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November 4, 2016

Jose Cuadrado, Project Manager
Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards

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

Subject: HI-STORM 100 Amendment 12 Responses to Requests for Supplemental Information

Reference: [1] Holtec Letter 5014811, "Holtec International HI-STORM 100 Multipurpose Canister Storage System Amendment Request 1014-12," dated June 14, 2016, from K. Manzione (Holtec) to M. Lombard (NRC)

[2] NRC Letter, "Acceptance Review of Request for Amendment No. 12 to Certificate of Compliance No. 1014 for the HI-STORM 100 Cask System – Request for Supplement Information," dated October 12, 2016, from J. Cuadrado (NRC) to K. Manzione (Holtec)

Dear Mr. Cuadrado,

Holtec appreciates the NRC staff review of Holtec's application for Amendment No. 12 to the HI-STORM 100 System [1] and understands that supplemental information is needed [2]. This letter provides the responses to those requests in Attachment 1. Changes needed to the CoC as a result of these RSIs are included as Attachment 2. Changes to the FSAR made as a result of these RSIs are included as Attachment 3. Additionally, a proprietary position paper is a supporting reference to one of the RSI responses and is included as Attachment 4.

Holtec considers Attachment 4 to be proprietary information; therefore, Attachment 5 to this letter is an affidavit prepared in accordance with 10 CFR 2.390 requesting that it be withheld from public disclosure.

If you have any questions, please contact me at (856)-797-0900 ext. 3951.

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Sincerely,

Kimberly Manzione
Licensing Manager
Holtec International

Attachment 1: HI-STORM 100 Amendment 12 RSI Responses (Non-proprietary)
Attachment 2: HI-STORM 100 Amendment 12 Revised CoC (Non-proprietary)
Attachment 3: HI-STORM 100 FSAR Rev 14.A, changed pages (Non-proprietary)
Attachment 4: Holtec Position Paper DS-213 (Proprietary)
Attachment 5: Affidavit Pursuant to 10 CFR 2.390 to Withhold Information from Public Disclosure

cc (via email): Mark Lombard, NRC
John McKirgan, NRC

Attachment 1
Holtec Letter 5014817

Request for Supplemental Information

Docket No. 72-1014
Certificate of Compliance No. 1014
Amendment No. 12 to the HI-STORM 100 Multipurpose Canister Storage System

Chapter 4 - Thermal Evaluation

4-1 Provide operational procedures for the cyclic vacuum drying system (VDS) and open loop low pressure drying (LPD) method.

The applicant proposed changes in the amendment application for (a) use of the cyclic VDS to perform vacuum drying of canisters with high burnup fuel or total decay heat exceeding threshold heat loads and (b) use of the open loop LPD method for non-cyclic drying of MPC-68M cavity. To justify the thermal features and the related model setup in the thermal review, the staff needs more information on both cyclic VDS and open LPD methods. Instead of short descriptions, the applicant should provide the details, such as specific thermal features and operational procedures for both cyclic VDS and open loop LPD.

This information is needed to determine compliance with 10 CFR 72.236(f).

Holtec Response:

To incorporate the additional drying procedures into the FSAR, and provide further clarification to the staff on these drying methods, Holtec has revised Chapter 8, Section 8.1.5, Step 6 as shown in the attachment to this letter.

4-2 Provide Figure 2.4.2 of Appendix B of the draft certificate of compliance for review.

The applicant stated in Note 2 to Table 2.4-3 of Technical Specifications Appendix B that an optional regionalized loading pattern for MPC-68M including damaged fuel and fuel debris is shown in Figure 2.4.2. However, Figure 2.4.2 is not provided in the proposed change pages of Appendix B.

This information is needed to determine compliance with 10 CFR 72.236(f).

Holtec Response:

Note 2 of Appendix B, Table 2.4-3 refers to the regionalized loaded pattern for MPC-68M canisters which include Damaged Fuel and Fuel Debris. The per cell allowable heat loads for Damaged Fuel and Fuel Debris have been incorporated into Figure 2.4-1. Holtec apologizes for the editorial error, and has corrected Note 2 of Table 2.4-3 to point to Figure 2.4-1, as shown in the revised CoC attached to this letter. Similar editorial corrections were also made in Appendix A, Table 3-2 and Appendix B, Table 2.4-2 (Note 1) for consistency.

Chapter 5 – Shielding Evaluation

5-1 Provide dose rate calculations for the 3-region loading pattern at the surface in comparison to the uniform loading scenario.

In Page 61 of the proposed FSAR Changed Pages (Attachment 5 to Holtec Letter 5014811), the applicant proposes the approval of an additional regionalized loading pattern for the MPC-68M canister, wherein the basket is segregated into three regions. The proposed minimum cooling time for the MPC-68M under this new loading pattern is 2.0 years. The applicant states that the surface dose rate results for this 3-region loading pattern are bounded by the dose rate from the uniform loading pattern. However, the application does not provide the dose rates calculations for the new loading pattern that would allow staff to confirm that these dose rates are bounded by the uniform loading pattern.

This information is necessary to determine compliance with 72.236(d).

Holtec Response:

The dose rate calculations for the new 3-region loading pattern have been performed and documented in Supplement 5.III of Chapter 5, as attached to this letter. The results of the calculations confirm that using a reference 3-region loading pattern (shown in Figure 2.III.1) the surface dose rate results are bounded by the uniform loading pattern as shown in Table 5.III.2.

Chapter 8 – Materials Evaluation

8-1 Provide supplemental information to support the material properties for MPC fabrication and closure welds constructed from UNS S32205 duplex stainless steel, including: (1) fracture toughness evaluation methods and acceptance criteria and (2) corrosion resistance. Section 1.A.1 of the proposed amendment states; "The duplex stainless steel is deemed to be extremely resistant to stress corrosion cracking (SCC) in marine environments." Information provided in the proposed amendment does not acknowledge that the microstructural stability of duplex stainless steels are sensitive to a number of factors, nor does it describe processes, controls and testing to ensure the corrosion resistance and mechanical properties will not be significantly altered by fabrication and welding.

