Chapter 1 – General Information

1.1 Clarify the statement that the free water may not exceed 1% by volume of the secondary container under package loading.

Section 1.2.2 of the application states, as one of the Model No. 3-60B package loading restrictions, that the free water may not exceed 1% by volume of the secondary container. Example 2 of Attachment 7.1 states that the swarf, contained in a sealed steel liner, is dewatered to 1% of the waste volume.

The application needs to clarify, or confirm, if the statement "the free water should not exceed 1% by volume of the secondary container under package loading" is applicable to either dewatered swarf, or powdered solids, or irradiated hardware, or to all the contents of the Model No. 3-60B package.

This information is required by the staff to determine compliance with 10 CFR 71.35, and 71.87.

RESPONSE

The water content of waste materials in the cask is dictated by the acceptance criteria of the site receiving the waste. A typical requirement, i.e., not more than 1% of the waste volume, was used in the hydrogen generation example calculation. Section 1.2.2 has been revised to state that the cask cavity is to be emptied of water to the extent practical, not to exceed the acceptance criterion of 8.1.8 (see response 3.2), and that wet solid waste, e.g., resins, in secondary containers is to be dewatered per ANSI/ANS-55.1-1992.

1.2 Explain why the radiolysis of water is the only primary gas generation mechanism analyzed in the Model No. 3-60B package.

The applicant performs hydrogen generation calculations with the radiolysis of water as the primary mechanism for gas generation, and neglects other mechanisms such as chemical or thermal activity.

The application needs to:

(i) Refer to Table 3.1 of NUREG/CR-6673 "Hydrogen Generation in TRU Waste Transportation Packages" for bounding G values of the package contents which contribute to hydrogen generation, and

(ii) Document why gas generation from other mechanisms, such as chemical or thermal, is expected to be insignificant for the Model No. 3-60B package.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE

The potential mechanisms of gas generation in the 3-60B cask are: radiolysis, chemical reactions, thermal degradation, and biological activity. The contents of the 3-60B are restricted to solid inorganic materials and explosives, pyrophorics, and corrosives (pH less than 2 or greater than 12.5), are prohibited (see Chapter 1). The restriction of the contents to inorganic materials eliminates the potential for gas generation due to thermal degradation or biological activity. The operating procedures of Chapter 7 require an assurance of chemical compatibility using EPA's Chemical Compatibility Chart, EPA-600/2-80-076 prior to loading. The content restrictions and material compatibility requirements preclude chemical reactions that might produce gases.

The remaining mechanism for gas generation is radiolysis. As noted in Reference 3.9, solid inorganic materials have a G value of zero, i.e., solid inorganic materials do not generate hydrogen or other gases through radiolysis. Solidified or dewatered material may contain some water and if the cask is loaded underwater, a small of amount of water may remain in the cavity after draining. The radiolytic generation of gases is limited to the radiolysis of this residual water. Hydrogen and oxygen may be produced in the cask by radiolytic decomposition of residual water in the cask contents. The amount of hydrogen must be limited to prevent the formation of a flammable mixture. The hydrogen concentration can be limited to 5% by limiting the decay heat for contents that include water.

This information has been added to Section 3.3.2

1.3 *Provide a detailed description of the characteristics of the contents and of their corresponding radioactive constituents which contribute to hydrogen generation due to radiolysis.*

The application does not include a detailed description of the characteristics of the contents (as currently listed in Section 1.2.2 of the application) and of their corresponding radioactive constituents (e.g., radiation types) which are considered to contribute to radiolytic hydrogen generation.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE

The hydrogen and oxygen generation rate is determined using the methodology developed by DOE for evaluation of TRU wastes (Reference 3.9) with a number of additional assumptions. The radioactive constituents may include byproduct, source, or SNM. These radionuclides may produce alpha, beta, and/or gamma radiation. In the 3-60B gas generation methodology, only the bounding G-value for water is used in the calculation of hydrogen generation. The bounding G value, 1.6 molecules per 100 eV absorbed, is independent of radiation type. Since the 3-60B will primarily transport gamma or mixed sources that are predominately gamma, use of the bounding G value is very conservative (the G value for gamma is ~0.4). Also, the total decay energy is conservatively assumed to be absorbed by the contents, i.e., all gamma and beta decay energy is assumed to be absorbed by the contents. Thus, the type of radiation does not affect the calculated amount of hydrogen generated.

The 3-60B gas generation methodology is not specific to a particular material type. Since all the decay energy is assumed to be absorbed and the radiation invariant bounding G value is used, the gas generation rate is unchanged for all the allowed content forms, e.g., powdered solids, solidified material, resins, or activated components.

1.4 Justify if the contents consisting of solidified material and resin are considered either as a type of irradiated hardware or as a powdered solid for the evaluation of hydrogen generation.

Section 1.2.2 of the application identifies component segments (irradiated hardware), inorganic solids (powdered solids), inorganic solidified material, and inorganic resins as contents of the Model No. 3-60 B package. The application provides examples for characterizing hydrogen generation only for powered solids and irradiated hardware contents, but not for the other types of contents.

The application needs to clarify how the corresponding approach for the evaluation of hydrogen generation is applicable to resins and solidified material.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE

The approach for determining hydrogen generation is not specific to the material particle size as discussed in the response to item 1.3. The 3-60B gas generation methodology calculates the amount of decay energy expressed as decay heat that will result in a hydrogen concentration of 5%. This amount of energy is defined as the decay heat limit and depends on only two variables, 1) the amount of water expressed as a fraction of the mass of the contents, and 2) the size of the void in which hydrogen may collect, expressed as a fraction of the volume of the cask cavity. Two examples were provided but the calculation method detailed in Section 7.1.2 is not specific to a particular material. The hydrogen generation rate calculation for waste in the 3-60B cask is equivalent to the method presented in NUREG/CR-6673. However, the only material undergoing radiolysis to produce hydrogen is water.

1.5 Justify why the dewatered swarf may be considered as a type of powdered solids for the determination of hydrogen generation.

The package contents are categorized into irradiated hardware and powdered solids for the hydrogen generation analysis. Irradiated hardware and dewatered swarf (a type of powdered solids) are used as examples for the evaluation of hydrogen generation.

The application should provide a detailed description of the dewatered swarf, including photos or pictures, to help confirm that dewatered swarf is a type of powdered solids suitable for the evaluation of hydrogen generation.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE

The definition of swarf is: material (as metallic particles and abrasive fragments) removed by a cutting or grinding tool (Webster's New Collegiate Dictionary, G.& C. Merriam Co., 1980). Thus, swarf is physically similar to a powdered solid. However, for hydrogen generation, the physical form is not important. See the response to Item 1.4.

1.6 Clarify the existence of an NRC-approved Quality Assurance Program.

Section 1.1 of the application states that the application is in accordance with Regulatory Guide No. 7.9; however, the application does not specifically refer to an NRC-approved Quality Assurance Program.

This information is required by the staff to determine compliance with 10 CFR 71.101.

RESPONSE

We are unable to find guidance in Regulatory Guide No. 7.9 indicating that reference to an NRC–approved Quality Assurance Program is a necessary part of the application. Please provide a reference to such guidance. As requested, the NRC letter approving the EnergySolutions QA program is attached.

Licensing Drawings

1.7 Explain the welding symbol as shown on Item No. 13, Inner Cask Shell, sheets No. 2 of 5 (section view) and No. 3 of 5 (containment boundary) of the 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0.

1.7.1 Explain if this symbol is a single V groove weld or a seam weld. Describe the intended purpose of this weld symbol including the orientation as welded on Item No. 13.

1.7.2 Explain why the weld symbol, used on sheet No. 2 of 5, depicts a weld "all around" symbol, but is excluded on the weld symbol, sheet No. 3 of 5, for the same weld.

The weld symbol depicts a single V groove joint design; however, the tail of the weld symbol states "typical seam weld."

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(5)(iii), and 71.39.

RESPONSE

Additional weld callout information is provided on sheets No. 2 of 5 (section view) and No. 3 of 5 (containment boundary) of the 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0; revised version dated 1/12/10 attached. The inner shell may be fabricated from one or more pieces. The welds joining the pieces are full penetration single groove welds as shown by the revised and/or additional weld callouts. The weld callouts show circumferential welds as "all around".

1.8 Explain the single V groove joint as shown joining Item No. 16 (Plate, 1-inch) to Item No. 6 (Bolt Ring), sheet No. 3 of 5 (containment boundary) of the 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0.

Describe the intended purpose of this weld joint and/or add a complete weld symbol including non-destructive examination (NDE) required to the drawing.

This single V groove joint is only identified or shown as a "V groove" on the drawing containment boundary view without a stated weld symbol, NDE requirements or any other American Welding Society standard description.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(5)(iii), and 71.39.

RESPONSE

The weld joining Item No. 16 (Plate, 1-inch) to Item No. 6 (Bolt Ring), sheet No. 3 of 5 (containment boundary) is a bevel groove weld. A weld symbol for this weld is added to Sheet 2 at region B-8. This weld is not a containment boundary weld. The NDE of non-containment boundary welds is covered by Note 2 (Sheet 1), which is changed from a flag note to a general note.

1.9 Explain how Item No. 53 (Plate, 6 1/2-inch thick by 37-inch diameter) is attached to Item No. 32 (Plate 4-inch thick by 48 3/4-inch diameter), sheet No. 4 of 5 (section H-H) of the 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0.

1.9.1 Provide a full description of the intended method to attach these items for the fabrication of the cask lid.

1.9.2 Provide a description of the intended fabrication methods of Item No. 53 if the fabrication facility chooses a direction in accordance with the General Note No. 16 of the drawing.

Items Nos. 32 and 53 are shown to make-up or fabricate the bolted cask lid. However, no method of how to join these two items is shown and/or described either in the drawing or in the application. Also, whether or not the lid can be manufactured as one piece is not specified. Further, no method for fabricating Item No. 53 is shown and/or described in the drawing or in the application as General Note No. 16 states, "Item No. 53 may be made from multiple pieces."

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(5)(iii), and 71.39.

RESPONSE

Item No.53 is attached to Item No.32 by welding.

1.9.1 The weld joining Item No. 53 to Item No. 32 is a bevel groove weld all around shown with a weld callout in Detail G of Sheet 4.

1.9.2 Weld symbols have been added to Detail J and Detail G of Sheet 4 to show how Item No. 53 can be fabricated if the option to use multiple pieces is chosen. Flag Note No. 16 is revised to include the statement :"See optional welding detail".

1.10 Delete or update the material designation "S/STL" (i.e., stainless steel) for Item No. 36 (Socket Head Cap Screw (SHCS), 1/2-13 UNC Thread, 1 1/2-inch long, S/STL) description on the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5, Bill of Materials.

Item No. 36 SHCS is fabricated to American Society for Testing & Materials (ASTM) A 193, Grade B7 specifications, and is a Chromium-Molybdenum (Cr-Mo) ferritic alloy steel i.e., not a stainless steel.

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

RESPONSE

"S/STL" has been deleted from Item No. 36. The material for both Item Nos. 36 and 27 has been changed to ASTM A574, which is the appropriate material for a socket head screw.

1.11 Change the material designation "Grade DB" for Item No. 33 (Seal Ring, 1/2-inch thick) description to reflect the correct Grade of material required for the Model 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5, Bill of Materials.

Change or provide the location (i.e., specification) of material designation "Grade B21, Class 1" for the same Item No. 33 described above.

Item No. 33, is fabricated to specification ASTM A 354, Grade DB or A 450, Grade B21, Class 1, as shown on the drawing Bill of Materials description; however, Grade DB and Grade B21, Class 1 do not exist as an option within their respective specifications. For ASTM A 354 a "Grade BD" is offered as an option, not "Grade DB"; therefore, this may be a typographical error made to Item No. 33 drawing description. In addition, for ASTM A 450, no material grade designation "Grade B21, Class1" can be found within this specification.

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

RESPONSE

A previous version of the drawing, dated 7/23/09, which was provided as a replacement on 7/29/09, lists the material for Item No. 33 as ASTM A240 Type 304L. This material designation is retained in the new version provided with the RAI response.

1.12 Provide the specification GSA document AA-595588, elastomer, referenced in Note No. 13, General Notes, to be used for Items Nos. 24, 30, 31, 38 and 39 on the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5.

Provide the specification and/or classification for Item No. 25 (elastomer, used with SHCS, drain port assembly), Bill of Materials, same drawing location as stated above.

No specification and/or classification is provided for material identification of the elastomer, Items Nos. 24, 25, 30, 31, 38 and 39. Specification ASTM D 2000, Standard Classification System for Rubber Products, provides a method for specifying rubber materials by the use of a simple "line call-out" designation. Suffix letters are defined and utilized as part of the line call-out.

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

RESPONSE

The specification listed in Note No. 13 is corrected to A-A-59588A, which is titled COMMERCIAL ITEM DESCRIPTION - RUBBER, SILICONE. A copy is provided with the response. The material designation for Item No.25 is changed to "Commercial Elastomer".

1.13 Evaluate the continued need and provide a copy of reference 2.3, ASTM F-501-93, "Aerospace Materials Response to Flame, With Vertical Test Specimen (For Aerospace Vehicles Standard Conditions)" of the application, Section No. 8, Appendix 8.3.1, Polyurethane Foam Specification ES-M-172, CHEM-NUCLEAR SYSTEMS Specification for Rigid Polyurethane Foam for Impact Limiters.

Reference 2.3 described above has been discontinued without replacement.

This information is required by the staff to determine compliance with 10 CFR 71.113.

RESPONSE

The standard, ASTM F-501-93, is provided as an attachment to the responses.

1.14 Provide reasonable assurance that any lubricant procured will not be detrimental to the fit, function or operation of the Model No. 3-60B lid bolts (Item No. 3, Hex HD. Bolt 1 1/2-6 UNC Thread, 5-inches long), vent cap screws (Item No. 36, SHCS, 1/2-13 thread, 1 1/2-inches long), drain line plug (Item No. 27, SHCS, 1-8 UNC thread, 8-inches long) and impact limiter bolts (Item No. 5, Hex Head Bolt, 7/8-9 UNC thread, 3-inches long) without specifying minimum requirements (e.g., nuclear grade) and/or a lubricant specification.

1.14.1 Change "Item No. 50" referred to in General Note No. 5 on the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5 to read "Item No. 5."

General Note No. 5 of the Model No. 3-60B Cask General Arrangement and Details Drawing states to torque (lubricated) the lid bolts, vent cap screws, drain line plug and impact limiter bolts, but provides no minimum requirements or specification. In addition, General Note No. 5, last sentence, states to "torque Item No. 50 impact limiter bolts." However, "Item No. 50" is the flat washer used with "Item No. 5" the hex head bolt. This should read, "torque Item No. 5 impact limiter bolts."

Proper lubricants should meet several essential needs for threaded connections. First, to control friction for obtaining true torque values. correct lubrication and tightening of critical connections ensures proper assembly seating. Second, to protect against corrosion by opposing oxidation and many chemicals. lubricants should reduce the destructive contact between dissimilar metals and withstand greater temperature stresses. Lastly, lubricants should allow for non-destructive disassembly.

This information is required by the staff to determine compliance with 10 CFR 71.39, and 71.43(d).

