0.0439 W/m-°K@550°K 0.0497 W/m-°K@650°K		
Note 1: Sensitivity studies show that fuel, containment seals and containment boundary temperatures are insensitive to wide band thermal conductivity variations of impact limiter crush material. Accordingly nominal properties are defined and adopted in the SAR.			

[1] Reasonably bounding values under normal and fire accident conditions are tabulated herein. During post-fire cooldown conductivity is understated (See Table 3.4.1).

Table 3.2.7: [PROPRIETARY TABLE REMOVED]

Table 3.2.12: HI-STAR 180 Component Temperature Limits

Component	Material	Normal Condition Temperature Limits °C (°F)	Short Term Operations & Accident Temperature Limits °C (°F)
[PROPRIETARY TEXT REMOVED]Seals	Note 1	371 (700)	371 (700)
Closure Lids Port Cover and Port Plug Seals	Note 1	371 (700)	371 (700)
Neutron Shield	Holtite-B	[PROPRIETARY TEXT REMOVED]	Note 2
Impact Limiter Bulk	[PROPRIETARY TEXT REMOVED]	Table 2.2.10	NA Note 3
Notes [PROPRIETARY TEXT REMOVED].			

[3.2.10] Kauder, L., "Spacecraft Thermal Control Coatings References," NASA Technical Procedure, NASA/TP-2005-212792, NASA/Goddard Space Flight Center, Greenbelt, MD, July 2005.

[3.2.11] "Fundamentals of Heat and Mass Transfer", 4th Edition, F.P. Incropera and D.P. DeWitt, John Wiley & Sons, Inc., New York, 1996.

[3.2.12] Not Used.

[3.2.13] Not Used.

[3.2.14] Aluminum Alloy 2219 Material Data Sheet, ASM Aerospace Specification Metals, Inc., Pompano Beach, FL.

[3.2.15] "Physical Properties of Polymers Handbook", James E. Mark, 2nd Edition.

[3.3.1] ANSYS Finite Element Modeling Package, Swanson Analysis Systems, Inc., Houston, PA, 1993.

[3.3.2] FLUENT Computational Fluid Dynamics Software (Fluent, Inc., Centerra Resource Park, 10 Cavendish Court, Lebanon, NH 03766).

[3.3.3] "Cladding Considerations for the Transportation and Storage of Spent Fuel", Interim Staff Guidance – 11, Rev. 3, (11/17/03).

[3.3.4] "Topical Report on the HI-STAR/HI-STORM Thermal Model and its Benchmarking with Full-Size Cask Test Data," Holtec Report HI-992252, Rev. 1, Holtec International, Marlton, NJ, 08053. (Holtec Proprietary).*

[3.4.1] "Thermal Analyses of the HI-STAR 180", Holtec Report HI-2073649, Latest Revision, (Holtec Proprietary).†

[3.4.2] "Thermal Measurements in a Series of Large Pool Fires", Sandia Report SAND85 – 0196 TTC – 0659 UC 71, (August 1971).

* Supporting document previously submitted with the HI-STAR 180 initial License Application (Docket 71-9325).
† Supporting document submitted with HI-STAR 180 LAR 9325-1.

Appendix 4.A
[THIS APPENDIX IS PROPRIETARY IN ITS ENTIRETY]

CHAPTER 8: ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.0 INTRODUCTION

This chapter identifies the acceptance tests and maintenance program to be conducted on the HI-STAR 180 Package to verify that the structures, systems and components (SSCs) classified as *important-to-safety* have been fabricated, assembled, inspected, tested, accepted, and maintained in accordance with the requirements set forth in this Safety Analysis Report (SAR), all applicable regulatory requirements, and the Certificate of Compliance (CoC). The acceptance criteria and maintenance program described in this chapter is in full compliance with the requirements of 10CFR Part 71 Subpart G [8.0.1].

The following specific SAR information is incorporated by reference in this Chapter. All other references to the SAR and Holtec documents are for completeness of information.

Reference Source	Specific Information Incorporated by Reference
SAR Table 2.2.12	• Maximum Total Load Needed to Compress Seals • Springback at Complete Decompression Criterion
SAR Table 2.1.14	All Code Alternatives
SAR Table 2.1.10 and Table 2.1.10A	All Fracture Toughness Test Criteria
Deleted	
Deleted	
Deleted	
SAR Table 1.2.12a	Metamic-HT Properties

Test results shall become part of the final quality documentation package.

8.1.5.2 Impact Limiter Crush Material Testing

Verification of the transport impact limiter crush material crush strength is accomplished by performance of a crush test of sample blocks. The verification tests are performed by the crush material supplier or third party testing facility in accordance with Holtec approved procedures. Impact limiter material crush strength is specified in the impact limiter drawing in Section 1.3 of the SAR.

The certified test results shall be retained by Holtec International as archive record for each batch of impact limiter crush material manufactured and used. Test results shall be documented and shall become part of the final quality documentation package.

8.1.5.3 Neutron Shielding Material

. Each manufactured lot of Holtite-B neutron shield material shall be tested to verify that [PROPRIETARY TEXT REMOVED]meet the requirements specified in Table 8.1.5. A manufactured lot is defined as the total amount of material used to make any number of mixed batches comprised of constituent ingredients from the same lot/batch identification numbers supplied by the constituent manufacturer. Testing shall be performed in accordance with written and approved procedures.

Test results for each manufactured lot of neutron shield material shall become part of the final quality documentation package.

Approved written procedures shall ensure that mix ratios and mixing methods are controlled in order to achieve proper material composition, [PROPRIETARY TEXT REMOVED]distribution, and that emplacement is properly controlled Holtec International shall maintain samples of each manufactured lot of neutron shielding material.

8.1.5.4 Neutron Absorber Material

Essential characteristics of Metamic-HT are described in Section 1.2 of this SAR. As described in Section 1.2, Metamic-HT is made from pure aluminum using a powder metallurgy process that results in pinning of the materials grain boundaries by dispersoids of nanoparticles of aluminum oxide. The manufacturing of Metamic-HT is governed by a set of quality validated shop procedures contained in the Metamic-HT Manufacturing Manual [1.2.25].

[PROPRIETARY TEXT REMOVED].
Metamic-HT panels will be manufactured to Holtec's purchase specification [1.2.26] that incorporates all requirements set forth in this SAR. The supplier of raw materials must be qualified under Holtec's quality program for important to safety materials and components or alternatively each lot of raw material shall be tested in accordance with Table 8.1.3

Table 8.1.5: [PROPRIETARY TABLE REMOVED]