Alteration of the microstructure in duplex stainless steels, particularly as a result of fabrication and welding processes, may result in reductions in corrosion resistance and mechanical properties (ASTM, 2014). The staff notes that duplex stainless steels are not immune from stress corrosion cracking (SCC) in marine environments. Operational experience has shown that SCC of welds in UNS S31803 can be susceptible to SCC at temperatures less than 100°C [212°F] (Leonard, 2003). A number of factors have been shown to affect the microstructure of welds in duplex stainless steels. Liou et al. (2002) showed that cooling rate and nitrogen content had a marked effect on the austenite to ferrite content. Fast cooling rates decreased the austenite content, and a weld microstructure with 70 percent ferrite was cited by Leonard (2003) as one of the factors that contributed to SCC of UNS S31803 in marine environments. Liou et al. (2002) also showed increased chloride SCC susceptibility when the austenite content decreased below 30 percent. Sieurin and Sandstrom (2007) compared time temperature transformation curves and critical cooling temperature curves for Type 2205 duplex stainless steels and concluded that, in order to avoid sigma precipitation and at the same time obtain a sufficient ferrite–austenite phase balance, the cooling rate should approximately be in the range 0.25–50K/second. In addition, Sieurin and Sandstrom (2007) stated that in order to avoid more than 1% σ (sigma) phase, the cooling rate from the solution treatment temperature should exceed 0.23K/second and the aging time at the most critical temperature 865°C [1590°F] must not exceed 134 seconds. Chen et al. (2002) showed significant decreases in impact energy for Type 2205 duplex stainless steel exposed to temperatures in the range of 800 to 950°C [1472 to 1742°F] for periods of 10 min or less corresponding to 5% σ (sigma) phase. Momeni and Dehghani (2010) showed that hot working strain rates can have a significant effect on σ (sigma) phase formation in Type 2205 duplex stainless steel.

This information is necessary to determine compliance with 10 CFR 72.236(b) and 10 CFR 72.158.

Holtec Response:

Holtec agrees with Staff's comments in this RSI which points to the vulnerability of duplex stainless steel (DSS) to welding process parameters. In order to address any concerns regarding microstructure stability and detrimental intermetallic phases in DSS

that affect corrosion resistance and toughness, Section 1.A.1 of the FSAR has been expanded as follows to include critical process limits and controls to be observed during fabrication and welding, and a testing program to insure that the final product meets the properties set down in the FSAR.

The text matter in the following echoes Staff's observations and commits to a confirmatory test program to insure that the manufactured Duplex Canisters meet the property requirements:

"Duplex stainless steels (DSS) are sensitive to the manufacturing processes employed in welding operations. Control of microstructure stability plays a vital role. The intermetallic microstructure is a complex function of the attendant parameters. For example, Cr and Mo promote ferrite and intermetallic phases, whereas N and Ni promote austenite.

During welding the balance between the ferritic and austenitic phases may be disturbed due to ferritization at high temperatures associated with welding operations. Ferrite content over 70% will lead to lower ductility and reduced corrosion resistance. Coarse ferritic grains are harmful for DSS toughness besides of impairing the austenite reformation at the heat affected zone (HAZ) [1.A.5]. The best metallurgical condition for welding is achieved by the most rapid quenching from the annealing temperature that produces a fine grained DSS structure with the required ferrite content (less than 70%).

Besides the austenite-ferrite phase balance, the second major concern with duplex steels and their chemical composition is the formation of detrimental intermetallic phases, precipitating preferentially in the ferrite, at elevated temperatures in the range of approximately 600 - 1750°F reaching an uncertain state of fragility at 887°F [1.A.4] and above. The mechanical (toughness) and corrosion properties of the weld and HAZ are deteriorated due to the presence of intermetallic phases.

Welding of DSS is associated with problems in HAZ which can be loss of corrosion, toughness, or post-weld cracking. The heat input and cooling rates in welding are important as they control ferrite to austenite transformation. Exceedingly low heat input may result in fusion zones and HAZ which are excessively ferritic (above 70%) [1.A.6]. Exceedingly high heat input increases the danger of forming intermetallic phases [1.A.6]. In both cases the impact toughness and corrosion resistance of the DSS will be seriously affected. Hence, heat input must be 0.6 – 2.6 kJ/mm to retain the phase balance, limit the width of the HAZ, and obtain a sigma phase free product [1.A.5]. Further, cooling rate from the solution annealing temperature must exceed 0.3°C/s to avoid sigma phase and satisfy the generally accepted toughness requirements [1.A.8]. The maximum interpass temperature is limited to 150°C (302°F) [1.A.6].

DSS have chloride stress corrosion cracking (CSCC) resistance significantly greater than that of the austenitic stainless steels, but they are not completely immune. Experimental results indicate that DSS is prone to stress corrosion cracking at temperatures above 100°C [1.A.9]. Poor welding practice, a low pH, presence of Hydrogen in welds, and/or high ferrite (>70%) can contribute to failures at temperatures

below 100°C.

Holtec will make sure that this material shall be used *only* if the metal temperature of the MPC shell can be assured to remain below the limit in Table 1.A.6 under all *normal operating* modes [1.A.3]. Likewise, under short term and accident conditions, such as the "inlet duct blockage" scenario, the maximum metal temperature of duplex stainless steel must be held below the limit in Table 1.A.6.

To confirm that the required properties are achieved in production, Holtec will implement a test program to insure that the weldments are tested for the absence of detrimental intermetallic phases. The test program will comply with ASTM A923 and will use metallographic examination, impact testing and corrosion testing to demonstrate the absence of such detrimental phases. The test will be intended to determine the presence or absence of intermetallic phase to the extent that it is detrimental to the toughness and corrosion resistance of the material. The test *shall* be implemented to products during weld procedure qualification as well as during fabrication which will provide the assurance that the weldments are *free* from detrimental intermetallic phases, and *provide* the required corrosion resistance and fracture toughness [1.A.7]."

References:

[1.A.4] C. Örnek, D. Engelberg, S. Lyon and T. Ladwein, "Effect of "475°C Embrittlement" on the Corrosion Behaviour of Grade 2205 Duplex Stainless Steel Investigated Using Local Probing Techiques," *Corrosion Management Magazine,* no. 115, pp. 9-11, 2013.

[1.A.5] C.R. Xavier, H.G. Delgado Jr., J.A de Castro, "An Experimental and Numerical Approach for the Welding Effects on the Duplex Stainless Steel Microstructure" – Materials Research Vol. 18(3) pp. 489-502, 2015.

[1.A.6] "Practical guidelines for Fabrication of Duplex Stainless Steels" – International Molybdenum Association, 2014.

[1.A.7] ASTM A923-14, "Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels" – W Conshohocken, PA, ASTM International 2014.

[1.A.8] J. Charles, "Duplex Stainless Steels, A Review After DSS '07 held in GRADO" – Steel Research International Vol. 79(6) pp. 455-465, 2008.

[1.A.9] A. Leonard, "Review of external stress corrosion cracking of 22%Cr duplex stainless steel, Phase 1 – Operational data acquisition," – HSE RR 129, Her Majesty's Stationery Office, Norwich, UK, 2003.

8-2 Provide supplemental information to support the physical properties of UNS S32205 duplex stainless steel at temperatures of −40°F including the design stress intensity in Table 1.A.1, Tensile Strength in Table 1.A.2, Yield Stresses in Table 1.A.3, Coefficient of Thermal Expansion in Table 1.A.4 and Thermal Conductivity in Table 1.A.5. Notes included in the tables indicate the sources of information; however, the information sources referenced do not contain physical property data at −40°F.