RESPONSE

Note No. 5 has been revised to:

Torque Lid bolts to 300 ± 30 ft-lb (lubricated). Vent cap screws and drain line plug, Items 27 and 36 to 20 ± 2 ft-lb (lubricated). Torque Item 5 Impact Limiter bolts to 75 ± 7 ft-lb (lubricated). Use Nuclear Grade Lubricant.

1.15 Explain the decision not to offer, as a minimum option, a vacuum grease to be used with the elastomer seals, Items Nos 24, 25, 30, 31, 38 and 39 of the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5, Bill of Materials.

Vacuum grease, a lubricant with low volatility, is designed for sealing and lubricating vacuum and pressure vessel systems may be used in addition to and act as an environmental barrier for elastomer seals. System compatibility and possible detrimental effects must be considered such as viscosity, which may be the most important factor in providing lubricant effectiveness. Various other factors to consider are additive type, thickener type, consistency, base chemistry, service temperature, specific gravity, melting point, vapor pressure, relative density, resistance to radiation, lubricity, out-gassing, coefficient of expansion and thermal conductivity. A shortened lubricant lifecycle may be an outcome of overlooking one or more of these properties.

This information is required by the staff to determine compliance with 10 CFR 71.39, 71.43(d).

RESPONSE

The operating procedure, Chapter 7, has been revised to include "Apply a thin coating of vacuum grease to the exposed surfaces of the O-rings and seals, as necessary to lubricate the elastomer surface." at each step where these items are inspected.

1.16 Change NDE requirements and acceptance criteria referenced in General Note No. 1 of the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No. 1 of 5 to read "Subsection NB-5000," in lieu of Subsection ND-5000.

General Note No. 1 states that NDE of containment welds shall meet the requirements and acceptance criteria of ASME Code, Section III, Division 1, Subsection ND-5000. "ND" refers to class 3 components; however, the staff suggests using "NB," which refers to class 1 components.

This information is required by the staff to determine compliance with 10 CFR 71.119

RESPONSE

The NDE requirements and acceptance criteria referenced in General Note No. 1 were chosen based on NRC guidance. The 3-60B cask is a Category 2 container per Table 1 of Regulatory Guide 7.11. Table 1.1 of NUREG/CR-3854, Fabrication Criteria for Shipping Containers, specifies ASME Section III, Subsection ND as the appropriate criterion for the containment boundary of Category 2 containers. Also, Table 2 of NUREG/CR-3019, Recommended

Welding Criteria for Use in Fabrication of Shipping Containers for Radioactive Materials, specifies ASME Section III Subsection ND for Category II containment related welds. Please provide a reference for staff's suggestion to use NB.

1.17 *Provide an expanded discussion of methods and allowances which are acceptable when evaluating a fabricator's decision to accept the option offered in General Note No. 10 of the Model No. 3-60B Cask General Arrangement and Details Drawing C-002-165024-001, Rev. No. 0, sheet No.1 of 5. General Note No. 10 states that any welds made to the cask body or lid following the lead pour may use a backing ring at the fabricator's option, a configuration approval required by the applicant.*

Staff's concerns include the following: (i) How much lead is required to be removed in the way of the backing ring?, (ii) What effect will the removal of lead shielding in the way of the backing ring have on external radiation dose?, (iii) Why allow the option whether to use the backing ring (i.e., reasonable assurance of weld integrity on a complete penetration joint welded from one side that no capillary attraction of lead contaminates the weld or without back-gouge sound metal is achieved)?, and (iv) What type of material may be used as a backing ring?

Measures should be utilized to keep doses received by workers and members of the public from exposures to sources of radiation as low as is reasonably achievable. It is insufficient to simply respect the appropriate dose limits and every reasonable effort should be made to maintain exposures to ionizing radiation as far below the dose limits as practical. In addition, the use of a backing ring would eliminate potential lead contamination, oxidation and provide radiation shielding within the region of lead removal.

This information is required by the staff to determine compliance with 10 CFR 71.39, 71.47(a).

RESPONSE

EnergySolutions agrees that requiring use of a backing ring is appropriate. Note No. 10 has been changed to require use of a backing ring subjected to EnergySolutions approval of the configuration. EnergySolutions approval will be based on the specifications of AWS D1.1 paragraph 5.10.3.

The AWS paragraph specifies the thickness of the ring to be no more than 3/8". The amount of lead displaced will increase the local dose rate by about 20% but this is in an area of the cask neither frequented by operating personnel nor the public so the impact on personnel exposure will be negligible and doses will be ALARA. The material of the backing ring is specified in the AWS criterion to be compatible with the base metal.

1.18 Explain the counterfeit/fraud inspection process for independent sampling and testing of cask materials used for components important to safety?

The NRC issued Generic Letter 89-02, Actions to Improve the Detection of Counterfeit and Fraudulently Marketed Products, March 21, 1989, and Information Notice No. 89-70, Possible Indications of Misrepresented Vendor Products, October 11, 1989, intended for all holders of operating licenses or construction permits for nuclear power reactors to alert for possible indications of misrepresented vendor products and to provide information related to detection of such products. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems.

The above NRC issued documents are publicly available through the NRC web site and are examples of the on-going NRC concerns in detecting counterfeit and fraud associated with all areas of commercial nuclear power generation.

This information is required by the staff to determine compliance with 10 CFR 71.31(c), 71.39, and 71.115(a)(b)(c).

RESPONSE

EnergySolutions has specified the 3-60B cask as a Quality Level 1 item. As such, suppliers must be qualified per ES procedure ES-QA-PR-003, Supplier Evaluation (attached). Procurement will be controlled by purchase orders (P.O.) prepared by Engineering staff using specifications and drawings also prepared by Engineering staff, which will include the critical characteristics of the items. On receipt of components, an inspection will be performed by certified QC personnel. The inspection will include review of documentation required by the P.O. and conformance to critical characteristic, such as dimensions, also specified on the P.O. or drawing. For the specific components of the 3-60B cask the following additional specific requirements for inspection and testing will be applied. Bulk materials, i.e., steel, weld material, and spacer wire, will only be procured from ASME Quality System Certificate holders who will be required to independently test all material and provide the appropriate certificates of conformance. Fabricated metal components, i.e., bolts and threaded inserts, will be procured from an evaluated and approved supplier, based on specifications developed by Engineering staff from the critical characteristics of the item, who will be required to provide appropriate certificates of conformance. Impact limiters will be procured from an approved supplier, who will be required to provide material test reports for the foam, including reports of tests of physical and chemical properties to demonstrate conformance to the critical characteristics specified in the P.O. O-rings and seals will be procured directly from the manufacturer and may additionally be subjected to specific tests performed by Engineering staff to verify critical characteristics.

Chapter 2 – Structural Evaluation

2.1 Justify the applicability of the boundary conditions used in the quasi-static analyses in ANSYS.

Subsection titled "Boundary Conditions," of Section No. 6.0 of ST-504, Revision No. 1, states, "The rigid body motion is prevented in the model by restraining it at the locations where such restrains have insignificant effect on the overall behavior of the model." Provide additional information related to the applied boundary conditions that present "insignificant effects" on the overall behavior for all ANSYS analyses. As stated above, the staff was unable to make a determination on the applicability of the boundary conditions from the reviewed ANSYS models.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

The displacement boundary conditions used in the drop analyses using ANSYS software package have now been included in document ST-504 (Reference 2-18) for end, side and corner drop analyses. For the end drop conditions (Figure 10), the nodes corresponding to the impact limiter foam have been restrained in the vertical direction to represent the reaction. For the other two drop orientations, since the applied boundary conditions comprised only the force field, some displacement restraints were needed to prevent the rigid body motion in the system. For the side drop, the restrained nodes are shown in Figure 18 and for the corner drop they are shown in Figure 26. It should be noted that these nodes are located far away from the impact limiter reactions. Nodal load summations have been performed to guarantee that they develop negligible total loads. The stress intensity plots have also been examined to ensure that there is no stress-field discontinuity at these locations.

2.2 Justify not including the end drop case in the benchmark evaluation.

In ST-551, Rev. No. 2, "Validation of the LS-DYNA Drop Analyses Results with the Test Data," benchmarking does not provide any analysis or explanation for not including an end drop case. Therefore, concluding on a conservative/realistic solution is not possible.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

The evaluation performed in ST-551 is for the purpose of benchmarking the test results of the VHLW cask with the analytical procedure developed by

Energy*Solutions*. The VHLW cask prototype model was tested for the side drop and shallow angle drop (slapdown) only. No tests in the end drop orientation were performed.

The side drop and shallow angle drop develop a complex field of deformation in the impact limiters as opposed to end drop where the deformation field is fairly uniform normal to the plane of impact. Therefore, a favorable comparison of the side drop and shallow angle drop results with the prototype test results are considered a sufficient validation of the methodology.

2.3 Provide additional discussions of the shallow angle drop case.

Section 7.1.4 of ST-504, Rev. No. 1 includes the following statement and how it relates to the effects of the shallow angle drop case. "The results of the shallow angle drop analyses show that the tail-end impact is more severe than the nose-end impact for the 3-60B cask. This result is consistent with the conclusion of Reference No. 11, which shows that for a slender cask with length-to-radius of gyration ratio larger than 2, the tail-end impact is more severe than the nose-end impact. For both shallow angle orientations (slapdown-1 and slapdown-2), and for cold and hot environmental conditions, the tail-end impact reactions are larger than nose-end impact limiter reactions (see Figure Nos. 86, 91, 96 and 101 of Reference No. 4). "

The shallow angle analysis is unclear based on the referenced Sandia National Laboratories (SNL) report No. SAND88-0616UC-71 (Reference No. 11, ST-504, Rev. No. 1) and the lack of a length-to-radius of gyration ratio (aspect ratio) determination.

The ANSYS analysis for the side drop conditions were amplified by using the ratio of impact limiter reaction forces for the side and shallow angle drop cases from LS-DYNA to verify the shallow angle drop scenario. Variations in the coefficient of friction (See RAI No. 2.6), and also on the aspect ratio of transportation packages are interrelated as reported in the SNL Report No. SAND90-2187, printed June 1991, "An Analysis of Parameters Affecting Slapdown of Transportation Packages."

Justify how the side drop case can be used to conservatively bound the shallow angle drop case.

This information is required by the staff to determine compliance with 10 CFR 71.73.

RESPONSE

The analysis process of the 3-60B Cask for all the drop orientations are summarized as follows:

- Obtain the impact reactions for all the drop orientations. This has been performed using explicit LS-DYNA code and is documented in ST-557.
- The reactions obtained in the previous step is applied to the FEM of the cask and analyzed using the implicit ANSYS code. This is documented in ST-504.

For the LS-DYNA analyses all the drop orientations (end, side, corner, and shallow angle) are explicitly analyzed. The statement, "(T)he results of the ......" in ST-504 is merely a repetition of the statement in ST-557 (Section 7.4). It is repeated in ST-504 in order to show the nature of the two impacts.

It should be noted that there is no intention, whatsoever, to compare the numerical results of the LS-DYNA analyses of the 3-60B cask with that of the SANDIA reports cited here. The SANDIA report's results have been derived with severe limitations, some of them are listed below:

- It does not have any provisions for inclusion of impact limiters as used in the 3-60B Cask. It assumes the cask package as a circular cylinder. A dumbbell shape package like 3-60B cask will have to be severely simplified to fit the SANDIA study.
- It does not have any provisions for the impact limiter attachment, and hence, the flexibility that arises because of the attachments cannot be incorporated into the SANDIA model.
-

In light of the above limitations, the SANDIA reports are of academic interest only. They provide useful trends for the shallow angle drop with respect to the slenderness ratio, drop angle, friction, contact rigidity, etc. Their quantitative results are severely limited because of the above simplifications. Comprehensive LS-DYNA analyses such as those performed for the 3-60B cask, on the other hand, provide a more accurate quantitative results.

SAND88-0616UC-71 (Reference No. 11), though, confirms a significant fact which has been observed in various other prototype tests, i.e. the cask having a slenderness ratio larger than 2 tend to undergo more severe impact on the initially non-impacting end than on the initially impacting end during a shallow angle drop test. The extent of the severity can only be predicted by the SANDIA reports with great limitations.

The 3-60B cask has the following properties:

Package total length (including the impact limiters), L = 128.625 in

Package radius (use cask radius for conservatism), a = 25.5 in

Radius of gyration, $r = [(L^2 + 3\ a^2)/12]^{½} = 39.26$ in

Thus, $L/r = 3.28 > 2.0$

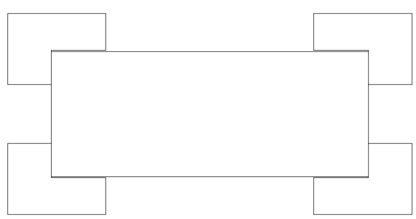
Therefore, the second impact is expected to be more severe than the initial impact. This trend is exhibited by the 3-60B analyses results. The statement cited above in ST-557 and ST-504 is merely alluding to this fact.

ST-501 has established a methodology that can be used to predict the impact limiter response conservatively. This methodology establishes among other things:

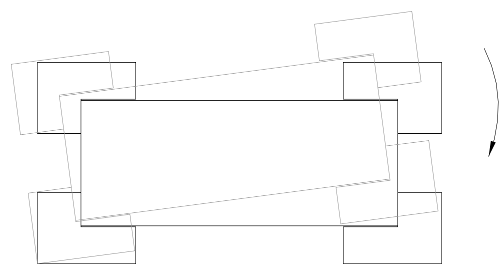
- Element types and their formulations.
- Material modeling and their associated parameters.
- Values of various analysis parameters, e.g. hour-glass control, damping.
- Coefficient of frictions between various components of the impact limiter and cask body used with the contact elements.

Energy*Solutions* developed these parameters in the proprietary document ST-551 after a considerable amount of research. These parameters were consistently used in the analyses of ST-551 to validate the analyses results with the prototype test results of the VHLW cask. Once it was established that the analyses with these parameters will predict conservative results, the same parameters (including the coefficient of friction) were used in the analyses of ST-557 to obtain the impact limiter reactions for various drop orientation and heights.

For the stress analyses of the 3-60B Cask, implicit finite element code (ANSYS) has been used. ST-504 documents these analyses. In these analyses, the impact limiter reactions, obtained from the LS-DYNA analyses, are used as the input forces. As shown in the following sketch, the shallow angle drop includes a drop on one of the impact limiters followed by an impact on the other impact limiter.



Side Drop



Shallow Angle Drop

It is during the second impact that the maximum impact limiter reaction occurs. At this time the cask is in the horizontal orientation, which is the same orientation as the side drop. Thus the distribution of the impact limiter reaction on the cask is similar to that of the side drop only its magnitude is different. The ratio of the impact limiter reaction for shallow angle-to-the side drop is used to amplify the side drop stresses to obtain the maximum stresses the cask will experience during the shallow angle drop. The above statement has been added to Section 2.7.1.4 of the SAR.

2.4 *Demonstrate that the orientation of the foam's properties is realistic and conservative for each drop test case.*

Justify the use of uni-directional rather than orthogonal properties of the foam for each drop case.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

Appendix 1 has been added to ST-557 that shows the impact limiter foaming process. It also shows how the directional foam properties are correlated to the drop analyses performed using the LS-DYNA software.