This information is necessary to determine compliance with 10 CFR 72.236(b).

Holtec Response:

We regret the confusion caused by the notes in Tables 1.A.1 – 1.A.5. It is true that the ASME code provides property values only from -20°F, which is above the -40°F minimum service temperature specified for the MPCs.

However, as stated in Section 1.A.3, for alloy X materials, the strength properties (viz., tensile strength and yield strength) improve as the temperature drops. For this reason, the strength related property values at the lowest design temperature (-40°F) for the HI-STORM 100 System have been assumed to be equal to the values at the lowest temperature (-20°F) reported in the ASME code [1.A.10]. As thermal conductivity and coefficient of thermal expansion decrease with decreasing temperature, the values for -40°F are linearly extrapolated from the 70°F value (with the slope based on data at 70°F and 100°F) for thermal conductivity, and 100°F value (with the slope based on data at 100°F and 150°F) for coefficient of thermal expansion.

The notes for Tables 1.A.1 – 1.A.5 in the FSAR will be revised accordingly for UNS S31803 (see response to RSI 8-4 for more information on alloy designation).

References:

[1.A.10] ASME Boiler & Pressure Vessel Code Section II, Part D, 2015.

8-3 Provide supplemental information to FSAR Section 9.1 on the MPC Lid-to-Shell weld inspection for MPCs that are constructed using UNS S32205 duplex stainless steel. For multilayer PT examination, provide a justification for the maximum weld deposit thickness for PT examination that is supported by the maximum allowable flaw size and fracture toughness acceptance criteria for fabrication and closure welds in MPCs constructed using UNS S32205 duplex stainless steel.

This information is necessary to determine compliance with 10 CFR 72.236(b).

Holtec Response:

Holtec Position Paper DS-213, which is referenced in FSAR Section 9.1, contains calculations using classical fracture mechanics to demonstrate that the maximum undetectable flaw in the Lid-to-MPC Shell (LTMS) weld (the "Weld"), made with a progressive PT examination, will not propagate in the event of a hypothetical accident event that subjects the weld joint to the most adverse stress field. This calculation has been repeated for the duplex stainless steel alloy in the updated position paper, and has been provided as Attachment 1 to this RSI response.

As shown in the updated Position Paper DS-213 (Attachment 4), a Charpy impact energy of 40 ft-lb at -40 deg. F (the lowest postulated service temperature for the MPC) is adequate to ensure that the maximum flaw size postulated for Alloy X will also apply to the UNS S31803 duplex stainless steel (see response to RSI 8-4 for more information on alloy designation).

As documented in DS-213, Revision 3, the actual Charpy data provided by the material supplier Outokumpu Stainless, Inc. from their database at -40 deg. F shows that the material has substantially higher Charpy energy. Another material manufacturer, Sandvik, provides Charpy impact energy vs temperature curve for the duplex alloy, which also shows the material to possess a substantial margin over the assumed Charpy value of 40 ft-lb at -40 deg. F (on which the critical flaw size is based).

It is therefore concluded that UNS S31803 duplex stainless steel can be added to the list of Alloy X materials determined to possess the necessary fracture strength to serve in the Confinement Boundary of the MPC. Moreover, the MPC Lid-to-Shell weld inspection requirements in FSAR Section 9.1 remain valid for MPCs that are constructed using UNS S31803 duplex stainless steel.

8-4 Provide supplemental information consistent with the information described in the ASME B&PV Code, Section II, Part D, Mandatory Appendix 5, "Guidelines on The Approval of New Materials under the ASME Boiler and Pressure Vessel Code," to support the requested licensing action which includes an exception to the ASME code to allow the use of UNS S32205 duplex stainless steel for construction of an ASME Section III Class 1 components (MPC). As noted in the proposed amendment, Type 2205 duplex stainless steel is included in ASME code case N-741 for ASME Section III Class 2 and 3 components. Code case N-741 has been accepted by the NRC in Regulatory Guide 1.84 Revision 36 (NRC, 2014).

Alternatively, the applicant may review the requirements of the ASME B&PV Code, Section II, Part D, Mandatory Appendix 7, "Guidelines for Multiple Marking of Materials." The NRC staff notes that ASME code case N-635-1, which addresses the use of UNS S31803 duplex stainless steel for Section III Class 1, 2, and 3 components is also accepted in Regulatory Guide 1.84, Revision 36. UNS S32205 duplex stainless steel is similar but has additional compositional restrictions compared to S31803. If available,

dual certified material (i.e., material with a certified material test report (CMTR) showing that the material meets both the compositional and physical property requirements of UNS S31803 and UNS S32205) may be an alternative to the requested exception to the ASME code to permit the use of UNS S32205 that is dual certified as UNS S31803 which is covered by the accepted N-635-1 code case.

This information is necessary to determine compliance with 10 CFR 72.236(b).

References:

ASTM A923-14, "Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels, West Conshohocken, PA: ASTM International, 2014.

Chen, T.H., K.L. Weng, J.R. Yang, "The effect of high-temperature exposure on the microstructural stability and toughness property in a 2205 duplex stainless steel," Materials Science and Engineering A. Vol. 338, pp. 259-270, 2002.

Leonard, A., "Review of external stress corrosion cracking of 22%Cr duplex stainless steel, Phase 1 – Operational data acquisition," HSE RR 129, Her Majesty's Stationery Office, Norwich, UK. 2003.

Holtec Response:

We appreciate staff's comments in this RSI. UNS S31803 material is certified for Section III Class 1 components without restrictions, and is accepted by ASME code case N-635-1. Hence, UNS S31803 DSS material will be used, as an alternative to the requested exception to the ASME code to permit the use of UNS S32205 DSS material.

The property values in Tables 1.A.1 – 1.A.5 have been revised accordingly for UNS S31803.

MPC-68M	
i. Cask Heat Load ≤ 28.19 kW -	0.1218 +/-10% g-moles/l
uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	OR ≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load > 28.19 kW - uniformly distributed or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and ≤ 48.5 psig
iii. Cask Heat Load ≤ 42.8 kW Regionalized Loading Pattern shown in Appendix B, Figure 2.4-1 ~~and 2.4-2~~	≥ 43.5 psig and ≤ 46.5 psig

Table 2.4-2

Fuel Storage Regions per MPC

MPC Model	Number of Storage Locations in Inner Region (Region 1)	Number of Storage Locations in Outer Region (Region 2)
MPC-24 and MPC-24E/EF	12	12
MPC- 32/32F	12	20
MPC-68/68FF/68M Note 1	32	36

Note 1: For an optional regionalized loading pattern for MPC-68M, see Figure 2.4-.1

Table 2.4-3

Allowable Heat Load for Damaged Fuel Assemblies and Fuel Debris under Regionalized Loading

MPC Model	Maximum Per Cell Allowable Heat Load for Damaged Fuel Assemblies and Fuel Debris Note 1
MPC-24E/24EF	$0.75*q_2$
MPC- 32/32F	$0.65*q_2$
MPC-68/68FF/68M Note 2	$0.75*q_2$

Note 1: q_2 is the maximum permissible heat load in Region 2 for intact fuel assemblies.

Note 2: An optional regionalized loading pattern for MPC-68M including Damaged Fuel and Fuel Debris is shown in Figure 2.4-.1, which provides per cell allowable heat loat for Damaged Fuel and Fuel Debris2

APPENDIX 1.A: ALLOY X DESCRIPTION

1.A ALLOY X DESCRIPTION

1.A.1 Alloy X Introduction

Alloy X is used within this licensing application to designate a group of stainless steel alloys. Alloy X can be any one of the following alloys:

- Type 316
- Type 316LN
- Type 304
- Type 304LN
- Duplex Stainless Alloy S3~~2205~~1803 [1.A.3]

Qualification of structures made of Alloy X is accomplished by using the least favorable mechanical and thermal properties of the entire group for all MPC mechanical, structural, neutronic, radiological, and thermal conditions. The Alloy X approach is conservative because no matter which material is ultimately utilized, the Alloy X approach guarantees that the performance of the MPC will meet or exceed the analytical predictions.

Duplex stainless steels (DSS) are sensitive to the manufacturing processes employed in welding operations. Control of microstructure stability plays a vital role. The intermetallic microstructure is a complex function of the attendant parameters. For example, Cr and Mo promote ferrite and intermetallic phases, whereas N and Ni promote austenite.

During welding the balance between the ferritic and austenitic phases may be disturbed due to ferritization at high temperatures associated with welding operations. Ferrite content over 70% will lead to lower ductility and reduced corrosion resistance. Coarse ferritic grains are harmful for DSS toughness besides of impairing the austenite reformation at the heat affected zone (HAZ) [1.A.5]. The best metallurgical condition for welding is achieved by the most rapid quenching from the annealing temperature that produces a fine grained DSS structure with the required ferrite content (less than 70%).

Besides the austenite-ferrite phase balance, the second major concern with duplex steels and their chemical composition is the formation of detrimental intermetallic phases, precipitating preferentially in the ferrite, at elevated temperatures in the range of approximately 600 - 1750°F reaching an uncertain state of fragility at 887°F [1.A.4] and above. The mechanical (toughness) and corrosion properties of the weld and HAZ are deteriorated due to the presence of intermetallic phases.

Welding of DSS is associated with problems in HAZ which can be loss of corrosion, toughness, or post-weld cracking. The heat input and cooling rates in welding are important as they control ferrite to austenite transformation. Exceedingly low heat input may result in fusion zones and

HAZ which are excessively ferritic (above 70%) [1.A.6]. Exceedingly high heat input increases the danger of forming intermetallic phases [1.A.6]. In both cases the impact toughness and corrosion resistance of the DSS will be seriously affected. Hence, heat input must be 0.6 – 2.6 kJ/mm to retain the phase balance, limit the width of the HAZ, and obtain a sigma phase free product [1.A.5]. Further, cooling rate from the solution annealing temperature must exceed 0.3°C/s to avoid sigma phase and satisfy the generally accepted toughness requirements [1.A.8]. The maximum interpass temperature is limited to 150°C (302°F) [1.A.6].

DSS have chloride stress corrosion cracking (CSCC) resistance significantly greater than that of the austenitic stainless steels, but they are not completely immune. Experimental results indicate that DSS is prone to stress corrosion cracking at temperatures above 100°C [1.A.9]. Poor welding practice, a low pH, presence of Hydrogen in welds, and/or high ferrite (>70%) can contribute to failures at temperatures below 100°C.

Holtec will make sure that this material shall be used *only* if the metal temperature of the MPC shell can be assured to remain below the limit in Table 1.A.6 under all *normal operating* modes [1.A.3]. Likewise, under short term and accident conditions, such as the "inlet duct blockage" scenario, the maximum metal temperature of duplex stainless steel must be held below the limit in Table 1.A.6.

To confirm that the required properties are achieved in production, Holtec will implement a test program to insure that the weldments are tested for the absence of detrimental intermetallic phases. The test program will comply with ASTM A923 and will use metallographic examination, impact testing and corrosion testing to demonstrate the absence of such detrimental phases. The test will be intended to determine the presence or absence of intermetallic phase to the extent that it is detrimental to the toughness and corrosion resistance of the material. The test *shall* be implemented to products during weld procedure qualification as well as during fabrication which will provide the assurance that the weldments are *free* from detrimental intermetallic phases, and *provide* the required corrosion resistance and fracture toughness [1.A.7].
~~The duplex stainless steel is deemed to be extremely resistant to stress corrosion cracking (SCC) in marine environments. However, its properties begin to deteriorate rapidly at temperatures above 600 °F reaching an uncertain state of fragility at 887 °F [1.A.4] and above. Therefore, this material shall be used *only* if the metal temperature of the MPC shell can be assured to remain below the limit in Table 1.A.6 under all *normal operating* modes [1.A.3]. Likewise, under short term and accident conditions, such as the "inlet duct blockage" scenario, the maximum metal temperature of duplex stainless steel must be held below the limit in Table 1.A.6.~~

For other stainless steels listed as members of Alloy X above, the design temperature limits in Table 2.2.3 remain unmodified.

This appendix defines the least favorable material properties of Alloy X.

1.A.2 Alloy X Common Material Properties

Several material properties do not vary significantly from one Alloy X constituent to the next. These

common material properties are as follows:

- density
- specific heat
- Young's Modulus (Modulus of Elasticity)
- Poisson's Ratio

The values utilized for this licensing application are provided in their appropriate chapters.

1.A.3 Alloy X Least Favorable Material Properties

The following material properties vary between the Alloy X constituents:

- Design Stress Intensity (S_m)
- Tensile (Ultimate) Strength (S_u)
- Yield Strength (S_y)
- Coefficient of Thermal Expansion (α)
- Coefficient of Thermal Conductivity (k)

Each of these material properties are provided in the ASME Code Section II [1.A.10]. Tables 1.A.1 through 1.A.5 provide the ASME Code values for each constituent of Alloy X along with the least favorable value utilized in this licensing application. The ASME Code only provides values ~~to~~ from -20°F. The design temperature of the MPC is -40°F, below -20°F, ~~to 725°F~~ as stated in Table 1.2.2. Most of the above-mentioned properties ~~become increasingly favorable~~improve as the temperature drops. ~~Conservatively~~For this reason, the values at the lowest design temperature for the HI-STORM 100 System have been assumed to be equal to the lowest value stated in the ASME Code. The lone exceptions ~~is~~are the coefficient of thermal expansion and thermal conductivity. As~~The~~ th~~ermal conductivite~~y decrease~~s~~ with ~~the~~ decreasing temperature~~.~~, ~~The thermal conductivity~~its value for -40°F is linearly extrapolated from the 70°F value ~~using the difference~~with the slope based on data from 70°F to 100°F.