2.5 Justify the properties of the impact limiter foam material.

Using the General Plastics publication, titled "Design Guide for Use of LAST-A-FOAM FR-3700 for Crash and Fire Protection of Radioactive Material Shipping Containers, iss005," staff was unable to replicate the applicant's tabulated data in Table No. 1 of ST-557, Rev. No.1.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

The excerpts from the General Plastics sales brochure have been included in Appendix 1 of ST-557. It has also been documented how the data from these cut-sheets have been used to arrive at the stress-strain properties used in the drop analyses.

2.6 Justify that the friction coefficient values used in the drop analyses are realistic and conservative.

The static and dynamic coefficients of friction are assumed to be 0.3 for all the contact surfaces for "Drop Analyses of the 3-60B Cask Package using LS-DYNA Program" (Section No. 5 of ST-557, Rev. No.1) and "Validation of the LS-DYNA Drop Analyses Results with the Test Data" (Section No. 5 of ST-551, Rev. No. 2).

Please refer to SNL Report No. SAND90-2187, "An Analysis of Parameters Affecting Slapdown of Transportation Packages," and provide a justification for using 0.3 for all contact and friction values.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

As explained in the response to 2.3, Energy*Solutions*, after a considerable amount of research, developed a methodology that is capable of predicting the drop test results of a cask which is similar in geometry and mass as the 3-60B cask, viz. the VHLW cask. This methodology is documented in the proprietary document ST-551. In order that the results were conservative with respect to the prototype drop test model, analytical parameters such as the hour-glass control, damping, friction coefficient, etc., were established. Analyses were performed using these parameters consistently to show that the analysis method predicts conservative results. The same sets of parameters have been used for the 3-60B cask analyses, following the same methodology.

2.7 *Justify the material stress intensity allowable limits for the "Peak Stress" criterion.*

The material allowable stresses are listed in Table No. 2-2 and explained in Table No. 2-3 of the application. The "Peak Stress" criterion for the normal conditions of transport (NCT) and the hypothetical accident conditions (HAC) are described as a combination of the primary membrane, primary bending, secondary membrane plus bending, and secondary peak. However, stress concentrations and fatigue conditions are not applicable to NCT and HAC. Therefore, the only allowable limits of stress intensities that should be considered are the combinations of primary membrane, primary bending, and thermal expansion.

The table of allowable stresses in Calculation Package ST-504, Section No. 5.0, illustrates the applicant's use of the "Peak Stress" criterion. For NCT, allowable stresses are listed for membrane, membrane plus bending and peak. Note No. 3 of the table states that the limit on peak stress is $3S_m$. ASME Section III, Division 3, WB-3200, Figure WB-3221-1 clearly shows that $3S_m$ is the limit for primary plus secondary stress, not peak stress. Peak stress is the increment of stress added to primary or secondary stress by a stress concentration or notch. The allowable peak stress is the alternating stress intensity obtained from a fatigue curve. Calculation ST-504 evaluates the cask under drop conditions, not fatigue. The use of peak stress would only be applicable if the applicant were performing a fatigue evaluation of vibrations normally incident to transport as required in 10 CFR 71.71(c) (5).

The applicant performed a linear elastic analysis to evaluate the containment boundary under drop impact conditions. At structural discontinuities, stresses are linearized and compared to secondary stress allowables. Peak stresses are never included.

The same situation occurs for HAC when the applicant defines a peak stress based on a fatigue allowable and proceeds to use it as an allowable stress in a drop impact evaluation. A cask drop has less than one stress cycle and does not involve fatigue.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

All the references to "peak" stress have been removed from the SAR and the reference documents. The stresses are categorized as membrane, membrane + bending, and secondary stresses.

The stress summary tables in the SAR and the referenced documents ST-501, ST-502, and ST-504 have been updated.

2.8 Provide a methodology for determining and identifying the worst stress intensity levels that need to be addressed for all drop cases:

The staff noted inconsistencies in identifying the worst case stress intensity levels. The location of maximum stress intensity must be determined for all drop cases. For example, the calculated stress intensity of approximately 29,000 psi was identified in Figure No. 33 of ST-504, Rev. No. 1, as the maximum value on the inner cask shell (Item No. 13). This stress occurred at a distance greater than the shell thickness above the shell to flange intersection. However, the maximum stress is expected to occur at the shell to flange intersection and is expected to be much greater than 29,000 psi.

The staff believes that the maximum stress did not occur at the intersection because of the applicant's method of applying nodal-stress-averaging. To properly utilize nodal-stress-averaging at this location, the shell must be isolated from the flange prior to employing nodal-stress-averaging to avoid nodal results from highly stressed elements to be averaged at the same node with lower stress element results, and thereby eliminating the true maximum stress.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

In the original SAR submittal the cask was separated into various components and the stresses were evaluated based on the finite element model nodes representing those components only. No component except the bolting ring assembly, which includes portions of inner and outer shell and the skirt, had a structural discontinuity. The bolting ring assembly, because of structural discontinuity, presented the situation pointed out in this comment arose. In the present submittal, the bolting ring assembly has been separated into three sub-components, viz. bolting ring, shell extension, and the skirt. Thus there is no structural discontinuity in any of the components of the cask now reported in the summary table. <u>The stresses in each component are reported based on only the nodes representing those components in the finite element model</u>.

The stress summary tables in the SAR and the referenced documents ST-501, ST-502, and ST-504 have been updated.

2.9 Provide an element mesh convergence study for the inner shell at the intersection with the flange to demonstrate that a single element through the thickness of the shell provides accurate results.

It has been the experience of the staff that a single SOLID185 element through the thickness of a shell in a region of high moment gradient may not produce sufficiently accurate results. As an alternative to performing the convergence study on the actual cask model, the staff will accept a simple mesh convergence study of a cylindrical shell fixed at its base or attached to a thick circular plate subjected to internal pressure loading. The aspect ratio of the elements should not be any greater than that of the element at the shell to flange intersection in current model.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

The shell components of the cask have been represented in the finite element model by SOLSH190 elements - not SOLID-185 elements. The write-up in the SAR and its reference document ST-504 has been updated to clarify this.

A new document ST-608 has been provided that performs the 3-60B Cask finite element model grid convergence study. It validates the modeling techniques used for the 3-60B cask FEM. It also provides verification of the results for simple models with the theoretical values.

The ANSYS input file has been provided for all the models on electronic media. The model dimensions are clearly identified in ST-608 which can be used to independently duplicate the results.

2.10 Provide an analysis in Calculation ST-504 that considers a realistic load-path from the impact limiter through the bolt-ring-lip and into the hex-head-bolts in order to maximize the shear stresses in the bolts.

Structural Analyses of the package under drop conditions (Figure No. 19, ST-504, Rev. No. 1) – calculated the stress intensity levels at the bolt-ring-lip (item No. 6, C-002-165024-001, Rev. No. 0) reaching approximately 2.8 times the yield-strength of the bolt-ring-lip material. Due to the fact that the lip was not allowed to deform plastically, it does not appear that the impact limiter resultant loads were transferred appropriately from the bolt-ring-lip through the cask-lid-assembly (item No. 2, C-002-165024-001, Rev. No. 0) onto the hex-head-bolt(s) (item No. 5, C-002-165024-001, Rev. No. 0).

Furthermore, results from this evaluation should be incorporated into the hex-head-bolt evaluations in section No. 2.7.1.9 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

RESPONSE

It had been observed that during the side and corner drop tests of the cask the bolting ring skirt develops high local stresses. These stresses were deemed acceptable because the skirt is a non-containment boundary component and its local deformation could not prevent the cask from performing its containment and shielding function. However, it was correctly pointed-out in this comment that the excessive deformation of the skirt may cause unintended loading on the lid bolts. Therefore, a new document ST-609 has been provided which performs the evaluation of the side and corner drops conditions using inelastic ANSYS finite element models of the local region. The results of these analyses show that during these drop tests:

- the skirt will make contact with the lid over a very small region near the impact point,
- the skirt will deform inelastically,
- The stresses in the bolts near the impact location will remain within the allowable values, and,
- The skirt will undergo less than 2% elastic deformation.

The results of the evaluation of ST-609 are included in Section 2.7.1.9 of the SAR by reference.

2.11 Justify the methodology used to satisfy the lifting and tie down criteria.

2.11.1 ST-503, Rev. No. 0, "3-60B Cask Trunnion Analyses under Various Load Conditions," lifting/handling analyses do not include a dynamic load factor for load cases 1 and 2. Section No. 7.2 of ANSI Standard No. 14.6, "Radioactive Materials – Special Lifting Devices for Shipping Containers Weighing 10000 Pounds (4500 kg) or More," requires a dynamic load factor for the design of critical load lifting.

Provide an analysis using an appropriate dynamic load factor and justify the value used.

This information is required by the staff to determine compliance with 10 CFR 71.45(a).

RESPONSE

A section has been added in ST-503 that addresses the lifting condition separately. The write-up in the SAR Section 2.4 has also been updated. A dynamic load factor of 1.30 has been incorporated into the lifting evaluation. This is larger than the normally accepted impact load factor of 1.1 (ASME NQA-1) and 1.15 (ASME NOG-1). The user of the cask has to perform an evaluation based on his/her crane characteristics to obtain the dynamic load factor and ensure that it is less than 1.30 in order to use this cask.

2.11.2 10CFR71.45(b)(1) requires that a static force, acting at the center of gravity of the package, with components of 2g vertical, 10g in direction of travel, and 5g transverse be analyzed. ST-503, Rev. No. 0 applies these loads as three separate conditions and the combination due to these three forces was not considered as required.

Provide an analysis for the combined system of forces such that maximum reactions at each support are achieved.

This information is required by the staff to determine compliance with 10 CFR 71.45(b).

RESPONSE

A load case that evaluates the trunnions with the three loads corresponding to the 10g, 5g and 2g, applied simultaneously, has been evaluated and added to ST-503 document. The write-up in the SAR has also been updated.

2.12 Correct the information regarding the EnergySolutions Quality Assurance program.

Section No. 2.3 of the application states the following: "EnergySolutions will apply its USNRC approved 10CFR71 Appendix B Quality Assurance Program, which implements a graded approach to quality based on a component's or material's importance to safety…." Please note that there is no 10CFR71 Appendix B QA program.

This information is required by the staff to determine compliance with 10 CFR 71 Subpart H.

RESPONSE

Section 2.3 has been revised to state "Energy*Solutions* will apply its USNRC approved 10CFR71 Subpart H Quality Assurance Program…"

Chapter 3 – Thermal Evaluation

3.1 Correct the mass fraction of water in the calculations of hydrogen generation for both irradiated hardware and dewatered swarf.

The applicant calculates the mass fraction of water F_w by excluding the water mass from the total mass in the cask, but includes the water volume in the calculation of void volume, VOID, for both irradiated hardware and dewatered swarf in Attachment 3B of the application. The applicant is required to correct the equation for the mass fraction of water from $F_w = M_w / (M_L + M_H)$ to $F_w = M_w / (M_L + M_H + M_w)$, to make both the mass fraction calculation and the void volume calculation consistent.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE

The corrections have been incorporated. The examples have been removed from Chapter 3 and are now found only in Chapter 7.

3.2 Provide the basis for the determination that 2 gallons of water remaining in the cask cavity, after the cask is drained, is a conservative assumption for the evaluation of hydrogen generation.

The applicant assumes that the grooves in the cask cavity base and the drain port have a combined volume of less than 0.02 gallons after the package is drained. The applicant estimates a volume of 2 gallons if any additional water remains on the base to a depth of 0.5 inch, and then uses a total of 4-gallon water for the determination of hydrogen generation in the package containing irradiated hardware waste form.

The applicant is required to (i) validate the assumption that there are 2 gallons of water remaining in the cask cavity for hydrogen generation after the package is drained, and (ii) demonstrate that such assumption is conservative for the analysis (see also RAI No. 7.1).

This information is required by the staff to determine compliance with 10 CFR 71.35. and 71.43(d).

RESPONSE

Energy*Solutions* is confident that the design of the cask will result in very little water being retained in the cavity after draining. To ensure no more than 2 gallons of water is retained after draining, the following acceptance criterion is added to the acceptance requirements of Chapter 8:

> No more than 2 gallons of water may be retained in the cask cavity and drain port when the cask sits vertically on an essentially horizontal flat surface.

A test to demonstrate is meet has been added as 8.1.8. This acceptance criterion validates the assumption that no more than 2 gallons of water is retained in cask cavity.

Since the amount of hydrogen generated is directly proportional to the amount of water available for irradiation, see Eqns. 3-2 and 3-3 of Chapter 3 of the SAR, the use of 4 gallons of water in the irradiated hardware example gives a conservative value for the decay heat limit.

3.3 Correct the maximum normal operating pressure (MNOP) for a hot-day case with the ambient temperature of 100ºF.

The applicant used a cavity gas temperature of 225ºF in the calculation of the MNOP for a hot-day case with the ambient temperature 100°F, which is inconsistent with the maximum cavity temperature of 227.3°F listed in Table 3-3 of the application. The applicant is required to correct the MNOP with the exact cavity gas temperature from Table 3-3 for a hot-day case.

This information is required by the staff to determine compliance with 10 CFR 71.35, and 71.71.

RESPONSE

The correction has been made and incorporated into the revised Chapter 3.

3.4 Explain why the fire shield temperature (1331ºF), as reported in Table No. 3-1 and illustrated in Figure No. 3-8 of the calculation package TH-023, is significantly less than the ambient air temperature (1475ºF) during the fire transient for 30 minutes for HAC thermal analysis of the Model No. 3-60B package.

During the HAC fire test for the Model No. 3-60B package, staff found out that the fire shield temperature was reported as 1331ºF when the ambient temperature the package is exposed to is 1475°F. Figure No. 3-8 of the calculation package TH-023 indicates that the fire shield and inner shell temperature rises to 1331ºF, while the outer shell temperature rises to 353.3°F, a difference of almost 1000ºF. The NCT model results seem to indicate that there is little to no temperature gradient across the fire shield, outer shell and inner shell of the package, which would not be anticipated for this type of design. A detailed explanation on why the temperature is significantly below the fire temperature of 1475ºF should be provided.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

RESPONSE

The 3-60B cask fire shield is connected to the cask body in such a way that it provides an air gap between the cask body and itself. During the hypothetical fire test, the air gap provides a thermal barrier which impedes the transfer of heat from the fire-shield to the cask. The transfer of heat from the fire source to the cask takes place by a combination of two phenomena - radiation and forced-convection. The total heat-flow rate to the cask is a function of resistance provided by the air gap and the equivalent resistance of the radiation heat transfer between the fire shield and the cask outer shell. A large resistance will reduce the heat transfer rate and it will take a long time for the fire-shield to attain the same temperature as the fire environment.

The finite element model of the 3-60B cask appropriately incorporates both these heat transfer phenomena. The air-mass resistance has been incorporated by temperature dependent conductivity and radiation heat transfer has been incorporated by the referenced text book formula (Holman; Reference 3-2 of the SAR). ES, therefore, believes that the temperature predicted by the finite element model, i.e. 1331ºF is a reasonable result, which should be expected during the HAC fire test.