The Alloy X material properties are the minimum values of the group for the design stress intensity, tensile strength, yield strength, and coefficient of thermal conductivity. Using minimum values of design stress intensity is conservative because lower design stress intensities lead to lower allowables that are based on design stress intensity. Similarly, using minimum values of tensile strength and yield strength is conservative because lower values of tensile strength and yield strength lead to lower allowables that are based on tensile strength and yield strength. When compared to calculated values, these lower allowables result in factors of safety that are conservative for any of the constituent materials of Alloy X. ~~Further discussion of the justification for u~~Using the minimum value~~s of coefficient~~ of thermal conductivity has the effect of reducing the heat rejection rate from the canister which is ~~given in Chapter 3~~conservative. The maximum and minimum values are used for the coefficient of thermal expansion of Alloy X. The maximum and minimum coefficients of thermal expansion are used as appropriate in this submittal to support a conservative safety evaluation. However, for any internal interference assessment the actual values of coefficients of

thermal expansion from the ASME Code or Table 1.A.4 will be used. ~~Figures 1.A.1-1.A.5 provide a graphical representation of the varying material properties with temperature for the Alloy X materials.~~

1.A.4 References

[1.A.1] ASME Boiler & Pressure Vessel Code Section II, 1995 ed. with Addenda through 1997.

[1.A.2] ASME Boiler & Pressure Vessel Code Section II, 2013 ed. with Addenda through 2014

[1.A.3] ASME Code Case N-~~741~~635-1 (2013)

[1.A.4] C. Örnek, D. Engelberg, S. Lyon and T. Ladwein, "Effect of "475°C Embrittlement" on the Corrosion Behaviour of Grade 2205 Duplex Stainless Steel Investigated Using Local Probing Techiques," *Corrosion Management Magazine,* no. 115, pp. 9-11, 2013.

[1.A.5] C.R. Xavier, H.G. Delgado Jr., J.A de Castro, "An Experimental and Numerical Approach for the Welding Effects on the Duplex Stainless Steel Microstructure" – Materials Research Vol. 18(3) pp. 489-502, 2015.

[1.A.6] "Practical guidelines for Fabrication of Duplex Stainless Steels" – International Molybdenum Association, 2014.

[1.A.7] ASTM A923-14, "Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels" – W Conshohocken, PA, ASTM International 2014.

[1.A.8] J. Charles, "Duplex Stainless Steels, A Review After DSS '07 held in GRADO" – Steel Research International Vol. 79(6) pp. 455-465, 2008.

[1.A.9] A. Leonard, "Review of external stress corrosion cracking of 22%Cr duplex stainless steel, Phase 1 – Operational data acquisition," – HSE RR 129, Her Majesty's Stationery Office, Norwich, UK, 2003.

[1.A.10] ASME Boiler & Pressure Vessel Code Section II, Part D, 2015.

Table 1.A.1

ALLOY X AND CONSTITUENT DESIGN STRESS INTENSITY (S_m) vs. TEMPERATURE

Temp. (°F)	Type 304	Type 304LN	Type 316	Type 316LN	Duplex Stainless Steel S3~~2205~~1803 [Notes ~~3~~3 ~~and 4~~]	Alloy X (minimum of constituent values)
-40	20.0	20.0	20.0	20.0	~~31.7~~30.0	20.0
100	20.0	20.0	20.0	20.0	~~31.7~~30.0	20.0
200	20.0	20.0	20.0	20.0	~~31.7~~30.0	20.0
300	20.0	20.0	20.0	20.0	~~30.6~~28.9	20.0
400	18.7	18.7	19.3	18.9	~~29.4~~27.8	18.7
500	17.5	17.5	18.0	17.5	~~28.7~~27.2	17.5
600	16.4	16.4	17.0	16.5	~~28.4~~26.9	16.4
650	16.2	16.2	16.7	16.0	~~28.3~~26.8	16.0
700	16.0	16.0	16.3	15.6	-	15.6
750	15.6	15.6	16.1	15.2	-	15.2
800	15.2	15.2	15.9	14.9	-	14.9

Notes:

1. Source: Table 2A on pages 314, 318, 326, and 330 of [1.A.1] for Type 316/316LN/304/304LN.
~~2~~2. Units of design stress intensity values are ksi.
~~3~~3. Design stress intensity values have been derived based on the basis established in Mandatory Appendix 2 page 924 and 925 which essentially states that the stress intensity value at temperature is the minimum of one-third of the tensile strength or two-thirds of the yield strength at temperature.
~~4~~4. Maximum temperature of use for duplex stainless steel under both long term storage and short term / accident conditions is noted in Table 1.A.6.

Table 1.A.2

ALLOY X AND CONSTITUENT TENSILE STRENGTH (S_u) vs. TEMPERATURE

Temp. (°F)	Type 304	Type 304LN	Type 316	Type 316LN	Duplex Stainless Steel S3~~2205~~1803 [Notes 4~~ and 5~~]	Alloy X (minimum of constituent values)
-40	75.0 (70.0)	75.0 (70.0)	75.0 (70.0)	75.0 (70.0)	9~~5~~0 (90~~5~~)	75.0 (70.0)
100	75.0 (70.0)	75.0 (70.0)	75.0 (70.0)	75.0 (70.0)	90~~5~~ (90~~5~~)	75.0 (70.0)
200	71.0 (66.2)	71.0 (66.2)	75.0 (70.0)	75.0 (70.0)	90~~5~~ (90~~5~~)	71.0 (66.2)
300	66.0 (61.5)	66.0 (61.5)	73.4 (68.5)	70.9 (66.0)	~~91.7~~86.8 (~~91.7~~86.8)	66.0 (61.5)
400	64.4 (60.0)	64.4 (60.0)	71.8 (67.0)	67.1 (62.6)	8~~8~~3.~~.2~~5 (~~88.2~~83.5)	64.4 (60.0)
500	63.5 (59.3)	63.5 (59.3)	71.8 (67.0)	64.6 (60.3)	~~86.1~~81.6 (~~86.1~~81.6)	63.5 (59.3)
600	63.5 (59.3)	63.5 (59.3)	71.8 (67.0)	63.1 (58.9)	~~85.2~~80.7 (~~85.2~~80.7)	63.1 (58.9)
650	63.5 (59.3)	63.5 (59.3)	71.8 (67.0)	62.8 (58.6)	~~85.0~~80.5 (~~85.0~~80.5)	62.8 (58.6)
700	63.5 (59.3)	63.5 (59.3)	71.8 (67.0)	62.5 (58.4)	-	62.5 (58.4)
750	63.1 (58.9)	63.1 (58.9)	71.4 (66.5)	62.2 (58.1)	-	62.2 (58.1)
800	62.7 (58.5)	62.7 (58.5)	70.9 (66.2)	61.7 (57.6)	-	61.7 (57.6)

Notes:

1. Source: Table U on pages 437, 439, 441, and 443 of [1.A.1] for Type 304/304LN/316/316LN.
2. Units of tensile strength are ksi.
3. The ultimate stress of Alloy X is dependent on the product form of the material (i.e., forging vs. plate). Values in parentheses are based on SA-336 forged materials (type F304, F304LN, F316, and F316LN) or SA-182 forged material (S3~~2205~~1803), which are used solely for the one-piece construction MPC lids. All other values correspond to SA-240 plate material
4. Table U on page 52~~9~~1 of [1.A.10~~2~~] for D~~uplex S~~Stainless~~ Steel~~ UNS S~~32205~~31803
5. Maximum temperature of use for duplex stainless steel under both long term storage and short term / accident conditions is noted in Table 1.A.6..

Table 1.A.3

ALLOY X AND CONSTITUENT YIELD STRESSES (S_y) vs. TEMPERATURE

Temp. (°F)	Type 304	Type 304LN	Type 316	Type 316LN	Duplex Stainless Steel S3~~2205~~1803 [Notes 3 ~~and 4~~]	Alloy X (minimum of constituent values)
-40	30.0	30.0	30.0	30.0	65.0 (~~70.0~~65.0)	30.0
100	30.0	30.0	30.0	30.0	65.0 (65.0~~1~~)	30.0
200	25.0	25.0	25.8	25.5	57.8 (~~62.2~~57.8)	25.0
300	22.5	22.5	23.3	22.9	53.7 (~~57.9~~53.7)	22.5
400	20.7	20.7	21.4	21.0	51.2 (~~55.2~~51.2)	20.7
500	19.4	19.4	19.9	19.4	49.6 (~~53.4~~49.6)	19.4
600	18.2	18.2	18.8	18.3	47.9 (~~51.6~~47.9)	18.2
650	17.9	17.9	18.5	17.8	46.9 (~~50.~~46.9~~5~~)	17.8
700	17.7	17.7	18.1	17.3	-	17.3
750	17.3	17.3	17.8	16.9	-	16.9
800	16.8	16.8	17.6	16.6	-	16.6

Notes:

1. Source: Table Y-1 on pages 518, 519, 522, 523, 530, 531, 534, and 535 of [1.A.1] for Type 304/304LN/316/316LN.
2. Units of yield stress are ksi.
3. Table Y-1 on page ~~676 and 677~~672 and 673 of [1.A.~~2~~10] for ~~Duplex Stainless Steel~~ UNS S3~~2205~~1803. Values in ~~paratheses~~parentheses are based on SA-182 forged material (S3~~2205~~1803) which is used solely for the one-piece construction MPC lids. All other values correspond to SA-240 plate material.
4. Maximum temperature of use for duplex stainless steel under both long term storage and short term / accident conditions is noted in Table 1.A.6.

Table 1.A.4

ALLOY X AND CONSTITUENT COEFFICIENT OF THERMAL EXPANSION vs. TEMPERATURE

Temp. (°F)	Type 304 and Type 304LN	Type 316 and Type 316LN	Duplex Stainless Steel S322051803 [Notes 3-and 4]	Alloy X Maximum	Alloy X Minimum
-40	8.55	8.54	6.637.1	8.55	6.638.547.1
100	8.55	8.54	7.1	8.55	8.547.1
150	8.67	8.64	7.3	8.67	8.647.3
200	8.79	8.76	7.5	8.79	8.767.5
250	8.90	8.88	7.6	8.90	8.887.6
300	9.00	8.97	7.8	9.00	8.977.8
350	9.10	9.11	7.9	9.11	9.107.9
400	9.19	9.21	8.0	9.21	9.198.0
450	9.28	9.32	8.1	9.32	9.288.1
500	9.37	9.42	8.3	9.42	9.378.3
550	9.45	9.50	8.4	9.50	9.458.4
600	9.53	9.60	8.4	9.60	9.538.4
650	9.61	9.69	8.5	9.69	9.618.5
700	9.69	9.76	8.6	9.76	9.698.6
750	9.76	9.81	8.7	9.81	9.768.7
800	9.82	9.90	8.8	9.90	9.828.8

Notes:

1. Source: Table TE-1 on pages 590 and 591 of [1.A.1], for Type 304/304LN/316/316LN.
2. Units of coefficient of thermal expansion are in./in.-°F x 10^{-6}.
3. Table TE-1 on page 753753 of [1.A.102] for Duplex Stainless Steel UNS S322051803.
4. Maximum temperature of use for duplex stainless steel under both long term storage and short term / accident conditions is noted in Table 1.A.6.

Table 1.A.5

ALLOY X AND CONSTITUENT THERMAL CONDUCTIVITY vs. TEMPERATURE

Temp. (^oF)	Type 304 and Type 304LN	Type 316 and Type 316LN	Duplex Stainless Steel S322051803 [Notes 3 and 4]	Alloy X (minimum of constituent values)
-40	8.23	6.96	7.83	6.96
70	8.6	7.7	8.2	7.7
100	8.7	7.9	8.3	7.9
150	9.0	8.2	8.6	8.2
200	9.3	8.4	8.8	8.4
250	9.6	8.7	9.1	8.7
300	9.8	9.0	9.3	9.0
350	10.1	9.2	9.5	9.2
400	10.4	9.5	9.8	9.5
450	10.6	9.8	10.0	9.8
500	10.9	10.0	10.2	10.0
550	11.1	10.3	10.5	10.3
600	11.3	10.5	10.7	10.5
650	11.6	10.7	10.9	10.7
700	11.8	11.0	11.2	11.0
750	12.0	11.2	11.4	11.2
800	12.2	11.5	11.6	11.5

Notes:

1. Source: Table TCD on page 606 of [1.A.1] for Type 304/304LN/316/316LN.
2. Units of thermal conductivity are Btu/hr-ft-^oF.
3. Table TCD on page 773773 of [1.A.210] for Duplex SStainless Steel UNS S31803.
4. Maximum temperature of use for duplex stainless steel under both long term storage and short term / accident conditions is noted in Table 1.A.6.