3.5 Provide clarification for the maximum allowable temperature of the seals listed in Table Nos. 3-1 and 3-2 of the application.

Section 3.2.2 of the application states that the seals are specified to be elastomer, 50 – 70 Durameter, temperature range of -40°F to 350°F. Table No. 3-1, "Summary of Maximum NCT Temperatures" and Table No. 3-2, "Summary of Maximum HAC Temperatures", list the maximum allowable temperature of the seals as 450°F, which is higher than the maximum specified in Section 3.2.2.

The applicant should clarify this discrepancy and specify a reference for the seal's maximum temperature.

This information is required by the staff to determine compliance with 10 CFR 71.43, 71.71 and 71.73.

RESPONSE

The maximum allowable temperatures listed in Tables 3-1 and 3-2 have been corrected to 350°F, which is consistent with Section 3.2.2 and the thermal analysis results shown in Tables 3-1 and 3-2 for the seals.

3.6 Clarify how the impact limiters affect the flow of heat into the package in the HAC model.
Section 5.0 of the calculation package No. TH-022 states that (i) the impact limiters are not modeled, (ii) the impact limiters support plates are modeled and, (iii) the outer surfaces of the impact limiter plates are not covered by foam but are considered to be totally insulated.

It is not clear how the heat migrates into the package through the impact limiter plates
during the HAC fire.

This information is required by the staff to determine compliance with 10 CFR 71.73.

RESPONSE

The calculation package TH-022 covers the NCT not the HAC fire. The HAC fire package is TH-023. Assuming that the comment, "*It is not clear how the heat migrates into the package through the impact limiter plates during the HAC fire*", pertain to TH-023; the ES response to this comment is as follows.

The heat input to the 3-60B Cask during the HAC fire is described in Section 3.0 of the SAR as follows.

"For the HAC fire the foam of the impact limiters is conservatively assumed not to provide any thermal insulation. In the structural analyses of the HAC drop and puncture drop conditions, it has been shown that after these tests, the casing of the impact limiter will be intact and remain attached to the cask body. Therefore, it is assumed that the fire directly hits the two ends of the cask through the 1/2" plate that form the casing of the impact limiters, in addition to the entire length of the fire-shield."

TH-023 mentions the above heat input process in various sections (e.g. radiation and forced convection). For more clarification the above paragraph will be added in Section 5.0 of TH-023.

3.7 Provide an analysis of the HAC fire with a radiation emissivity of 0.9 and an ambient temperature of 1475°F.

In the Calculation Package TH-023, the applicant assumes the emissivities of the fire shield and the environment to be 0.8 and 0.9 respectively, and derives an overall emissivity of 0.7347 by equation for radiation heat transfer between the fire shield and the environment.

10 CFR 71.73 requires a flame emissivity of at least 0.9 provided in the test when the specimen is fully engulfed in the fire, and a package surface absorptivity of at least 0.8 used in the calculation when the package is fully exposed to the fire.

To ensure package safety and compliance with 10 CFR 71.73, the model should implement the following requirements:

a) A package surface absorptivity of 0.8 or greater and an ambient temperature of 1475°F should be used in a 30 minute HAC fire calculation,

b) A uniform internal heat loading should be used for the temperature of the waste component.

c) The rest of the package calculation setups should remain the same as those in TH-023 for a 30-minute fire and its cool down (post-fire) phase.

An update of the calculation package TH-023 with new data, tables, and plots of HAC fire, including maximum material/component temperatures, maximum temperature difference through-wall results, nodal temperature distributions, and temperature transients of fire shield, O-ring, lead gamma shield, cavity bulk air, and inner and outer steel shells should be provided in responding to this RAI.

This information is required by the staff to determine compliance show compliance with 10 CFR 71.33 and 71.73.

RESPONSE

TH-023 in Section 5.3 (Radiation Modeling) includes the following paragraph.

"The regulations (Article 71.73 of Reference 2) require that an average environment emissivity coefficient of 0.9 must be used for HAC fire test. It also requires that for purpose of calculation, the surface absorptivity coefficient must be either that which the package may be expected to possess if exposed to fire specified or 0.8, whichever is greater. It is conservatively assumed in the analyses that the package has an absorptivity of 1.0. Therefore, an emissivity coefficient of 0.9 has been conservatively specified for all the elements that radiate heat to the environment. Form factor value of 1.0 is used and the area of the surface is automatically calculated by the computer program."

Therefore,

a) The HAC fire analysis uses surface absorptivity of 0.9 which is larger than that requested in this comment. The ambient temperature of 1475°F has been used in the analysis (see Section 6.0 of TH-023).

b) Uniform internal heat loading has been used in the analyses. To envelop the maximum temperature on the cask inside wall surface as well as that on the waste container, ES has gone a step further than requested in this RAI. The waste has been simulated in two different ways (1) implicit internal heat load modeling, and (2) explicit internal heat load modeling. Please see Sections 5.5.1 and 5.5.2 for the detailed description of these simulations.

c) Since (a) and (b) are already addressed in the analyses, (c) does not apply.

Thus no updating of the analyses performed in TH-023 is needed. All the results requested in this RAI have been provided in TH-023. For reference their location is identified below.

Maximum material/component temperatures: Table 7.1 of TH-023 & Table 3-2 of the SAR.

Temperature transient of the requested components: Figures 9 & 10 of TH-023 and Figures 3-10 & 3-11 of the SAR.

Temperature transients of the cavity bulk air and waste: Figure 18 of TH-023

Nodal temperature distribution in the cask body at various time instants: Figures 11 through 17, Figure22 of TH-023 and Figures 3-12 of the SAR.

Nodal temperature distribution in the waste container: Figure 21 of TH-023.

Chapter 4 – Containment Evaluation

4.1 Determine how the containment seal will be characterized as an equivalent to the Parker Lock-O-Seal critical characteristics.

Section 4.1.1 of the application states that a socket head cylindrical rod is threaded into the exterior opening to shut the drain port during transport. The cylindrical rod is torqued shut and sealed tight with a Parker Lock-O-Seal (or its equivalents).

The evaluation of an equivalent seal to the Parker Lock-O-Seal should be based on the critical characteristics of a seal in (i) low temperature performance, (ii) high temperature performance under NCT, (iii) high temperature performance under HAC, (iv) dimensional tolerance, (v) hardness, (vi) permeability, (vii) radiation resistance, and (viii) environmental (corrosion) resistance.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.51.

RESPONSE

The seal was incorrectly identified as a "Lock-O-Seal". It has been changed to a Parker Stat-O-Seal which has no market equivalent. As such "or equivalent" has been removed.

4.2 Clarify the pre-shipment leak test statement provided for LSA contents or for fissile contents which are exempted from classification as fissile material.

The applicant describes the package contents in Section No. 1.2.2 of the application and specifies in Section No. 4.5 that "the pre-shipment leak test is not required for contents that meet the definition of low specific activity material or surface contaminated objects in 10 CFR 71.4 and also meet the exemption standard for low specific activity material and surface contaminated objects in 10 CFR 71.14(b)(3)(i)."

The applicant is required to clarify if LSA, SCO, or exempt materials are requested as authorized contents and if other leak testing procedures should apply.

This information is required by the staff to determine compliance with 10 CFR 71.4, 71.14(b)(3)(i), 71.15, and 71.51.

RESPONSE

The pre-shipment leak test statement provided for LSA and SCO contents is essentially identical to condition 10(a) added to the Model 10-160B CoC in Revision 3 to the CoC issued January 10, 2000; and revised with Revision 10 in May 2005 due to changes in numbering in Part 71 when Part 71 was revised in 2004. The SER issued with Revision 3 stated "The above text clarifies that leak testing is required for all shipments except LSA material and SCO that also meet the exemption standard in 10 CFR 71.10(b)(2). Shipments of LSA material and SCO meeting the exemption standard do not require a pre-shipment leak test. This is consistent with the requirements for shipment of other low level radioactive material under the provisions of 49 CFR 173.427(b)(5)."

The requested contents of the 3-60B cask may include LSA material or SCO that meet the external dose rate limit in 10 CFR 71.14(b)(3)(i).

4.3 Provide a description of the materials characteristics of R-134a halogen gas to prove its suitability as a tracer gas for leak testing.

The applicant states in Section No. 4.5 and Table No. 4.2 of the application that the fabrication, maintenance, and periodic leakage tests may be performed using helium, R-12 halogen, and R-134a halogen, as tracer gases, and that the corresponding acceptance criteria are adjusted for the individual properties of each tracer gas.

The staff needs more detailed information on the characteristics of the R-134a halogen gas to document its suitability as test gas for leak testing.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.51.

RESPONSE

Information on the characteristics of R-134a halogen gas is attached.

4.4 Provide descriptions of (1) the characteristics of the cavity filler material, (2) the corresponding installation procedures, and (3) the materials suitable as filler materials in the leak test.

The applicant states in Section No. 4.5 of the application that some of the volume of the cavity may be temporarily filled with cavity filler material in the periodic leak tests for the closure lid and vent port to reduce the volume of tracer test gas required to conduct the tests.

The application shall include (1) the characteristics of this cavity filler material, (2) the related installation procedures, and (3) the list of the filler materials to ensure that the filler material will not interact with or be penetrated by the test gases (helium, R-12, and R-134a) and will not thermally expand to cover the drain opening during the leak tests.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.35, and 71.43(d).

RESPONSE

A sealed right circular metal canister will be used to partially fill the cask cavity during the periodic leak test. The canister will have standoff appendages to ensure the drain opening is not obstructed. The metal must be chemically compatible with the cask liner and the test gases. Installation of the can has been included in the test instructions of Chapter 8.

4.5 Explain (a) the difference between the backfill pressures of helium and R-12/R-134a of the leak test, and (b) if the pressurization to 1 psig for helium in the leak test is sensitive enough for leak test.

The applicant describes test procedures, in Section No. 4.5 of the application, for the maximum allowable leak rates. The package void is first evacuated to 20" Hg vacuum for each tracer gas, and then pressurized to 25 psig for both R-12 and R-134a, or 1 psig for helium.

The demonstration that the backfill pressure of 1 psig is sensitive enough for the helium test gas in the leak test should be included in the application.

This information is required by the staff to determine compliance with ANSI N14.5 and 10 CFR 71.51.

RESPONSE:

The backfill pressures are different for the halogen test gases (R12 and R-134a) and helium to allow sufficient sensitivity in the test measurement. The mass-spectrometer used for helium detection is much more sensitive than a halogen detector. A mass-spectrometer is capable of detection of leak rates of 10^{-8} cm^3/sec (as noted in ANSI 14.5), which is much lower than the required sensitivity for the helium leak test, shown in Figure 4.14 of Section 4.5, which was calculated from a backfill pressure of 1 psig.. The less sensitive halogen detectors require a higher backfill pressure so that the sensitivity requirements can be met.

In developing the responses to questions concerning Section 4.5, we noted that the test sensitivity for the halogen measurements was near the lower limit of available instruments. To ensure adequate measurement sensitivity, the test conditions were changed, i.e., the halogen backfill pressure was increased to 42 psig, resulting in a higher leak test limit and required sensitivity. These changes are reflected in the revised Chapter 4, Sections 4.5.1 and 4.5.2, provided with the RAI response.

4.6 Provide a derivation for the equations relative to the allowable test leakage and allowable test leakage sensitivity as a function of temperature for the tracer gases used in the leak test.

The applicant is required to provide the derivations of allowable test leakage rate and allowable test leakage sensitivity for the tracer gases of helium, R-12, R-134a, helium/air mixture, R-12/air mixture and R-134a/air mixture, to their final forms as a function of the temperature only, in Section Nos. 4.5.1, 4.5.2, and 4.5.3 of the application. Such derivations are needed for the staff to confirm the validity of Figure Nos. 4.4 through 4.14 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.51.

RESPONSE

The equations for test leakage and test sensitivity are taken from ANSI N14.5 – 1997. The Section 4.5 was revised to include notes indicating the equations that were taken from ANSI 14.5 as had been provided for Sections 4.2 and 4.3 in the previous revision.

4.7 Provide the calculations to determine the charge time, H, of the vent port and the drain port in the leak test.

The application should provide the data of dimensions used to calculate the volume of the annulus for the vent port (4.1 cm^3) and the volume of drain port cavity (21.9 cm^3) which help determine that a volume of 31.6 cm^3 used in the Equation B.14 of ANSI N14.5 is more conservative for the determination of the charge time in the leak test.

The application should also provide all parameters used in the calculation to determine the charge time of 12.2 minutes on the vent port and the drain port leak tests.

This information is required by the staff to determine compliance with ANSI N14.5, 10 CFR 71.35, and 71.51.

RESPONSE

The calculations for the determining the charge time for the vent and drain port have been included in Chapter 4, Section 4.5.4.

Chapter 7 – Operating Procedures

7.1 Provide a description of the container dewatering process during wet loading.

The applicant only delineates in Section No. 7.1.2.4.c of the application that one should "leave the cask suspended and allow water to drain from the cavity."

The description of the container dewatering process under wet loading should address details such as vacuum pump operation, valve operation, measurement of cavity pressure, backfilling of helium, and other required operations for the container dewatering process.

This information is required by the staff to determine compliance with 10 CFR 71.85 and 71.87.

RESPONSE

The process for using the 3-60B cask when loaded underwater requires that the cask cavity be drained to the extent practical after removal from the pool. This is accomplished by suspending the cask over the pool with the vent and drain port open until no water is visible exiting the drain port. Vacuum drying or inert gas backfilling is not required. Step 7.1.2.4 has been revised to include waiting until no water is visible exiting the drain port.

7.2 Revise Attachment No. 7.1 to be a stand-alone procedure in Chapter 7.0 "Package Operations" for package users to determine the flammable gas concentration for the authorized contents.

The applicant develops a method for the determination of the hydrogen generation to ensure that the flammable gas concentration does not exceed a limit *of 5%, and describes this method in Chapter 3.0 and Attachment No. 7.1 of the application.*

The applicant is required to revise Attachment 7.1 as a stand-alone procedure for package users to determine the void fraction (Fv), the mass fraction of water (Fw), and the allowable decay heat load (Q) for the loaded contents.

The procedure should instruct users for categorizing the contents (irradiated hardware, powder solids, etc.), listing all parameters/values used in the calculations and applying the appropriate formulas for determining F_v, F_w and Q, as generally described in Section 3.3.2 and the current examples in Attachment No. 7.1 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.33, 71.35, 71.43(d) and 71.87.

RESPONSE

Attachment 7.1 has been revised to include a step-wise process for determining the decay heat limit. The user of the package determines volumes and masses based on configurations of the packaged material and engineering evaluations, which would be performed under the users NRC authorized QA program. The process is invariant with the physical form of the contents of the secondary container, i.e., the process is the same for irradiated hardware, dewatered particulate material (swarf or ion-exchange resin) or solidified material. An additional example, solidified material, has been added. The examples are not intended to be all-inclusive but to provide the user guidance in applying the process provided in Attachment 7.1.

7.3 Clarify how the water content and density of the dewatered swarf are determined for the evaluation of hydrogen generation.