SUPPLEMENT 5.III

EVALUATION OF THE MPC-68M BASKET, AND THE 10x10F AND 10x10G ASSEMBLY CLASSES

5.III.0 DISCUSSION

The MPC-68M is a variation of the 68 cell BWR canister MPC-68 evaluated in the main part of this chapter, but with a basket design consisting of aluminum oxide and finely ground boron carbide dispersed in a metal matrix of pure aluminum. The boron carbide content is 10% (minimum) by weight. This results in a B-10 areal density that is slightly above that in the MPC-68. ~~To show that the baskets are essentially identical from a shielding perspective, t~~The relevant differences between the baskets are listed below, and then discussed in respect to its effect on the photon and neutron dose rates.

Differences between the MPC-68M compared to the MPC-68, in respect to the characteristics important for the dose calculations, are as follows:

- The MPC-68M has a slightly higher B-10 content
- The MPC-68M is lighter, since it consists of aluminum and boron carbide, but no steel
- In the enclosure shell, the MPC-68M is surrounded by aluminum basket shims

To evaluate the effect of these differences, studies in the main part of Chapter 5 regarding dose contributions from a regionalized loading scheme are utilized. These studies, described in Section 5.4, show that the inner region on an MPC-68 (32 assemblies = 47 % of the content) contributes about 27% of the neutron dose rate, but only about 2 % of the photon dose rate. This means that the self-~~-~~shielding of the fuel and basket for neutron radiation is low, while for photon radiation it is very high. The low neutron self-~~-~~shielding means that the neutron doses are not significantly affected by the reduced basket weight, since the majority of the neutron shielding function is provided by the overpack around the MPC. Also, for MPCs filled with water, there is a further reduction in neutron dose due to the increased absorption of thermal neutrons from the increased B-10 loading. The high self-~~-~~shielding for photons means that only the outer basket panels are effective for gamma shielding. For the MPC-68M, the shielding in this area is enhanced due to the presence of the basket shims, and therefore comparable to the absorption in the steel basket walls. In summary, the effect of the design differences between MPC-68 and MPC-68M on dose rates is small. ~~Therefore, no specific dose calculations are performed for the MPC-68M, and all results and conclusions from the MPC-68 are directly applicable here.~~

Additionally, two BWR array classes designated 10x10F and 10x10G have been added as approved contents in the MPC-68M only. From a radiological perspective, the additional array classes are bounded by the design basis GE 7x7 source term calculations, since those design basis assemblies have higher initial uranium masses. In terms of grouping assemblies for the polynomial factors presented in Section 2.1.9, the new array classes are added to groups which

represent assemblies of a higher mass. This is conservative since a heavier assembly results in a higher decay heat, which reduces the allowable assembly burnup. In summary, no new analyses are necessary to qualify those additional array classes.

Therefore, the main body of this chapter remains fully applicable for the HI-STORM 100 System using an MPC-68M and the new assembly classes.

As discussed in Subsection 2.0.1, each MPC basket, except MPC-68F, allows for two loading strategies, namely the uniform fuel loading and the regionalized loading with two regions. An additional 3-region loading pattern, shown in Figure 2.III.1, is evaluated to determine acceptability as approved contents in the MPC-68M only. This evaluation performs a dose rate comparison between a uniform loading pattern (results shown in Table 5.4.9) and a 3-region pattern (Table 5.III.1) in which one region contains 2-year cooled spent nuclear fuel.

It should be noted that the design basis GE 7x7 source term calculations, discussed in Section 5.2 of the main part of this chapter, are performed using the SCALE 4.3 system [5.1.2, 5.1.3]. The evaluation in this Supplement 5.III is performed with an updated version of SCALE (SCALE 5.1) which is consistent with other approved Holtec applications [5.III.3]. (SCALE 4.3 is no longer maintained by Oak Ridge National Laboratory, and does not work on contemporary computer operating systems.) To ensure that the dose rate comparison is not affected by the SCALE code version, a comparison between results generated using SCALE 4.3 and SCALE 5.1 was performed. There were no significant differences in the neutron and fuel gamma source terms between the two SCALE versions. The Cobalt-60 photon source calculated with SCALE 5.1 were substantially higher than the Cobalt-60 source calculated using SCALE 4.3 which is encompassed in the first two dose rate results columns of Table 5.III.2. The remaining comparisons shown in Table 5.III.2 are performed using the updated version of SCALE (SCALE 5.1), which compared the uniform loading pattern (50,000 MWD/MTU, 3-year cooling time) against the 3-region loading pattern presented in Table 5.III.1 for both the MPC-68[1] and MPC-68M.

Table 5.III.2 shows the dose rates for the 3-region loading pattern (Figure 2.III.1 and Table 5.III.1) are bounded by the uniform loading pattern (50,000 MWD/MTU and 3-year cooling). For this reason, the 3-region loading pattern shown in Figure 2.III.1 is added as approved contents of the MPC-68M. The minimum cooling time criteria for the MPC-68M is updated to 2.0 years (see Table 2.0.1). The minimum cooling time criteria for the MPC-68 remains at 3.0 years (see Table 2.0.1).

[1] The 3-region loading pattern shown in Figure 2.III.1 and Table 5.III.1 is approved for the MPC-68M only. All results related to the 3-region loading pattern (in Figure 2.III.1 and Table 5.III.1) in the MPC-68 are for the purposes of comparison only.

~~The shorter cooling time allowed within the MPC-68M offsetsource term. Using a reference 3-region loading pattern (shown in Figure 2.III.1) the surface dose rate results are bounded by the uniform loading pattern dose rate results shown in Table 5.4.9.~~

5.III.1 REFERENCES

[5.III.1] I.C. Gauld and O.W. Hermann, "SAS2: A Coupled One-Dimensional Depletion and Shielding Analysis Module," ORNL/TM-2005/39, Revision 5.1, , Oak Ridge National Laboratory, November 2006.

[5.III.2] I.C. Gauld, O.W. Hermann, and R.M. Westfall, "ORIGEN-S: SCALE System Module to Calculate Fuel Depletion, Actinide Transmutation, Fission Product Buildup and Decay, and Associated Radiation Source Terms," ORNL/TM-2005/39, Version 5.1, Oak Ridge National Laboratory, November 2006.

[5.III.3] Holtec International Report HI-2114830, Final Safety Analysis Report on the HI-STORM FW System, USNRC Docket 72-1032, latest revision.

[5.III.4] Holtec International Report HI-2146423 Revision 1, HI-STAR 190 Source Terms and Loading Patterns.

Table 5.III.1

3-REGION LOADING PATTERN FOR MPC-68M

Region	Assemblies Per Region	Heat Load Limit[1] (kW)	Burnup (MWD/MTU)	Enrichment (wt%)	Cooling Time (years)	Calculated Heat Load[2] (kW)
1	24	0.4	50000	3.6	7	0.436
2	16	1.2			2	1.336
3	28	0.5			5	0.550

[1] As shown in Figure 2.III.1.