Attachment No. 7.1 of the application mentions that the swarf, contained in a sealed steel liner, is dewatered to 1% of the waste volume and has a density of 4.0 g/cc for the evaluation of hydrogen generation. The applicant is required to clarify how the water content and density of the swarf are determined for the calculations.

This information is required by the staff to determine compliance with 10 CFR 71.35 and 71.43(d).

RESPONSE:

The water content of waste materials like swarf and ion-exchange resin is governed by disposal site requirements in accordance with U.S. NRC Waste Form Technical Position, Rev.1, January 24, 1991 and determined in accordance with the generator's Process Control Program (PCP), as described in ANSI/ANS-55.1-1992, Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants, Section 9. Operation and Maintenance.

The density of swarf can be determined by measurement or estimated by calculation. The text of the example is revised to indicate the density was determined by measurement.

7.4 Provide clarification that an empty package would comply with 49 CFR 173.443 and properly describe the package's closure requirements.

Section 7.3 of the SAR lacks a description of the package's closure requirements. In addition, an explanation demonstrating compliance with 49 CFR 173.443 is not provided.

This information is required by the staff to determine compliance with 10 CFR 71.87 and 49 CFR 173.443.

RESPONSE:

Section 7.3 has been revised to provide more detail as follows: (Note that the requirement to comply with 49 CFR 173.428 is retained from the previous version; 49 CFR 173.428 requires compliance with 49 CFR 173.443(a) as well as many other sections of 49 CFR 173, which are not specifically cited).

7.3 PREPARATION OF AN EMPTY PACKAGE FOR TRANSPORT

7.3.1 Preparation

7.3.1.1 Confirm the cavity is empty of contents are far as practicable
7.3.1.2 Survey the interior; decontaminate the interior if the limits of 10 CFR 428(e) are exceeded
7.3.1.3 Install the lid.
7.3.1.4 Install the lid closure bolts. Torque all bolt to 300 ft-lbs.
7.3.1.5 Re-install the vent and drain port plugs with their O-rings and seals. Torque the drain and vent port bolts to 20 ft-lbs.
7.3.1.6 Decontaminate the exterior surfaces of the cask as necessary.
7.3.1.7 Inspect the exterior and confirm it is unimpaired.
7.3.1.8 Attach lifting and handling equipment to the cask lifting trunnions, move the cask to the conveyance loading area, and mount the cask in its shipping cradle on the transport trailer.
7.3.1.9 Install the impact limiters.
7.3.1.10 Attach the tamper-indicating seals.
7.3.1.11 Confirm the requirements of 49 CFR 173.428 are met.

7.3.2 Special Preparations

No special preparations or procedures are required for transporting the 3-60B empty.

Chapter 8 – Acceptance Tests and Maintenance Program

8.1 Specify the backfill pressures for the tracer gases of helium/air, R-12/air, and R-134a/air mixtures used in the leak test.

The applicant calculates the allowable test leakage rates of the test gases using a test pressure of 20" Hg for helium and helium/air mixture (air, 30.8%), and a test pressure of 25.0 psig for R-12, R-134a, R-12/air mixture (air, 12.2%), and R-134a/air mixture (air, 12.2%) in Section No. 4.5 of the application, but only specifies the required backfill pressures of helium, R-12, and R-134a in Section No. 8.1.4 of the application. The applicant is required to document the backfill pressures of the tracer gases of helium/air mixture, R-12/air mixture, and R-134a/air mixture in Leakage Tests of Section No. 8.1.4.

This information is required by the staff to determine compliance with ANSI N14.5 and 10 CFR 71.51.

RESPONSE:

As stated in 8.1.4 and summarized in Table 8.1, the cavity is evacuated to 20" Hg vacuum and then backfilled with the test gas until a specified cavity pressure is reached. Since 20" Hg is only a partial vacuum, air will still fill the cavity at this reduced pressure. Introducing the test gas into the partially evacuated cavity creates an air/test gas mixture, which will have the specified pressure, e.g., 42 psig for R-12 test gas, when backfilling is completed. The specified backfill pressure is the pressure of the air/test gas mixture, not the pressure of the test gas.

8.2 Provide a justification for the omission of thermal and maintenance acceptance tests from the Acceptance Tests portion of the application, or revise the application to include a thermal acceptance test.

In Section No. 8.1.7 of the application, the applicant states that no thermal acceptance testing would be performed on the packaging and refers to Chapter 3 of the application. The thermal acceptance test of a package provides an indication of the quality and accuracy of manufacturing and the thermal evaluation of the package. An adequate justification should be provided if no tests are to be performed. The justification should consider uncertainties in calculations, fabrication, accuracy, and the influence of gaps in heat transfer performances, thermal margins, and package aging.

This information is required by the staff to determine compliance with 10 CFR 71.93(b).

RESPONSE:

The sophisticated thermal analyses performed on the 3-60B are a more than adequate substitute for thermal testing. The materials of construction, i.e. stainless steel and lead, are not subject to a change in material properties due to aging that would affect heat transfer performance. Thus, no heat transfer testing is performed in the maintenance program.

8.3 Revise Section No. 8.2.2.1 of the application as a stand-alone procedure in instructing the user to perform appropriate maintenance and periodic leak tests.

The procedure should combine/arrange the leak test information displayed in Figure Nos. 4.1 through 4.3 (Periodic Leak Tests for Lid, Vent Port, and Drain Port), Figure Nos. 4.7, 4.11, and 4.14 (Allowable Test Leakages), and Table No. 8.1 (Periodic Leak Test of 3-60B) of the application, and then revise Section No. 8.2.2.1 (Periodic Leak Test in Maintenance Program) in a way that specifies the maintenance and periodic leak test steps in a sequential order.

The procedure should also specify the critical criteria of each tracer gas, and ensure that the cask user performs appropriate leak tests in accordance with ANSI N14.5.

This information is required by the staff to determine compliance with 10 CFR 71.85 and 71.87.

RESPONSE:

Section 8.2.2.1 refers to Section 8.1.4 for the performance of the periodic leak test. Section 8.1.4 is revised to specify the leak test steps in a sequential order, require the use of pure test gas, and require use of a test method meeting ANSI N14.5.

Designation: F 501 – 93

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St. Philadelphia, Pa 19103
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If not listed in the current combined index, will appear in the next edition.

Standard Test Method for Aerospace Materials Response to Flame, With Vertical Test Specimen (For Aerospace Vehicles Standard Conditions)[1]

This standard is issued under the fixed designation F 501; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is intended for use in determining the resistance of materials to flame and glow propagation when tested in accordance with 12 and 60-s ignition. It is used for evaluating materials or constructions used in the interiors of aerospace vehicles but may be utilized in other applications as specified in applicable procurement and regulatory documents. In addition to the vertical position of the test specimen and flame exposure conditions common to tests of this type, this test method also defines gas composition, burner, cabinet, temperature and humidity, and test conditions since it is designated for interlaboratory testing of similar materials or constructions. This test is designed for use in air atmosphere at standard temperature and pressure.

1.2 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

1.3 The values stated in inch-pound units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Apparatus

2.1 Tests shall be conducted in a draft-free cabinet fabricated in accordance with requirements specified in Figs. 1, 2, 3, and 4. Galvanized sheet metal, 0.040 in. (1 mm) thick, (see Note 1), shall be used for the bottom surface of the chamber holder to accommodate specimens up to 1 in. (25 mm) thick. The specimen holder shall also be of corrosion-resistant metal. The entire inside back wall of the cabinet shall be painted black to facilitate the viewing of the test specimen and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces.[2]

NOTE 1: Warning—It is suggested that the cabinet be located inside an exhaust hood for clearing the cabinet of smoke after each test.

2.2 *Burner*,[3] having a ⅜-in. (10-mm) inside diameter barrel, shall be equipped with a needle valve to adjust the flame height.

2.2.1 The necessary gas connections and the applicable plumbing shall be essentially as specified in Fig. 3. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2½ ± ¼ psi (17 ± 2 kPa) at the burner inlet shall be installed between the gas supply and the burner.

2.2.2 There shall be a flame indicator spaced 1 in. (25 mm) from the barrel and extending above the burner. The indicator shall have a prong, 5/16 in. (8 mm) in length, marking the distance of 1½ in. (38.1 mm) above the top of the burner. (See Fig. 4.)

2.2.3 The burner shall be positioned so that the center of the barrel of the burner is under the vertical face of the lower surface of the specimen regardless of specimen thickness. See Fig. 5. For this purpose, the bottom of the chamber shall possess a method of guiding the burner to stop directly under the specimen and also be capable of being removed at least 3 in. (76.2 mm) from the specimen.

2.3 Methane gas of 99 % minimum purity natural gas, or propane shall be used for the burner fuel.

NOTE 2—Ninety-nine percent minimum purity methane is preferred. If this gas is not available, natural gas, commercial grade (90 % methane) or better, or propane may be used.

2.4 *Stop Watch* or other device, calibrated and graduated to measure the time of application of the burner flame, flame time, glow time, and drip flaming time.

2.5 *Scale*, in 0.1-in. (1-mm) graduations, to measure the burn length.

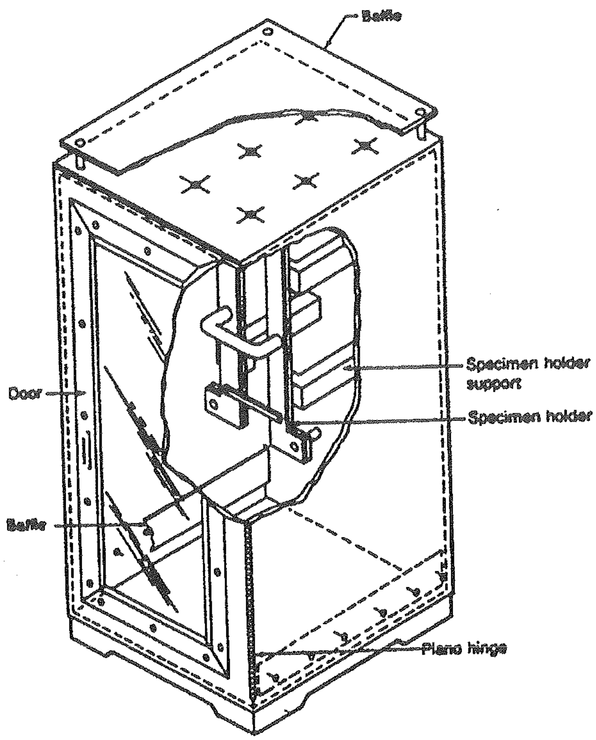
3. Test Specimens

3.1 The specimen shall be a rectangle at least 2¾ by 12 in. (70 by 305 mm) with the long dimension in the vertical position. Materials shall be tested either as a section cut from a fabricated part as installed in the vehicle or as a specimen simulating a cut section, such as a specimen cut from a flat

[1] This test method is under the jurisdiction of ASTM Committee F-7 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.06.
Current edition approved Jan. 15, 1993. Published April 1993. Originally published as F 501 – 77. Last previous edition F 501 – 88.

[2] A test chamber of the type described, manufactured by U.S. Testing Co., 1415 Park Ave., Hoboken, NJ 07030, Atlas Electric Devices Co., 4114 N. Ravenwood Ave., Chicago, IL 60613, and The Gormark Organization, Inc., P.O. Box 807, Bellmore, NY 11710 has been found suitable.

[3] A burner available as Catalog No. R3726A from Rascher & Betzold, Inc., 5410 N. Damen Ave., Chicago, IL 60625 has been found suitable.



NOTE—The specimen holder may be positioned so that the specimen faces the door.

FIG. 1 Vertical Bunsen Burner Test Cabinet

sheet of material or a model of the fabricated part. The specimen may be cut from any location in a fabricated part; however, fabricated units, such as sandwich panels, shall not be separated for testing. The specimen thickness shall be no thicker than the minimum thickness to be qualified for use in the vehicle except that (*1*) thick foam parts, such as seat cushions, shall be tested in ½-in. (13-mm) thicknesses, and (*2*) for materials used in small parts that shall be tested, the generic material shall be tested in no more than ⅛-in. (3-mm) thicknesses. (See Note 3.) In the case of coated and uncoated textiles, both the warp and fill direction of the weave must be tested. When performing the tests, the specimen shall be mounted in a metal frame so that the two long edges are held securely. The exposed area of the specimen shall be 2 in. (1 mm) in width and 12 in. (304 mm) in length. At least three specimens shall be tested.

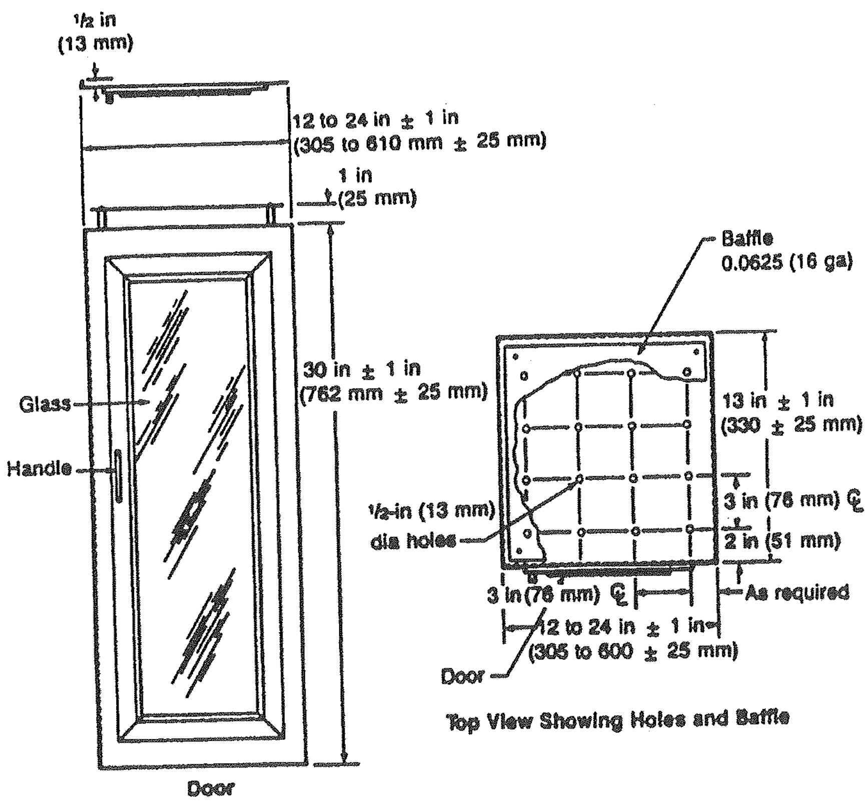
NOTE 3—Foams with skins shall have specimens cut with the skin on one face. For foams without skins, specimens shall be cut from the center of the foam bun.

4. Conditioning

4.1 Condition specimens to 70 ± 5°F (21 ± 3°C) and at 50 ± 5 % relative humidity for 24 h minimum. Remove only one specimen at a time from the conditioning environment immediately before being tested.

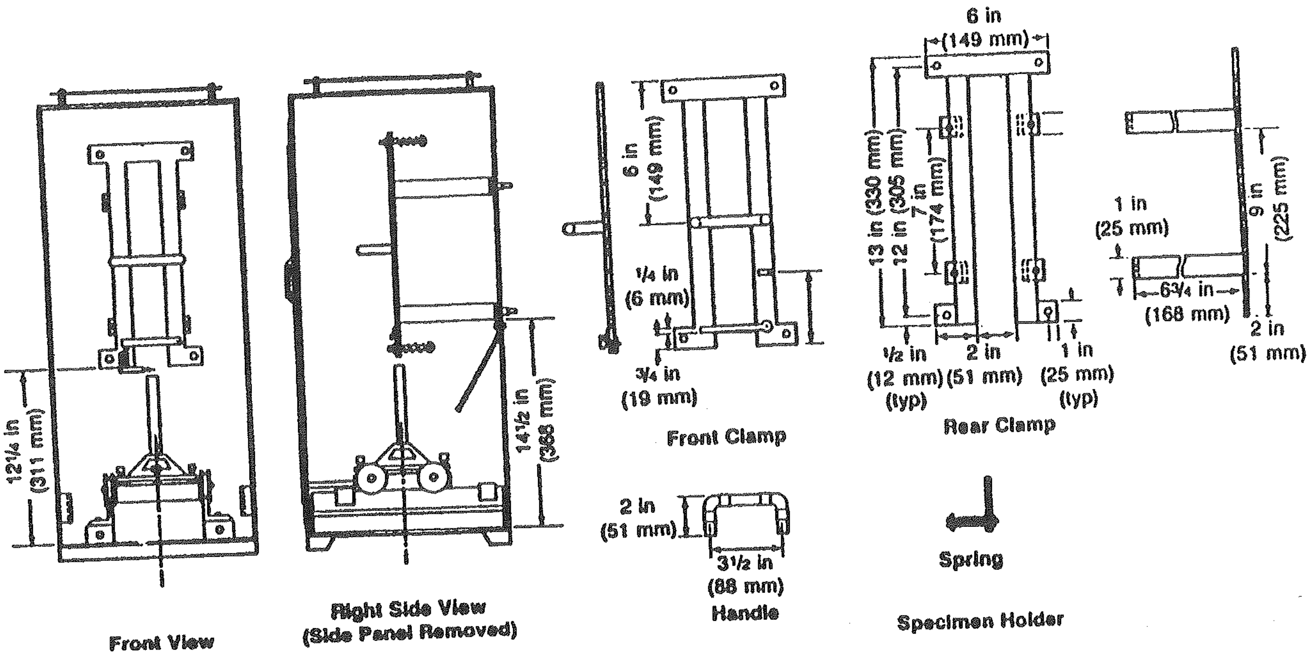
5. Procedure

5.1 Use a flame temperature indicator with 24-gage chromel-alumel bare wire (thermocouple) with a suitable



NOTE—See Table X1.1 for SI equivalents.

FIG. 2 Front and Side View of Bunsen Burner Test Cabinet



NOTE—See Table X1.1 for SI equivalents.

FIG. 3 Vertical Bunsen Burner Test Specimen Holder

recorder to measure actual flame temperatures (minimum 1550°F).

5.2 Evaluate the material undergoing testing for the characteristics specified in the applicable procurement or regulatory document; that is, flame time, glow time, drip flaming time, and burn length on each specimen as applicable.

5.3 Expose each specimen to be tested to the test flame as defined in Section 4.

5.4 Prior to inserting the specimen, adjust the burner flame as follows:

5.4.1 Shut off the air supply to the burner.

5.4.2 Open the stopcock in the gas line fully.

5.4.3 Light the burner.

5.4.4 Adjust the needle valve to give a flame height of 1½ in. (38 mm) with the uppermost portion (tip) of the flame level with the tip of the metal prong (see Fig. 4) specified for the adjustment of flame height.

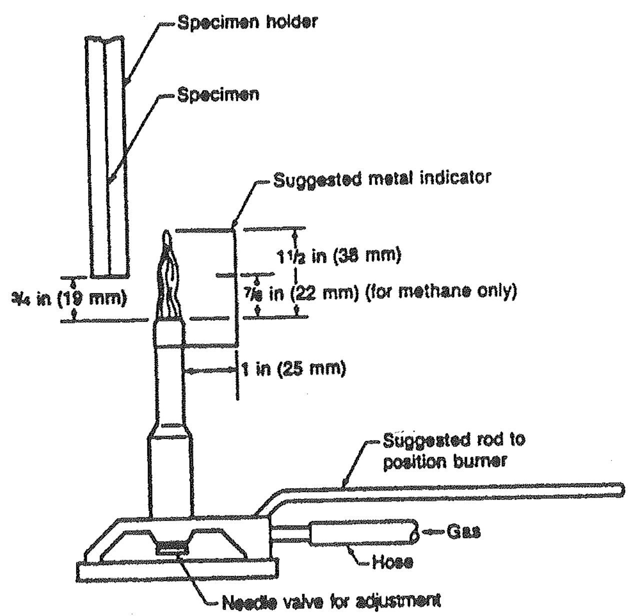
5.5 Insert the specimen and suspend it vertically with its lower edge ¾ in. (20 mm) above the top of the burner and close the cabinet door. Start the timer and simultaneously position the burner so that the flame is applied as defined in 2.2.3 for a period of time as required by the applicable material specification. The cabinet door shall remain shut during testing. Move the burner a minimum of 3 in. (76.2 mm) away from the specimen at the end of the exposure period.

5.6 The flame time shall be the time in seconds that the specimen continues to flame after the burner is removed from under the specimen. Determine the flame time and record.

5.7 The glow time in seconds shall be the time the specimen continues to glow after it has ceased to flame. Remove the specimen and record the glow time.

5.8 The drip flaming time shall be the time in seconds that any dripping material continues to flame after dripping to the floor of the chamber. Record this drip flame time. If there is more than one drip, record the longest drip flame time. However, if succeeding drips reignite earlier drips, then record the total flame time.

5.9 After each specimen is removed, clear the test cabinet of fumes, drips, and smoke and clean the window if required



NOTE 1—The burner does not need to be resting on the cabinet bottom, but it is considered more convenient in this mode.

NOTE 2—See Table X1.1 for SI equivalents.

FIG. 4 Burner Plumbing and Burner Flame Height Indicator

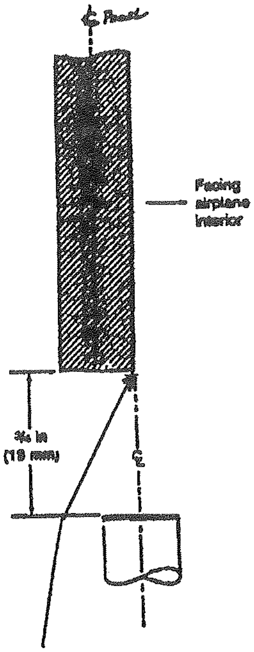


FIG. 5 Flame position on vertical specimens

prior to testing the next specimen.

5.10 After both flaming and glowing have ceased, measure and record the burn length. The burn length is the distance from the original specimen edge to the farthest evidence of damage to the test specimen due to that area's combustion, including areas of partial consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored, nor areas where material has shrunk or melted away from the heat. Do not include damage due to mechanical delamination or splitting of the specimen in the burn length. Use a moderate solvent to remove soot and stainparticles from tested specimens. Do not use any solvent that dissolves or attacks the specimen material.

6. Report

6.1 Fully identify the material tested, including thickness. Report the flame application time and specification requirements.

6.2 The flame time, glow time, drip flaming time, andburn length of the sample unit shall be the average of the results obtained from the individual specimens tested. Record all values obtained from the individual specimens including a statement as to whether the specimen dripped.

6.3 Report the flame time to the nearest 0.2 s, and the glow and drip flame time to the nearest 1 s. Report the burn length to the nearest 0.1 in. (2.5 mm).

7. Precision and Bias

7.1 Each testing agency has the responsibility of judging the acceptance of its own results. The precision of the results is a function of the procedures and equipment utilized as well as compliance to the applicable materials specification.

7.2 As soon as sufficient data have been obtained, a more definitive statement on precision and bias will be included.

APPENDIX

(Nonmandatory Information)

TABLE X1.1 Metric Equivalents for Figs. 2, 3, and 4

in.	mm	in.	mm	in.	mm	in.	mm
0.0625	1.6	1	25.4	8½	216	14	356
⅛	3.2	1½	38.0	10½	267	16⅝	422
¼	6.4	2	50.8	11½	292	23½	596.4
⅜	9.5	3	76.2	12	305	24	610
½	12.7	4	102	12⅛	308	24⅛	613
¾	19.0	4½	114	12½	318	30	762
		4¾	121	13	330	31	787

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 8, 2008

Mr. Richard E. Campbell
Corporate Director, Quality Assurance
EnergySolutions
140 Stoneridge Drive
Columbia, South Carolina 29210

SUBJECT: QUALITY ASSURANCE PROGRAM APPROVAL FOR RADIOACTIVE MATERIAL PACKAGES NO. 0935, REVISION 4

Dear Mr. Campbell:

Enclosed is the Quality Assurance (QA) Program Approval for Radioactive Material Packages No. 0935, Revision No. 4, in response to your letter dated July 15, 2008, to consolidate 71-0935 with your additional location at 2105 S. Bascom Avenue, Suite 160, Campbell, CA 95008, and to terminate your 71-0804, Revision 7, QA Program Approval. This Approval satisfies the requirements of 10 CFR 71.17(b) and 71.101(c) for a QA Program approved by the U.S. Nuclear Regulatory Commission (NRC).

This Approval will remain in effect until the expiration date, indicated in Block No. 3. Termination of your materials license does not cause this Approval to be automatically terminated. If you wish to renew, amend, or terminate this Approval, please request it in writing.

This letter also serves as a reminder that if you are using or planning to use an NRC-approved packaging, you must be registered for use of that packaging with NRC. Registration for use of NRC-approved packagings should be made pursuant to 10 CFR 71.17(c)(3).

If you have any questions, please contact me at 301-492-3299 or Frank Gee at 301-492-3329.

Sincerely,

David W. Pstrak

David W. Pstrak, Chief
Rules, Inspections, and Operations Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket Nos.: 71-0935 and 71-0804

Enclosure: QA Program Approval No. 71-0935, Rev. 4

NRC FORM 311 (10-2006) 10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

QUALITY ASSURANCE PROGRAM APPROVAL
FOR RADIOACTIVE MATERIAL PACKAGES

1. APPROVAL NUMBER: 0935

REVISION NUMBER: 4

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Part 71, and in reliance on statements and representations heretofore made in Item 5 by the organization named in Item 2, the Quality Assurance Program identified in Item 5 is hereby approved. This approval is issued to satisfy the requirements of Section 71.101 of 10 CFR Part 71. This approval is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

2. NAME: EnergySolutions

STREET ADDRESS: 140 Stoneridge Drive

CITY: Columbia | STATE: SC | ZIP CODE: 29210

3. EXPIRATION DATE: November 30, 2018

4. DOCKET NUMBER: 71-0935

5. QUALITY ASSURANCE PROGRAM APPLICATION DATE(S)

December 29, 2006; May 21, 2007; October 15, 2007; and July 15, 2008

6. CONDITIONS

1. Activities conducted regarding transportation packagings are to be executed under applicable criteria of 10 CFR Part 71, Subpart H. Authorized activities include: design, procurement, fabrication, assembly, testing, modification, maintenance, repair, and use of transportation packagings.

2. Records shall be maintained in accordance with the provisions of 10 CFR Part 71. Specifically:

   a. Records of each shipment of licensed material shall be maintained for 3 years after that shipment [10 CFR 71.91(a)].

   b. Records providing evidence of packaging quality shall be maintained for 3 years after the life of the packaging [10 CFR 71.91(d)].

   c. Records describing activities affecting packaging quality shall be maintained for 3 years after this Quality Assurance Program Approval is terminated [10 CFR 71.135].

3. Planned and periodic audits of all aspects of the Quality Assurance Program shall be conducted in accordance with written procedures or checklists, by appropriately trained personnel not having direct responsibility in the areas being audited, in accordance with 10 CFR 71.137.

EnergySolutions:

140 Stoneridge Drive, Suite 500, Columbia, South Carolina 29210

740 Osborn Road, Barnwell, South Carolina 29812

1700 Longwood Road, Columbia, SC 29209

2105 S. Bascom Avenue, Suite 160, Campbell, CA 95008

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

SIGNATURE: David W. Pstrak

DATE: 10/8/08

DAVID W. PSTRAK, CHIEF
RULES, INSPECTIONS, AND OPERATIONS BRANCH
DIVISION OF SPENT FUEL STORAGE AND TRANSPORTATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

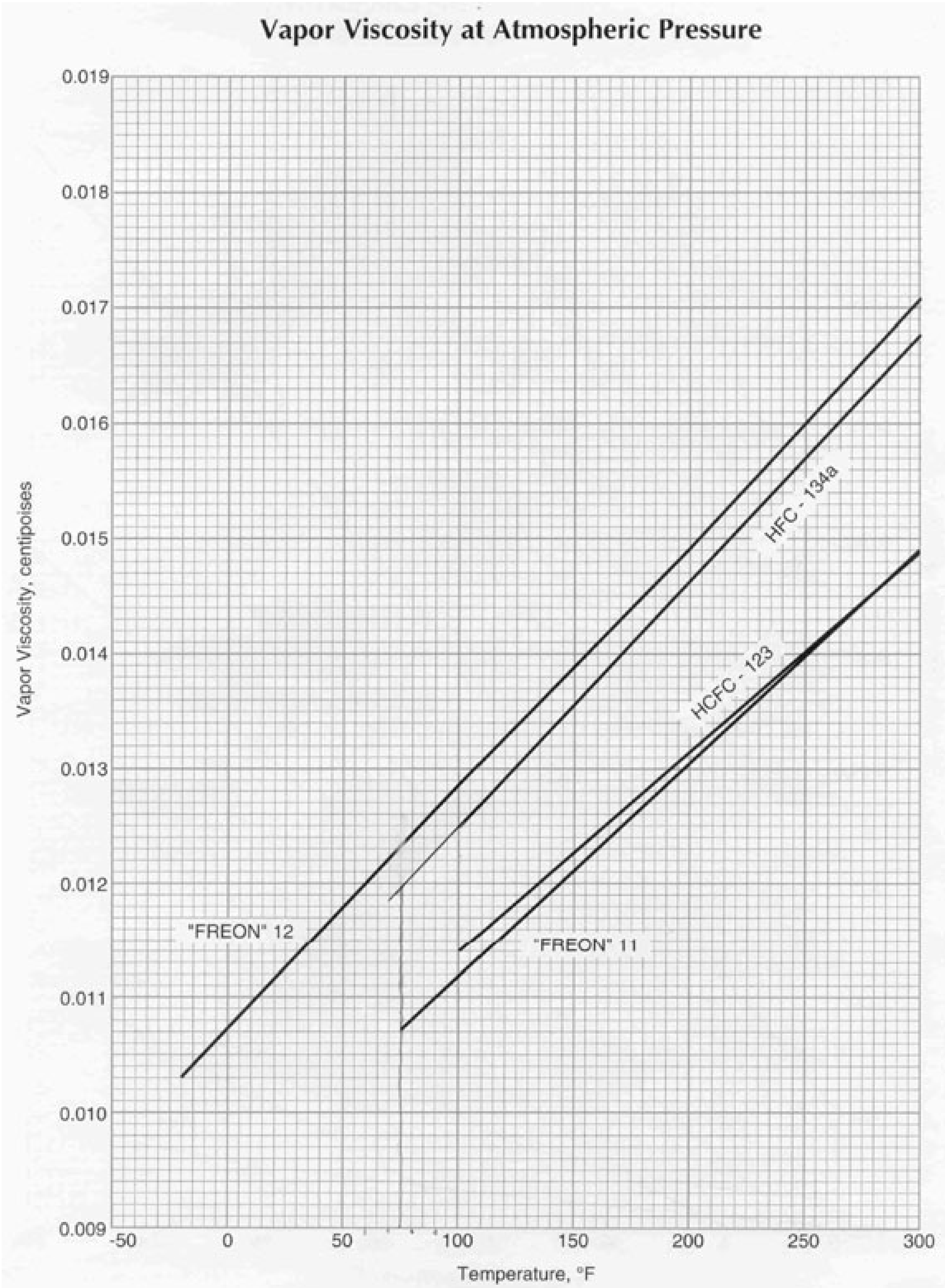
P134a

Suva®
refrigerants

DuPont HFC-134a

Properties, Uses, Storage, and Handling

Suva® 134a refrigerant
Suva® 134a (Auto) refrigerant
Formacel® Z-4 foam expansion agent
Dymel® 134a aerosol propellant