[2] Decay heat is calculated in Reference [5.III.4]; this shielding analysis reference case conservatively exceeds the heat load limits set in Figure 2.III.1.

Table 5.III.2

DOSE RATES COMPARISON BETWEEN UNIFORM[4] AND 3-REGION[5] LOADING PATTERN FOR 100-TON HI-TRAC

Dose Point Location	Totals Uniform MPC-68 From Table 5.4.9 (SCALE 4.3) (mrem/hr)	Totals Uniform MPC-68 (SCALE 5.1) (mrem/hr)	Totals 3-Region MPC-68 (SCALE 5.1) (mrem/hr)	Totals Uniform MPC-68M (SCALE 5.1) (mrem/hr)	Totals 3-Region MPC-68M (SCALE 5.1) (mrem/hr)
ADJACENT TO THE 100-TON HI-TRAC					
1	1745.39	1978.3	1631.8	2068.0	1706.5
2	2992.98	3025.3	1803.6	2742.7	1672.9
3	991.17	1145.0	950.0	1526.4	1240.3
4	715.82	767.4	570.2	866.7	625.6
5 (pool lid)	8069.5	9414.2	6815.3	9848.6	6979.4
ONE METER FROM THE 100-TON HI-TRAC					
1	552.67	575.2	381.7	541.2	369.0
2	1257.27	1278.1	750.5	1169.9	702.7
3	289.97	323.3	242.9	375.1	284.7

[4] Design Basis GE 7x7 spent fuel with a burnup of 50,000 MWD/MTU, cooling time of 3 years, and initial enrichment of 3.6 wt% U-235.

[5] As shown in Figure 2.III.1 and Table 5.III.1.

Note:

Vacuum drying or moisture removal using FHD (for high burn-up fuel or high decay heat) is performed to remove moisture and oxidizing gasses from the MPC. This ensures a suitable environment for long-term storage of spent fuel assemblies and ensures that the MPC pressure remains within design limits. The vacuum drying process described herein reduces the MPC internal pressure in stages. Dropping the internal pressure too quickly may cause the formation of ice in the fittings. Ice formation could result in incomplete removal of moisture from the MPC. The moisture removal process limits bulk MPC temperatures by continuously circulating gas through the MPC. Section 8.1.5 Steps 6a through q are used for the vacuum drying method of drying and backfill, with optional steps for open loop low pressure drying (LPD) for 68M MPCs per Section 4.III.5. Section 8.1.5 Steps 7a through i are used for the FHD method of drying and backfill.

6. Dry and Backfill the MPC as follows (Vacuum Drying Method):

Note:

During vacuum drying, the annulus between the MPC and the HI-TRAC must be maintained full of water. Water lost due to evaporation or boiling must be replaced to maintain the water level. The vacuum drying process described herein reduces the MPC internal pressure in stages. Dropping the internal pressure too quickly may cause the formation of ice in the fittings. Ice formation could result in incomplete removal of moisture from the MPC.

   a. Fill the annulus between the MPC and HI-TRAC with clean water. The water level must be within 6" of the top of the MPC.

   b. Attach the drying system (VDS) to the vent and drain port RVOAs. See Figure 8.1.22a. Other equipment configurations that achieve the same results may also be used.

Note:

The vacuum drying system may be configured with an optional fore-line condenser. Other equipment configurations that achieve the same results may be used.

Note:

To prevent freezing of water, the MPC internal pressure should be lowered in incremental steps. The vacuum drying system pressure will remain at about 30 torr until most of the liquid water has been removed from the MPC.

Caution:

For MPC heat loads greater than defined threshold limits, cyclic vacuum drying can be used. The method and acceptance criteria to determine the cycle time limits are specified in Section 4.5. Once vacuum drying time limit is reached for a cycle, MPC shall be backfilled with helium as described in Section 4.5 and vacuum drying cycle shall be repeated. For MPC-68M canisters, LPD method ~~Steps r. through x. may be used in lieu of Steps d. through q. after~~may be used after vacuum drying time limit in the first cycle is reached.

c. Open the VDS suction valve and reduce the MPC pressure to below 3 torr. Refer to Section 4.5 for method to determine vacuum drying time and cycle limits. If MPC vacuum drying acceptance criteria are not met during allowable time, backfill the MPC cavity with helium to a pressure of ≥ 0.5 atm and reset the vacuum drying time (see Technical Specifications) or, for MPC-68M, implement the following steps for LPD:

Note:
Helium used for drying shall be in accordance with the Technical Specification using 99.995% (minimum) purity. Other equipment configurations that achieve the same results may be used.

Caution:
MPC internal pressure during LPD process will be less than the Technical Specification minimum backfill requirement. The MPC must be backfilled to the minimum helium pressure required by the Technical Specification to place the MPC in an acceptable condition.

i. Disconnect the VDS equipment and establish helium flow into the MPC top vent to establish required internal MPC pressure.

ii. Bleed helium to atmospheric pressure through the top drain vent to establish required flow rate per Table 4.III.10.

iii. Monitor moisture removal until LCO 3.1.1 is met for MPC dryness.

iv. While monitoring the temperatures into and out of the MPC, adjust the helium pressure in the MPC to provide a backfill pressure as required by the technical specifications.

v. Go to Step o. after backfill is complete.

d. Shut the VDS valves and verify a stable MPC pressure on the vacuum gage.

Note:
The MPC pressure may rise due to the presence of water in the MPC. The dryness test may need to be repeated several times until all the water has been removed. Leaks in the vacuum drying system, damage to the vacuum pump, and improper vacuum gauge calibration may cause repeated failure of the dryness verification test. These conditions should be checked as part of the corrective actions if repeated failure of the dryness verification test is occurring.

e. Perform the MPC drying pressure test in accordance with the technical specifications. If MPC vacuum drying acceptance criteria are not met during allowable time, backfill the MPC cavity with helium to a pressure of ≥ 0.5 atm and reset the vacuum drying time (see Technical Specifications) and restart vacuum drying.~~.~~

f. Close the vent and drain port valves.

g. Disconnect the VDS from the MPC.

h. Stop the warming pad, if used.

i. Close the drain port RVOA cap and remove the drain port RVOA.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, Kimberly Manzione, 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 provided in Attachment 4 to Holtec Letter 5014817. 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).

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(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, 4.b, and 4.e 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

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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)

Kimberly Manzione, being duly sworn, deposes and says:

That she 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 4th day of November, 2016.

Kimberly Manzione
Licensing Manager
Holtec International

Subscribed and sworn before me this 4th day of November, 2016.

ERIKA GRANDRIMO

NOTARY PUBLIC
My Commission Expires 1/17/2017