Vapor Viscosity at Atmospheric Pressure
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
Vapor Viscosity, centipoises
-50
0
50
100
150
200
250
300
Temperature, °F
HFC - 134a
HCFC - 123
"FREON" 12
"FREON" 11

SUVA®

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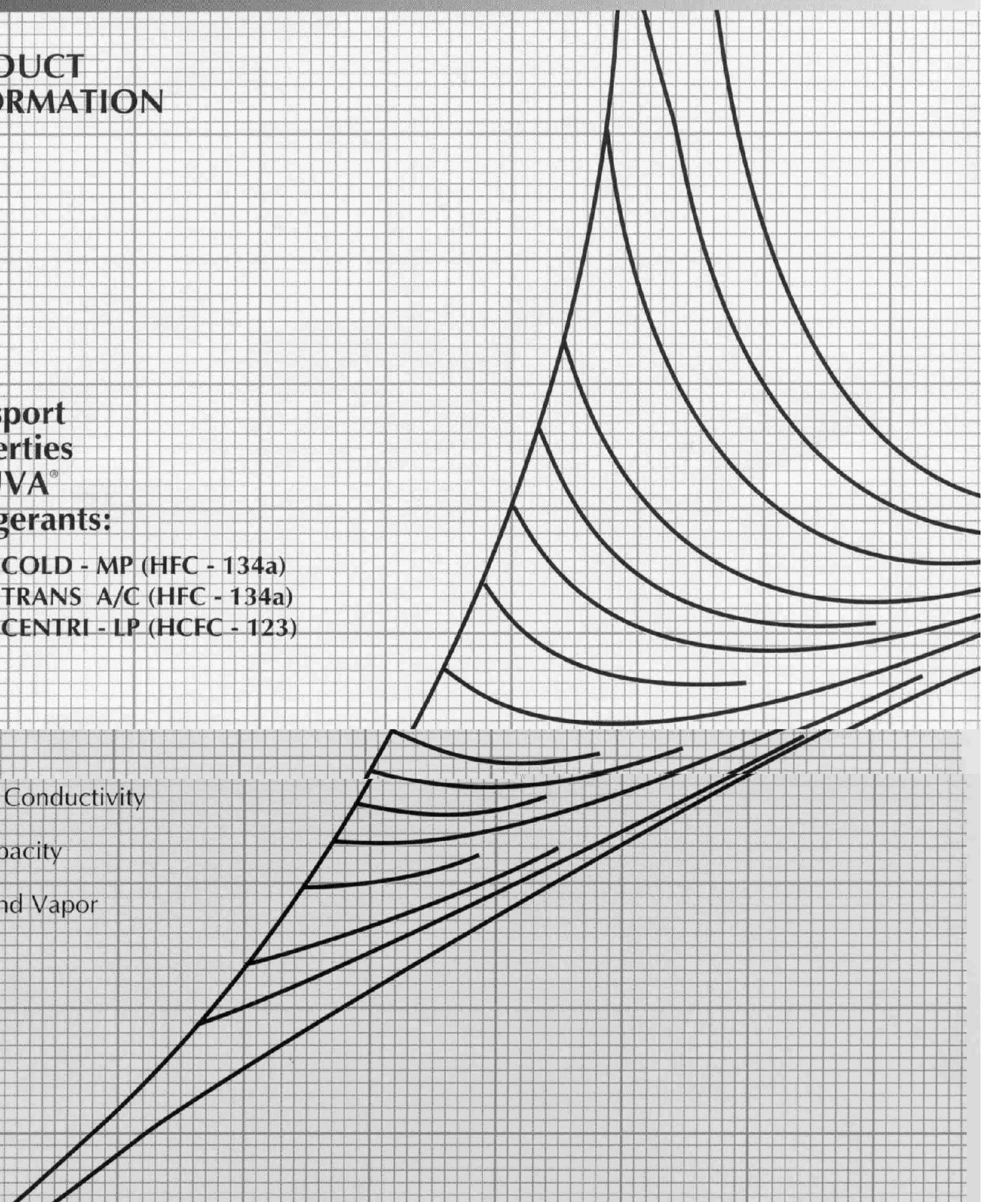
REFRIGERANTS ART - 1

PRODUCT INFORMATION



Transport Properties of SUVA® Refrigerants:

SUVA® COLD - MP (HFC - 134a)
SUVA® TRANS A/C (HFC - 134a)
SUVA® CENTRI - LP (HCFC - 123)

Viscosity
Thermal Conductivity
and
Heat Capacity
for the
Liquid and Vapor

DUPONT

Table 2
Physical Properties of HFC-134a

Physical Properties	Units	HFC-134a
Chemical Name	—	Ethane, 1,1,1,2-Tetrafluoro
Chemical Formula	—	CH_2FCF_3
Molecular Weight	—	102.03
Boiling Point at 1 atm (101.3 kPa or 1.013 bar)	°C °F	−26.1 −14.9
Freezing Point	°C °F	−103.3 −153.9
Critical Temperature	°C °F	101.1 213.9
Critical Pressure	kPa $lb/in.^2$ abs	4060 588.9
Critical Volume	m^3/kg ft^3/lb	1.94×10^{-3} 0.031
Critical Density	kg/m^3 lb/ft^3	515.3 32.17
Density (Liquid) at 25°C (77°F)	kg/m^3 lb/ft^3	1206 75.28
Density (Saturated Vapor) at Boiling Point	kg/m^3 lb/ft^3	5.25 0.328
Heat Capacity (Liquid) at 25°C (77°F)	kJ/kg·K or Btu/(lb) (°F)	1.44 0.339
Heat Capacity (Vapor at Constant Pressure) at 25°C (77°F) and 1 atm (101.3 kPa or 1.013 bar)	kJ/kg·K or Btu/(lb) (°F)	0.852 0.204
Vapor Pressure at 25°C (77°F)	kPa bar psia	666.1 6.661 96.61
Heat of Vaporization at Boiling Point	kJ/kg Btu/lb	217.2 93.4
Thermal Conductivity at 25°C (77°F)		
Liquid	W/m·K Btu/hr·ft°F	0.0824 0.0478
Vapor at 1 atm (101.3 kPa or 1.013 bar)	W/m·K Btu/hr·ft°F	0.0145 0.00836
Viscosity at 25°C (77°F)		
Liquid	mPa·S (cP)	0.202
Vapor at 1 atm (101.3 kPa or 1.013 bar)	mPa·S (cP)	0.012
Solubility of HFC-134a in Water at 25°C (77°F) and 1 atm (101.3 kPa or 1.013 bar)	wt %	0.15
Solubility of Water in HFC-134a at 25°C (77°F)	wt %	0.11
Flammability Limits in Air at 1 atm (101.3 kPa or 1.013 bar)	vol %	None
Autoignition Temperature	°C °F	770 1418
Ozone Depletion Potential	—	0
Halocarbon Global Warming Potential (HGWP) (For CFC-11, HGWP = 1)	—	0.28
Global Warming Potential (GWP) (100 yr. ITH. For CO_2, GWP = 1)	—	1200
TSCA Inventory Status	—	Reported/Included
Toxicity AEL[a] (8- and 12-hr TWA)	ppm (v/v)	1000

[a] AEL (Acceptable Exposure Limit) is an airborne inhalation exposure limit established by DuPont that specifies time-weighted average concentrations to which nearly all workers may be repeatedly exposed without adverse effects.

Note: kPa is absolute pressure.

INCH-POUND

A-A-59588A
7 July 2005
SUPERSEDING
A-A-59588
12 January 2001

COMMERCIAL ITEM DESCRIPTION

RUBBER, SILICONE

The General Service Administration has authorized the use of this commercial item description for all federal agencies.

1. SCOPE. This commercial item description (CID) covers six classes of silicone rubber, in various grades.

2. CLASSIFICATION. The silicone rubber shall be of the following classes and grades, as specified:

Class 1A - Low temperature resistant.
Grades - 40, 50, 60, 70, 80

Class 1B - Low temperature resistant and low compression set at high temperature.
Grades - 40, 50, 60, 70, 80

Class 2A - High temperature resistant.
Grades - 25, 40, 50, 60, 70, 80

Class 2B - High temperature resistant and low compression set.
Grades - 25, 40, 50, 60, 70, 80

Class 3A - Low temperature, tear and flex resistant.
Grades - 30, 50, 60

Class 3B - Tear and flex resistant.
Grades - 30, 50, 60, 70, 80

Comments, suggestions, or questions on this document should be addressed to: Defense Supply Center Philadelphia, ATTN: DSCP-ITAA, 700 Robbins Avenue, Philadelphia, PA 19111-5096 or emailed to mailto:dscpg&ispeccomments@dla.mil Since contact information can change, you may want to verify the currency of this information using the ASSIST Online database at http://assist.daps.dla.mil/

3. SALIENT CHARACTERISTICS

3.1 Materials and composition. The material shall be silicone rubber, formulated and processed to meet the performance of this CID.

3.2 Physical and mechanical properties. Unless otherwise specified, the silicone rubber shall meet the physical and mechanical properties specified in table I when tested in accordance with the standards in table I. Proof of compliance may be required (see 5.1.1).

3.3 Form. The silicone rubber shall be in the form of sheets, strips or tape; extruded shapes or tubing; or molded shapes, as specified in the contract or purchase order (see 7.2).

3.4 Dimensions and tolerances. Dimensions and tolerances shall be as indicated in the contract or purchase order (see 7.2). If no tolerances are specified, A-3 commercial tolerances of the Rubber Manufacturer's Association (RMA) Rubber Handbook shall apply for molded solid rubber products, as shown in table II, and the commercial tolerances of the RMA Rubber Sheet Packing Handbook shall apply for packing, as shown in table III. Commercial tolerances, as shown in tables IV, V, and VI shall be applied for extruded shapes, extruded tubing and calendered sheet, respectively. Dimensions and tolerances for o-rings shall be as specified in SAE-AS568 (see A-A-55801 for standard part numbers), or in accordance with the applicable part number for non-standard sizes.

3.5 Extruded tubing. Unless otherwise specified in the contract or purchase order (see 7.2), the length of extruded tubing shall be furnished in coils containing 100, 200, 500, or 1000 feet per coil. Each coil shall contain not more than three individual lengths of tubing per 100 feet. No individual length of tubing shall be less than 15 feet.

3.6 Color. Unless otherwise specified (see 7.2), the color of the silicone rubber shall be the natural color of the compound furnished.

TABLE I. Physical and mechanical properties of silicone.

		PROPERTY VALUES AND RECOMMENDED ASTM TEST METHODS							
		UNAGED					AFTER OVEN AGING 2/		
CLASS	GRADE	Hardness, maximum Shore-A-Durometer ASTM D 2240	Tensile strength, minimum MPa (psi) ASTM D 412	Elongation minimum % ASTM D 412	Tear resistance, minimum kN/m (ppi) ASTM D 624	Compression set, maximum % 1/ ASTM D 395	Hardness change maximum durometer ASTM D 2240	Tensile strength change, maximum % ASTM D 412 & ASTM D 573	Elongation change, maximum % ASTM D 412 ASTM D 573
1A & 1B	40	40 ± 5	4.83 (700)	250	-	35	± 15	-30	-50
	50	50 ± 5	4.83 (700)	225	-	35	± 15	-30	-50
	60	60 ± 5	4.48 (650)	175	-	35	± 15	-30	-50
	70	70 ± 5	4.14 (600)	150	-	40	± 15	-30	-50
	80	80 ± 5	3.45 (500)	125	-	45	± 15	-30	-50
2A & 2B	25	25 + 5, -10	4.83 (700)	400	-	35-2A 25-2B	± 10	-20	-40
	40	40 ± 5	4.83 (700)	240	-	35-2A 25-2B	± 10	-20	-40
	50	50 ± 5	4.83 (700)	200	-	35-2A 25-2B	± 10	-20	-40
	60	60 ± 5	4.48 (650)	150-2A 100-2B	-	40-2A 25-2B	± 10	-20	-40
	70	70 ± 5	4.48 (650)	125-2A 80-2B	-	40-2A 25-2B	± 10	-25	-40
	80	80 ± 5	4.48 (650)	100-2A 60-2B	-	45-2A 30-2B	± 10	-25	-40
3A	30	30 +5, -10	5.86 (850)	500	14.00 (80)	40	+ 10	-25	-25
	50	50 ± 5	8.28 (1,200)	500	30.63 (175)	40	+ 10	-40	-50
	60	60 ± 5	7.59 (1,100)	400	26.25 (150)	40	+ 10	-35	-35
3B	30	30 ± 5	6.90 (1,000)	500	26.25 (150)	25	± 5	-20	-35
	50	50 ± 5	8.28 (1,200)	500	26.25 (150)	20	± 10	-25	-30
	60	60 ± 5	8.28 (1,200)	400	26.25 (150)	25	± 10	-30	-35
	70	70 ± 5	7.59 (1,100)	350	26.25 (150)	25	± 10	-30	-45
	80	80 ± 5	5.52 (800)	200	12.25 (70)	40	± 10	-25	-40

1/ Aging period shall be: Class 1A – 22 hours at 100ºC (212ºF)
Classes 1B, 2A, 2B – 70 hours at 150ºC (302ºF)
Classes 3A, 3B – 70 hours at 100ºC (212ºF)

2/ After oven aging: Classes 1A, 1B, 2A, 2B – 70 hours at 225ºC (437ºF)
Classes 3A, 3B – 70 hours at 200ºC (392ºF)

TABLE I. Physical and mechanical properties of silicone. (Continued)

		PROPERTY VALUES AND RECOMMENDED ASTM TEST METHODS					
		LOW TEMPERATURE REQUIREMENTS		AFTER WATER IMMERSIONS 4/	OTHER REQUIREMENTS		
CLASS	GRADE	Brittle point, minimum ºC (ºF) 3/ ASTM D 2137	Torsional stiffness Ratio hours at -75ºC, maximum ratio ASTM D 1053	Volume change, maximum percent ASTM D 471	Flex resistance, (crack growth), cycles 5/ ASTM D 813	Specific gravity ASTM D 297 Variation from pre-production rate	Impact resilience, minimum percent ASTM D 2632
1A & 1B	40	-75 (-103)	15	-	-	± 0.03	-
	50	-75 (-103)	15	-	-	± 0.03	-
	60, 70, 80	-75 (-103)	15	-	-	± 0.03	-
2A & 2B	25, 40	-62.2 (-80)	-	+ 10	-	± 0.03	-
	50	-62.2 (-80)	-	+ 5	-	± 0.03	-
	60	-62.2 (-80)	-	+ 5	-	± 0.03	-
	70	-62.2 (-80)	-	+ 5	-	± 0.03	-
	80	-62.2 (-80)	-	+ 5	-	± 0.03	-
3A	30	-90 (-130)	15	+ 5	40,000	± 0.03	-
	50	-90 (-130)	15	+ 5	10,000	± 0.03	-
	60	-90 (-130)	15	+ 5	10,000	± 0.03	-
3B	30	-70 (-94)	-	+ 5	500,000	± 0.03	40
	50	-70 (-94)	-	+ 5	140,000	± 0.03	45
	60	-70 (-94)	-	+ 5	50,000	± 0.03	35
	70	-70 (-94)	-	+ 5	2,500	± 0.03	35
	80	-70 (-94)	-	+ 5	-	± 0.03	35

3/ All test specimens shall not fail after single-impact blow, at the temperature specified.
4/ 70 hours at 100ºC (212ºF)
5/ No specimen shall show a crack in excess of 1/2 inch in length when flexed the specified number of cycles.

TABLE II. RMA A3 dimensional tolerances for molded solid rubber products. 1/

TOLERANCES FOR MOLDED SOLID RUBBER PRODUCTS – COMMON							
SIZE (millimeters)		Fixed dimension tolerance 2/ (millimeters)	Closure dimension tolerance 3/ (millimeters)	SIZE (inches – approximate)		Fixed dimension tolerance 2/ (inches)	Closure dimension tolerance 3/ (inches)
Above	Inclusive			Above	Inclusive		
0 -	9.99	± 0.20	± 0.32	0 -	0.399	± 0.008	± 0.013
10 -	15.99	± 0.25	± 0.40	0.40 -	0.629	± 0.010	± 0.016
16 -	24.99	± 0.32	± 0.50	0.63 -	0.999	± 0.013	± 0.020
25 -	39.99	± 0.40	± 0.63	1.00 -	1.599	± 0.016	± 0.025
40 -	62.99	± 0.50	± 0.80	1.60 -	2.499	± 0.020	± 0.032
63 -	99.99	± 0.63	± 1.00	2.50 -	3.999	± 0.025	± 0.040
100 -	159.99	± 0.80	± 1.25	4.00 -	6.299	± 0.032	± 0.050
160 & over		To find fixed dimensional tolerances, multiply size by 0.5 percent		6.30 & over		To find fixed dimensional tolerances, multiply size by 0.5 percent	

1/ This table should be used only with common shaped, all rubber parts.
2/ Fixed dimension tolerances apply individually to each fixed dimension by its own size.
3/ Closure dimension tolerances are determined by the largest closure dimension, and this single tolerance shall be used for all other closure dimensions. (Closure dimension refers to any dimension in a plane parallel to the plane traced when the mold closes.)

TABLE III. RMA commercial tolerances for rubber sheet packing.

TOLERANCES FOR RUBBER SHEET PACKING			
THICKNESS		TOLERANCES	
Millimeters	Inches (approximate)	Millimeters	Inches
Under 0.80	Under 0.031	± 0.25	± 0.010
0.80 to 1.59	0.031 to 0.059	± 0.30	± 0.012
1.60 to 3.19	0.060 to 0.124	± 0.40	± 0.016
3.20 to 4.79	0.125 to 0.186	± 0.50	± 0.020
4.80 to 9.49	0.187 to 0.374	± 0.80	± 0.031
9.50 to 14.29	0.375 to 0.561	± 1.20	± 0.047
14.30 to 19.19	0.562 to 0.749	± 1.60	± 0.063
19.20 to 25.39	0.750 to 0.999	± 2.40	± 0.093
25.40 and over	1.00 and over	± 10%	± 10%

TABLE IV. Commercial tolerances for special extruded shapes, except tubing.

TOLERANCES FOR SPECIAL EXTRUDED SHAPES			
DIMENSIONS		TOLERANCES	
Millimeters	Inches (approximate)	Millimeters	Inches
0 to 2.49	0 to 3/32	± 0.41	± 0.016
2.50 to 3.99	3/32 to 5/32	± 0.51	± 0.020
4.00 to 6.29	5/32 to 1/4	± 0.64	± 0.025
6.30 to 9.99	1/4 to 13/32	± 0.76	± 0.030
10.00 to 15.99	13/32 to 5/8	± 1.02	± 0.040
16.00 to 24.99	5/8 to 1	± 1.60	± 0.063
25.00 to 39.99	1 to 1-5/8	± 2.03	± 0.080
40.00 to 63.00	1-5/8 to 2-1/2	± 2.03	± 0.080

TABLE V. Commercial tolerances for extruded tubing.

TOLERANCES FOR SPECIAL EXTRUDED SHAPES							
		TOLERANCES OF MANDREL CURED ITEMS		TOLERANCES OF OTHER CURED ITEMS			
SIZES		INSIDE DIAMETER		INSIDE DIAMETER		OUTSIDE DIAMETER	
Millimeters	Inches (approx.)	Millimeters	(Inches)	+ Millimeters	(Inches)	+ Millimeters	(Inches)
0 to 9.99	0.00 - 0.399	+0 -0.25	(+0 -0.010)	0.51	(0.020)	0.78	(1/32)
10 to 15.99	0.40 - 0.629	+0 -0.31	(+0 -0.012)	0.78	(1/32)	1.19	(3/64)
16 to 24.99	0.63 - 0.999	+0 -0.40	(+0 -0.016)	0.78	(1/32)	1.19	(3/64)
25 to 39.99	1.00 - 1.599	+0 -0.50	(+0 -0.020)	1.19	(3/64)	1.69	(1/16)
40 to 62.99	1.60 - 2.499	+0 -0.63	(+0 -0.025)	1.19	(3/64)	1.69	(1/16)
63 to 100.00	2.50 - 4.000	+0 -0.80	(+0 -0.032)				

TABLE VI. Commercial tolerances for calendered sheets.

TOLERANCES FOR CALENDERED SHEETS			
DIMENSIONS		TOLERANCES	
Millimeters	Inches (approximate)	Millimeters	Inches
0 to 0.99	0 to 0.039	± 0.18	± 0.007
1.00 to 1.74	0.04 to 0.069	± 0.30	± 0.012
1.75 to 3.39	0.07 to 0.134	± 0.43	± 0.017
3.40 and over	0.135 and over	± 0.56	± 0.022

3.7 Marking. Unless otherwise specified (see 7.2), sheet material and strips (cut from sheet) shall be marked with the following information: CID number, class and grade designation, and the supplier's designations. The class and grade designations, separated by a dash, shall be enclosed within parentheses. The markings shall be legible and placed in rows of constantly recurring symbols from one end of the sheet to the other, spaced approximately 5 inches apart. The supplier's designation shall appear immediately below the constantly recurring CID symbols. The symbols shall be legible, and shall not be less than 3/8 inch high. Symbols shall be marked using white colored marking fluid for other than white silicones, and black colored marking fluid for white colored silicones. The markings shall not be obliterated by normal handling or by the action of petroleum-base oils.

3.8 Workmanship. The end product shall be clean, smooth finished, free from dirt, flash or rough edges, to the extent permitted by the acceptable quality levels in section 5.

4. REGULATORY REQUIREMENTS

4.1 Health, safety, and environment. The rubber products shall adhere to all federal, state, and local health, safety, and environmental regulations. No environmentally prohibited material or components shall be used in manufacturing, finishing, or packaging of the products.

4.2 Recycled materials. The supplier or contractor is encouraged to use recovered materials to the maximum extent practicable, in accordance with paragraph 23.403 of the Federal Acquisition Regulation (FAR).

5. PRODUCT CONFORMANCE PROVISIONS

5.1 Product conformance. The products provided shall meet the salient characteristics of this commercial item description, conform to the producer's own drawings, specifications, standards, and quality assurance practices, and are the same products offered for sale in the commercial market. The Government reserves the right to require proof of such conformance.

5.1.1 Test data. The supplier or contractor shall provide test data or lab results, of meeting the salient characteristics and special requirements, when specified by the procuring activity in the contract or purchase order (see 7.2).

5.1.2 Warranty. The supplier or contractor shall provide a warranty of replacing defective items as a special requirement (see 7.2), when specified by the procuring activity in the contract or purchase order.

6. PACKAGING. Preservation, packing, and marking shall be as specified in the contract or order (see 7.2). When no special packaging requirements are specified, ASTM D 3951 packaging guidance applies.

7. NOTES

7.1 Source of documents.

7.1.1 ASTM Standards are available from the American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or http://www.astm.org

7.1.2 SAE Standards are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or http://www.sae.org

7.1.3 RMA Specifications are available from the Rubber Manufacturers Association, 1400 K Street, NW, Suite 900, Washington, DC 20005 or http://www.rma.org

7.2 Ordering data. The contract or order should specify the following:

a. Title, number, and date of this document.
b. Class and grade required (see 2).
c. Form, with dimensions, required (see 3.3).
d. Dimensions and tolerances (see 3.4).
e. Extruded tubing requirements (see 3.5).
f. Color required, if other than natural color of compound furnished (see 3.6)
g. Special marking requirements (see 3.7 and 6).
h. Test data requirements (see 5.1.1).
i. Warranty requirements (see 5.1.2).
j. Packaging requirements (see 6).

7.3 Cross reference data. Table VII lists converted ZZ-R-765 slash sheet CIDs and their titles numerically by shape to allow cross reference to the slash sheets. The shape numbers that appear in the CID titles correspond directly to the former slash sheet numbers for ZZ-R-765 (e.g., ZZ-R-765/10, corresponds to CID A-A-55754, Rubber Silicone, Round Section, Shape 10 in table VII).

TABLE VII. Commercial item descriptions that replaced former ZZ-R-765 slash sheets, (see 7.3)

A-A-55450	Rubber, Silicone; Channel, Nonmetallic, Shape 1	A-A-55761	Rubber, Silicone; Strip, Shape 17
A-A-55449	Rubber, Silicone; Channel, Nonmetallic, Shape 2	A-A-55762	Rubber, Silicone; Strip Shape 18
A-A-55451	Rubber, Silicone; Channel, Nonmetallic, Shape 3	A-A-55763	Rubber, Silicon; Nonmetallic, Special Shaped Section, Shape 19
A-A-55452	Rubber, Silicone; Channel, Nonmetallic, Shape 4	A-A-55764	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 20
A-A-55749	Rubber, Silicone; Channel, Nonmetallic, Shape 5	A-A-55765	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 21
A-A-55750	Rubber, Silicone; Nonmetallic, Shape 6	A-A-55766	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 22
A-A-55751	Rubber, Silicone; Channel, Nonmetallic, Shape 7	A-A-55767	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 23
A-A-55752	Rubber, Silicone; Channel, Nonmetallic, Shape 8	A-A-55768	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 24
A-A-55753	Rubber, Silicone; Tubing, Nonmetallic, Round, Flexible, Shape 9	A-A-55769	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 25
A-A-55754	Rubber, Silicone; Round Section, Shape 10	A-A-55770	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 26
A-A-55755	Rubber, Silicone; Packing Material, Shape 11	A-A-55771	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 27
A-A-55756	Rubber, Silicone; Packing Material, Shape 12	A-A-55772	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 28
A-A-55757	Rubber, Silicone; Gasket, Shape 13	A-A-55773	Rubber, Silicone; Nonmetallic, Special Shaped Section, Shape 29
A-A-55758	Rubber, Silicone; Gasket, Shape 14	A-A-55774	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 30
A-A-55759	Rubber, Silicone; Rubber Sheet Solid, Shape 15	A-A-55775	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 31
A-A-55760	Rubber, Silicone; Strip Shape 16	A-A-55776	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 32

TABLE VII. Related commercial item descriptions. (Formerly ZZ-R-765 slash sheets) (Continued)

A-A-55777	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 33	A-A-55790	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 46
A-A-55778	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 34	A-A-55791	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 47
A-A-55779	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 35	A-A-55802	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 48
A-A-55780	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 36	A-A-55792	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 49
A-A-55781	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 37	A-A-55793	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 50
A-A-55782	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 38	A-A-55794	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 51
A-A-55783	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 39	A-A-55795	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 52
A-A-55784	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 40	A-A-55796	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 53
A-A-55785	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 41	A-A-55797	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 54
A-A-55786	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 42	A-A-55798	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 55
A-A-55787	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 43	A-A-55799	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 56
A-A-55788	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 44	A-A-55800	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 57
A-A-55789	Rubber, Silicone; Nonmetallic Special Shaped Section, Shape 45	A-A-55801	Rubber, Silicone; Packing Preformed, Shape 58

7.4 Intended use. The silicone rubber covered by this specification is intended generally for use under the conditions listed below. Users should, however, consider all the requirements of this specification when selecting a class and grade of silicone rubber.

Class 1 - Where resistance to extreme low temperature is required to approximately -73ºC (-100ºF). Class 1 material also possesses resistance to extreme high temperature (to approximately 219ºC (425ºF)), but length of service at high temperatures is less than that of the class 2 materials. The class 1B material also possesses low compression set at high temperature.

Class 2 - Where resistance to extreme high temperature is required to approximately 219ºC (425ºF). Class 2 material possesses low temperature resistance, but only to about -62ºC (-80ºF). Class 2B material also possesses low compression set.

Class 3A - Where resistance to extreme low temperature to approximately -75ºC (-103ºF), and resistance to tearing and flexing are required. Class 3A material also possesses resistance to extreme high temperature to approximately 204ºC (400ºF).

Class 3B - Where resistance to tearing and flexing are required, but the resistance to extreme low temperature requirement is less than that of the class 3A material. Temperature range for the class 3B material is approximately between -70ºC (-94ºF) and 204ºC (400ºF).

7.5 Part identification number (PIN). The following PIN procedure is for government purposes and does not constitute a requirement for the contractor.

The example describes a part numbering system for CID A-A-59588.

A-A-59588 – 1A25

Grade – 25, 30, 40, 50, 60, 70, 80

Class – 1A, 1B, 2A, 2B, 3A, 3B

CID number

MILITARY INTERESTS:

Custodians
Army – MR
Navy – AS
Air Force – 11

Reviewers
Army – AR, CR, CR4, GL, MD, MI, SM
Navy – OS, SH
Air Force – 84, 99

CIVIL AGENCY COODINATION ACTIVITY:
GSA-FSS

Preparing activity:
DLA – IS

(Project 9320-0051)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil/