GENERAL ATOMICS

August 5, 1998
370-2955

Document Control Desk
Attn: Mr. William F. Kane
Director, Spent Fuel Project Office
US Nuclear Regulatory Commission
Washington, DC 20555

Subject: **Docket No. 71-9226 (TAC No. L22363)**
GA-4 Legal Weight Truck Spent Fuel Shipping Cask

Reference: (1) K. E. Asmussen letter dated November 4, 1997, from General Atomics to U.S. NRC
(2) T.J. McGinty letter dated May 8, 1998, from U.S. NRC to General Atomics

Dear Mr. Kane:

General Atomics (GA) hereby submits the enclosed revised application for a Certificate of Compliance for the GA-4 Legal Weight Truck Spent Fuel Shipping Cask, Docket No. 71-9226 (TAC No. L22363). This revision changes individual pages of the proprietary (Revision E) and nonproprietary (Revision F) versions previously submitted (Ref. 1). Revision G pages should be inserted into Revision E and Revision G and H pages should be inserted into Revision F according to the instructions provided at the beginning of each revision.

The "additional information" requested in Reference 2 is contained in Enclosure 1 and is nonproprietary. Per your request in Reference 2 we have enclosed a proposed Certificate of Compliance for the Model GA-4 cask as Enclosure 2.

No proprietary information was changed from the previous revision, however, a few of the changed pages contain proprietary information. The same information is identified as proprietary as in previous submittals and is requested to be withheld from public disclosure, pursuant to the provisions of 10 CFR Section 2.790 (b)(1). The subject SARP contains proprietary commercially strategic information which GA has held in confidence, and which is customarily held in confidence, and is not available in public sources. The enclosed affidavit sets forth the basis for which the information should be withheld from public disclosure by the Commission, and addresses specifically the considerations listed in paragraph (b)(4) of 10 CFR Section 2.790 of the Commission's regulations.

GA is submitting ten (10) copies of the change pages to the Revision G proprietary version of the SARP, thirteen (13) copies of the requested "additional information" containing nonproprietary information, and three (3) copies of the change pages to the Revision H nonproprietary SARP version. The proprietary versions of the change pages to the SARP have brackets around proprietary text and clouds around proprietary information on drawings and figures. In the nonproprietary versions, the proprietary information within the brackets and clouds has been removed.

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3550 GENERAL ATOMICS COURT, SAN DIEGO, CA 92121-1194 PO BOX 85608, SAN DIEGO, CA 92186-5608 (619) 455-3000

If you need additional information, please call me at 619-455-2823 (FAX 619-455-2822) or Mr. Alan Zimmer at 619-455-4326 (FAX 619-455-2596).

Very truly yours,

Keith E. Asmussen

Dr. Keith E. Asmussen, Director
Licensing, Safety and Nuclear Compliance

Enclosures:

1. Additional Information Requested by Ref. 2
   1 Nonproprietary copy

2. Affidavit Pursuant to 10 CFR 2.790

3. Safety Analysis Report for Packaging (SARP)
   1 Proprietary copy of Revision G change pages to SARP, with instructions
   1 Nonproprietary copy of Revision H change pages to SARP, with instructions

cc: Ms. Virginia Tharpe, U.S. NRC Licensing Assistant (with enclosures below)

1. Additional Information Requested by Ref. 2
   9 Proprietary copy

2. Affidavit Pursuant to 10 CFR 2.790

3. Safety Analysis Report for Packaging (SARP)
   9 Proprietary copies of Revision G change pages to SARP, with instructions
   2 Nonproprietary copies of Revision H change pages to SARP, with instructions

STATE OF CALIFORNIA)
) ss
COUNTY OF SAN DIEGO)

AFFIDAVIT OF JAMES R. EDWARDS

I, James R. Edwards, Vice President, General Counsel and Secretary of General Atomics, do hereby affirm and state:

(1) I am an officer of General Atomics and I am authorized to execute this affidavit on behalf of General Atomics.

(2) The affidavit is submitted under the provisions of 10CFR Part 2.790 in order to withhold the enclosed confidential commercial information of General Atomics from public disclosure or publication.

(3) The information sought to be withheld is contained in the document entitled "GA-4 Legal Weight Truck Spent Fuel Shipping Cask, Safety Analysis Report for Packaging (SARP)," Document No. 910469 including Enclosure 1, "Additional Information Requested by the Referenced Letter." The proprietary material in this document is delineated by proprietary designation on specific pages, or by brackets around text, or clouds around information on drawings and figures.

(4) In making this application for withholding of proprietary information of which it is the owner, General Atomics relies upon the exemption from disclosure set forth is the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4) and 2.790(a)(4) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential." The material for which exemption from disclosure is hereby sought is all "confidential commercial information," and some portions also qualify under the narrower definition of "trade secret," within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

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

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

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

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

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

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

(6) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence, is of a sort customarily held in confidence by General Atomics, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by General Atomics. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (7) and (8) following.

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

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

(9) The information classified as proprietary was developed and compiled by General Atomics at a significant cost to General Atomics. This information is classified as proprietary because it contains detailed historical data and analytical results not available elsewhere. This information would provide other parties, including competitors, with information from General Atomics' technical database and the results of evaluations performed using codes developed by General Atomics. Release of this information would improve a competitor's position without the competitor having to expend similar resources for the development of the database. A substantial effort has been expended by General Atomics to develop this information.

(10) Public disclosure of the information sought to be withheld is likely to cause substantial harm to General Atomics' competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of General Atomics' comprehensive transportation base, and its commercial value extends beyond the original development cost.

The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

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

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

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

GENERAL ATOMICS

James R. Edwards, Vice President
General Counsel and Secretary

Subscribed and sworn to before me this 31st day of July 1998.

Linda R. Eady
Notary Signature

LINDA R. EADY
Commission #1077927
Notary Public — California
San Diego County
My Comm. Expires Nov 19, 1999

ENCLOSURE 1

RESPONSES TO U.S.N.R.C. REQUESTS FOR ADDITIONAL INFORMATION FOR THE MODEL GA-4 LEGAL WEIGHT TRUCK SPENT FUEL SHIPPING CASK DOCKET NO. 71-9226 TAC NO. L22363

CHAPTER 1 GENERAL INFORMATION

Section 1.1 Introduction

Question

1-1 Revise (edit) Section 1.1 to be consistent with the criticality-control transport index of 100 for the GA-4 package.

Response

SAR revised to change the criticality-control transport index for the GA-4 package to 100 as described in Chapter 6.

Section 1.2.1.1 Cask Assembly

Question

1-2 Show that the containment system is in full compliance with ASME Section III, Division 3, including material, design, fabrication, examination, testing, inspection, and certification. Indicate General Atomic's (GA's) intentions with regard to establishing an agreement with the Authorized Inspection Agency to provide inspection and audit services for Design Owners, Packaging Owners, and Class TP Certificate Holders.

This position is stated in the staff's draft "Standard Review Plan for Transportation Packages for Spent Fuel" (NUREG-1617), which is currently available for public comment.

Response

GA review of ASME Section III Division 3 indicates that the current GA-4 cask meets all containment system requirements except for radiography of the final closing weld of the containment system as required by Subsections WB-3342.3 and WB-5230(a) for a Category C butt weld. The GA design chose a thickness transition and butt weld for this joint to reduce stresses and provide a more efficient weld design. The weld cannot be radiographed because of interference from the depleted uranium. Instead, it is volumetrically examined using ultrasonic and progressive liquid penetrant inspection as allowed in CR/NUREG 3019, section 3.3. The Code recognizes that a valid radiograph may not be possible for a category C butt weld. This means that the code does consider

ultrasonic examination as acceptable when a radiograph is not possible.

This approach was discussed in meetings with NRC staff, and the recommended liquid penetrant examination after each weld pass in addition to ultrasonic examination was incorporated in the cask requirements. Inspection and audit services will not be able to stamp the cask as meeting ASME Section III, Division 3 because of this weld, but inspection and audit services may be used by the fabricator for inspection during fabrication.

Section 1.3.2 License Drawings

Question

1-3 Revise Sheet 2 of Drawing 031348 to show that all absorber holes in the fuel support structure (FSS) are a single diameter.

This drawing shows two sizes of absorber holes in the FSS. However, the current FSS design analysis is based on only one hole size. All drawings should be revised or annotated to reflect the current design.

Response

Drawing 031348, Sheet 2 was revised to show all the hole sizes for the B_4C pellets to be the same as shown on Drawing 031348, Sheet 9 and is consistent with the B_4C poison assumptions used in the criticality evaluation.

Question

1-4 Revise Sheet 18 of Drawing 031348 to show that the depleted uranium used for the gamma shield will have a maximum ^{235}U concentration of 0.3 weight percent.

This is consistent with the depleted uranium assumptions used in the criticality evaluation.

Response

Drawing 031348, Sheet 18 was revised to show that the depleted uranium used for the gamma shield will have a maximum ^{235}U concentration of 0.2 weight percent as defined in Section 2.3.

CHAPTER 2 STRUCTURAL EVALUATION

Section 2.10.9 Cavity Liner and Fuel Support Structural Assembly Analysis

Question

2-1 Provide a fatigue evaluation of the FSS to demonstrate adequate design margin.

The present fatigue evaluation considers only the cavity liner and does not address the FSS.

Response

Attachment 1 contains the fatigue evaluation of the FSS.

CHAPTER 3 THERMAL EVALUATION

No additional information is required at this time.

CHAPTER 4 CONTAINMENT

No additional information is required at this time.

CHAPTER 5 SHIELDING EVALUATION

The following regulatory requirements are applicable in this chapter: 10 CFR 71.7(a), 71.35(a), 71.39, 71.41, 71.43(f), 71.47, 71.51(a), 71.71(a), 71.73(a), and Subpart G. It should be noted that other regulatory requirements may be applicable to this section.

Section 5.2.2 Neutron Source

Question

5-1 (a) Revise (edit) Table 5.2-6b to include the total neutron source strength for each energy group.

(b) Clarify the total neutron source strength for the "RP=1.2" group in Table 5.2-6(b).

It appears that the sum of source strengths for each energy group does not equal the total listed for "RP=1.2."

Response

We revised Table 5.2-6b to include the total neutron source strength for each energy group. We corrected the neutron source strength for the "RP-1.2" group in Table 5.2-6b. There was a typographical error for Group 4, which should have been 2.856+07 n/s per assembly. The total for RP-1.2 was correct.

Section 5.4.5 Shielding Calculations

Question

5-2 Provide the MCNP and PATH shielding calculations (input/output files) to support the bounding axial and radial dose rates for the 45 GWD/MTU / 15-year cooled spent fuel configuration.

Response

Attachment 2 contains the information faxed to you on June 11, 1998 as requested. In a follow on conference call on July 21, 1998 you indicated that based on your analysis using the faxed information, the NRC no longer requires the information requested in Question 5-2.

CHAPTER 6 CRITICALITY EVALUATION

Section 6.1 Discussion and Results

Question

6-1 State (edit) all criticality results in Chapter 6 with a 2• statistical error.

Current criticality results are stated with a 1• error. Results to be revised include those presented in Figure 6.1-3, Sections 6.4.1.4 and 6.4.3, and Tables 6.4-2, 6.4-3, and 6.4-4.

Response

We changed all criticality results in Chapter 6 to include a 2σ error.

Section 6.3.1 Description of Calculational Model

Question

6-2 Revise in Section 6.3.1 the description of the modeling assumptions to include a discussion of the basis for the assumed 2.38-inch distance between the bottom of the active fuel and the floor of the cask cavity.

It is important to explain the basis for this modeling assumption because the effective neutron multiplication (k_{eff}) could be sensitive to the assumed elevation of the active fuel.

Response

We have moved the location of the active fuel from 2.38 in. to 3.13 in. above the floor of the cask cavity. We made this change since the PWR assembly that has the active fuel closest to the floor of the cask cavity is the EXX/A CE at approximately 3.18 in. This is conservative since this PWR assembly is not the most reactive as shown in Table 6.4-2. We added a discussion of the basis for this in Section 6.3.1.

Section 6.4 Criticality Calculations

Question

6-3 Revise the criticality analysis to use the correct density of B_4C with 96 wt % ^{10}B.

The criticality analysis uses the default B_4C density in the SCALE 4.3 standard composition library. As indicated in the SCALE Manual (NUREG/CR-0200, Rev. 5), this density is for B_4C with naturally enriched boron. The density of B_4C with 96 wt % ^{10}B is 2.38 g/cm^3.

Response

We used the theoretical density of 2.38 g/cm^3. The density used in the criticality analysis is 2.056 g/cm^3, which is 86.4% of theoretical density (accounting for 4% manufacturing uncertainty and 10% margin). We revised all the criticality analyses to reflect this revision. Section 6.6-1 contains the input decks for all the revised computer runs.

CHAPTER 7 OPERATING PROCEDURES

The following regulatory requirements are applicable in this chapter: 10 CFR 71.7, 71.35(a), 71.39, 71.71(a), 71.73(a), 71.111, and Subparts A and G, including U.S. Department of Transportation regulations referenced in 10 CFR 71.5 and Subpart G. It should be noted that other regulatory requirements may be applicable to this section.

Section 7.1.1.4 Cask Loading

Question

7-1 Revise the procedures in Sections 7.1.1.4 and 7.1.2.4 for the pressure-rise test to meet the assembly verification leak test requirements of ANSI N14.5-1987.

The current procedures for the pressure-rise test suggest that a detectable increase in pressure would be acceptable if it is less than the pressure change associated with a leak of 5.0×10^{-4} std-cm^3/sec. However, any increase in pressure would indicate leakage which results in failure of the assembly verification leak test, unless it is shown that the leakage does not exceed 1.0×10^{-7} std-cm^3/sec. As stated in ANSI N14.5-1987, the pre-shipment assembly verification leak test must be performed with a sensitivity of at least 1.0×10^{-3} std-cm^3/sec. This testing sensitivity does not imply that the GA-4 allowable leak rate can be greater than 1.0×10^{-7} std-cm^3/sec.

Response

We changed Sections 7.1.1.4.16 and 7.1.2.4.15 to state that there shall be no detectable pressure rise when measured to a sensitivity of 1×10^{-3} std-cm^3/sec. We also stated that the pressure gage shall have a sensitivity sufficient to read the pressure given by the formula in the SAR that calculates the pressure rise for a leak rate of 1.0×10^{-3}.

CHAPTER 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The following regulatory requirements are applicable in this chapter: 10 CFR 71.7, 71.35(a), 71.39, 71.71(a), 71.73(a), and Subparts G and H. It should be noted that other regulatory requirements may be applicable to this section.

Section 8.1.4.4 Boron Carbide

Question

8-1 Revise the minimum boron carbide density stated in Section 8.1.4.4.

The boron carbide acceptance criteria refers to a minimum pellet density of 0.088 lb/in^3 that appears to be based on 96% of the theoretical density of 2.54 g/cm^3. The correct theoretical density for 96 wt % ^{10}B boron carbide is 2.38 g/cm^3 (See item 6-3).

Response

We changed the minimum pellet density to 0.0825 lb/in^3 that is 96% of the theoretical density of 2.38 g/cm^3.

Question

8-2 Revise the boron carbide density specifications, stated in Section 8.1.4.4 and Chapters 1 and 6, to include specifications for boron carbide chemical impurities.

Enriched boron carbide pellets always contain chemical impurities (typically about 1 wt %) and may not have a boron/carbon stoichiometry that is exactly four. Table 6.3-1 and the CSAS25 input files listed in Section 6.6.1 suggest that "96% of theoretical density" refers to a ^{10}B absorber content equal to 96% that of chemically pure and theoretically dense boron carbide (B_4C). Without a specification for chemical impurities, the density specification could be misinterpreted as only requiring the mass-density of the pellets, including impurities, to be at least 96% of 2.38 g/cm^3.

Response

We have added a requirement on sheet 9 of drawing 031348 and in Section 8.1.4.4 that the weight of ^{10}B in each stack of pellets with a minimum dia. of 0.426 in. and a minimum length of 7.986 in. must be a minimum of 0.0694 lb (31.5 gm) accounting for impurities. This weight (multiplied by 0.9 to account for margin) is consistent with the amount of ^{10}B used in the criticality analysis.

Question

8-3 Revise (edit) all boron carbide enrichment values, stated in Section 8.1.4.4 and in Chapters 1 and 6, to specify whether the enrichment values are atom or weight percent.

Response

We have edited all boron carbide enrichment values stated in Sections 8.1.4.4 and 2.3 and in Chapter 6 to state that the enrichment values are weight percent.

Question

8-4 (a) Revise the acceptance tests and criteria for the minimum ^{10}B content to account for smoothness and perpendicularity irregularities that could be found on individual boron carbide pellets.

The staff has found that a stack of pellets with perpendicularity and smoothness irregularities could contain less ^{10}B than what is expected for a stack of pellets with perfect smoothness and perpendicularity. Therefore, the acceptance tests and criteria should specify smoothness and perpendicularity criteria and/or specify other methods, such as a pellet-stack weighing procedure, to assure minimum boron content of each pellet stack.

(b) Revise, as appropriate, Sheet 9 of Drawing 031348 to include additional dimensions and tolerances (e.g., smoothness and perpendicularity) for a single boron carbide pellet, to assure minimum boron content of each pellet stack.

Response

(a) We have chosen a method to require that the ^{10}B content in the pellet stack be controlled as discussed in the response to Question 8-2. This method requires that the weight of ^{10}B in the stack be a minimum of 0.0694 lb (31.5 gm) that is equivalent to the weight of ^{10}B in a perfect stack of pellets with minimum dimensions and a minimum density of 96% of the theoretical density of 2.38 g/cm^3.

(b) We have added a minimum weight requirement of 0.0694 lb (31.5 gm) of ^{10}B for the stack of pellets instead of adding additional dimensions and tolerances.

Section 8.2.2.1 Containment System Periodic Verification Leakage Test

Question

8-5 Revise (edit) the minimum sensitivity for the periodic verification test to state 5 x 10^{-8} std-cm^3/sec.

Response

We edited the minimum sensitivity for the periodic verification test to state 5 x 10^{-8} std-cm^3/sec.

Section 8.2.3 Subsystem Maintenance

Question

8-6 Revise the maintenance procedures to include the leak test requirements required for any modified and/or replaced containment components, as defined in ANSI N14.5-1987.

Section 6.3.2 of ANSI N14.5-1987 states, "When components of reusable Type B package containment systems are modified, or when replacement is made of components not routinely replaced, the affected portion of the containment system shall be tested according to 6.3.1 [fabrication verification]."

Response

We revised the maintenance procedure (Section 8.2.3) to include the leak test requirements for any modified and/or replaced containment components, as defined in ANSI N14.5-1987.

ATTACHMENT 1

Fuel Support Structure (FSS) Fatigue Evaluation. The maximum stress condition for cyclic normal loading conditions on the FSS is dominated by the thermal stress at the center of the FSS cruciform during the hot environment. The stresses during other conditions and at other locations are much smaller. Therefore, the worst fatigue condition occurs at the center of the FSS during cycles from hot environment to cold environment, MNOP to vacuum and transport vibration loads to no contents loading. At the center of the FSS the thermal stresses during cold conditions are zero since the center is free to contract. Table 1 summarizes the maximum stresses for fatigue evaluation.

Table 1 MAXIMUM FSS STRESSES FOR FATIGUE EVALUATION

Stress Location (a)		Stress Type (ksi)									
		Sx	Sy	Sz	Sxy	Sxz	Syz	Sxy	σ_1	σ_2	σ_3
28 Center of FSS	Thermal (b)	0	0	-21	0	0	0	0			
	MNOP (c)	2.51	0	0	0	0	0	0			
	Vibration										
	Ovality (d)	1.27	0	0	0	0.04	0	0			
	ANSYS frame analysis (e)	1.11	0.72	-0.09	0	0.17	0	0			
	Total	4.90	0.72	-21.09	0	0.21	0	0	4.90	0.72	-21.09
28	Vacuum (f) dry	-.47	0	0	0	0	0	0	-.47	0	0

a) See SAR Fig. 2.10.9-4, page 2.10.9-5.
b) Hot Environment, from SAR Fig. 2.10.9.-21, page 2.10.9-34.
c) From SAR Table 2.10.9-55, page 2.10.9-151.
d) From SAR Table 2.10.10-3, page 2.10.10-21. Normal corner orientation case multiplied by 0.12, the ratio of the vibration vertical g level (1.9g, (0.9g vibration + 1.0 g dead load), page 2.6-33) /1-ft drop g-level (15.6g, page 1.10.10-12).
e) From SAR Table 2.10.10-13, page 2.10.10-35. 1-ft Drop Adjusted Stress multiplied by 0.12, the ratio of the vibration vertical g level (1.9g, (0.9g vibration + 1.0 g dead load), page 2.6-33) /1-ft drop g-level (15.6g, page 1.10.10-12).
f) From above MNOP values multiplied by –15psi / 80psi.

The total stress amplitude at the center of the FSS is calculated using the above principal stresses ($\sigma_1, \sigma_2, \sigma_3$), for both conditions and the stress difference equations in page 2.10.9-65.

$S_{12}' =$ 4.65 ksi,
$S_{23}' =$ 21.80 ksi, and
$S_{31}' =$ -26.45 ksi

The maximum alternating stress is

$S_a = ½ \max | S_{12}', S_{23}', S_{31}' |,$
$= ½ (26.45) = 13.23$ ksi.

And $S_{alt} = (E_{base} / E_{295\,^\circ F})(F)(S_a) = 54.4$ ksi (midcavity),

where:
$E_{base} =$ 2.83E+07,
$E_{295\,^\circ F} =$ 2.75E+07, and
$F = 4.$

Using the fatigue curve from the ASME Code, SAR Fig. 2.1-1,

$N > 20{,}000$ cycles.

During the life of the cask, the maximum number of normal operating cycles will be 50 years x 25 shipments a year =1250.

D.M. = (N/1250) –1 = + high.

The alternating stresses due to vibration are so small compared to the endurance allowable that there is negligible damage on the FSS due to transport vibration.

ATTACHMENT 2
INPUT DECKS

```
Fri Jun 19 15:42:00 CDT 1992
=sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 17.5 gwd/mtu (;p=0.5), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
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eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 4.388-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=8.73 burn=313.5 down=78.4 end
power=8.73 burn=313.5 down=78.4 bfrac=0.95 end
power=8.73 burn=313.5 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 13$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Fri Jun 19 16:19:01 CDT 1992
+sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 24.5 gwd/mtu (rp=0.7), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 4.388-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=12.222 burn=313.5 down=78.4 end
power=12.222 burn=313.5 down=78.4 bfrac=0.95 end
power=12.222 burn=313.5 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Fri Jun 19 16:28:10 CUT 1992
=sas2      parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 31.5 gwd/mtu (rp=0.9), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 4.388-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=15.714 burn=313.5 down=76.4 end
power=15.714 burn=313.5 down=78.4 bfrac=0.95 end
power=15.714 burn=313.5 down=3630 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Fri Jun 19 16:37:13 CDT 1992
=sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 35.0 gwd/mtu (rp=1.0), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 4.368-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=17.46 burn=313.5 down=78.4 end
power=17.46 burn=313.5 down=78.4 bfrac=0.95 end
power=17.46 burn=313.5 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
GSS a8 26 a11 71 e 188 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3SS 21 a3 1 a33 18 2t
4t
```

```
Fri Jun 19 16:46:33 CUT 1992
=sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 38.5 gwd/mtu (rp=1.1), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-14^ 1 0 1.0-20 1000 end
sm-[illegible] 1 0 1.0-20 1000 end
sm-1[illegible] 1 0 1.0-20 1000 end
sm-15[illegible] 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircaloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 4.388-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/c,c=1
   printlevel=4 lightel=7
power=19.206 burn=313.5 down=78.4 end
power=19.206 burn=313.5 down=78.4 bfrac=0.95 end
power=19.206 burn=313.5 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Thu Jun 18 22:43:29 CDT 1992
=sas2     parm='halt03,skipshipdata'
w15x15 assembly (0.469 mtu), 42.0 gwd/mt. (rp=1.2), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.0 92238 96.97 92234 0.03 end
zr-94  1 0 1.0-20 1[illegible] end
mo-94  1 0 1.0-20 [illegible] end
nb-9[illegible]  1 0 1.0-20 1[illegible] end
mo-95  1 0 1.0-20 1000 [illegible]
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 [illegible].7113 581 end
b-10  3 0 4.588-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/./c=1
   printlevel=4 lightel=7
power=20.952 burn=313.5 down=78.4 end
power=20.952 burn=313.5 down=78.4 bfrac=0.95 end
power=20.952 burn=313.5 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 0.4 zr 102 nb 0.33 b 0.036
end
=origens
033 a8 26 a11 71 e 133 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
333 21 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 15:22:42 CUT 1992
=sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 22.5 gwd/mtu (rp=0.5), 0.5-30 year cooling
27burnuplib   latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=7.915 burn=444.4 down=106.0 end
power=7.915 burn=444.4 down=106.0 bfrac=0.95 end
power=7.915 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
033 a8 26 a11 71 e 188 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
355 21 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 15:31:44 CDT 1992
=sas2     para=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 31.5 gwd/mtu (rp=0.7), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=11.081 burn=444.4 down=106.0 end
power=11.081 burn=444.4 down=106.0 bfrac=0.95 end
power=11.081 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1c
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 15:40:55 CUT 1992
=sas2      parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 40.5 gwd/mtu (rp=0.9), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=14.247 burn=444.4 down=106.0 end
power=14.247 burn=444.4 down=106.0 bfrac=0.95 end
power=14.247 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 15:48:23 CDT 1992
=sas2     para=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 45.0 gwd/mtu (rp=1.0), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=15.83 burn=444.4 down=106.0 end
power=15.83 burn=444.4 down=106.0 bfrac=0.95 end
power=15.83 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 1$$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ z1 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 15:56:01 CDT 1992
=sas2      parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 49.5 gwd/mtu (rp=1.1), 0.5-30 year cooling
27burnuplib  latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nl.b/cyc=1
   printlevel=4 lightel=7
power=17.413 burn=444.4 down=106.0 end
power=17.413 burn=444.4 down=106.0 bfrac=0.95 end
power=17.413 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 138 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

```
Mon Jun 22 16:14:32 CDT 1992
=sas2     parm=(halt03,skipshipdata)
w15x15 assembly (0.469 mtu), 54.0 gwd/mtu (rp=1.2), 0.5-30 year cooling
27burnuplib   latticecell
uo2  1 0.9577 1000 92235 3.2 92238 96.77 92234 0.03 end
zr-94  1 0 1.0-20 1000 end
mo-94  1 0 1.0-20 1000 end
nb-95  1 0 1.0-20 1000 end
mo-95  1 0 1.0-20 1000 end
tc-99  1 0 1.0-20 1000 end
rh-103 1 0 1.0-20 1000 end
rh-105 1 0 1.0-20 1000 end
ru-106 1 0 1.0-20 1000 end
xe-131 1 0 1.0-20 1000 end
cs-134 1 0 1.0-20 1000 end
cs-135 1 0 1.0-20 1000 end
cs-137 1 0 1.0-20 1000 end
pr-143 1 0 1.0-20 1000 end
nd-143 1 0 1.0-20 1000 end
ce-144 1 0 1.0-20 1000 end
nd-145 1 0 1.0-20 1000 end
nd-146 1 0 1.0-20 1000 end
nd-147 1 0 1.0-20 1000 end
pm-147 1 0 1.0-20 1000 end
sm-147 1 0 1.0-20 1000 end
nd-148 1 0 1.0-20 1000 end
pm-149 1 0 1.0-20 1000 end
sm-149 1 0 1.0-20 1000 end
sm-150 1 0 1.0-20 1000 end
sm-151 1 0 1.0-20 1000 end
eu-151 1 0 1.0-20 1000 end
sm-152 1 0 1.0-20 1000 end
eu-152 1 0 1.0-20 1000 end
eu-153 1 0 1.0-20 1000 end
eu-154 1 0 1.0-20 1000 end
gd-154 1 0 1.0-20 1000 end
eu-155 1 0 1.0-20 1000 end
gd-155 1 0 1.0-20 1000 end
gd-156 1 0 1.0-20 1000 end
gd-157 1 0 1.0-20 1000 end
gd-158 1 0 1.0-20 1000 end
gd-160 1 0 1.0-20 1000 end
zircalloy   2 1 605 end
h2o   3 0.7113 581 end
b-10  3 0 5.0-6 581 end
co-59 3 0 1.0-20  581 end
end comp
squarepitch  1.43 0.92964 1 3 1.07188 2 0.94844 0 end
more data szf=0.9 end
npin/assm=204 fuelength=365.76 ncycles=3 nlib/cyc=1
   printlevel=4 lightel=7
power=18.996 burn=444.4 down=106.0 end
power=18.996 burn=444.4 down=106.0 bfrac=0.95 end
power=18.996 burn=444.4 down=3650 bfrac=0.92 end
o 62.6 fe 4.6 co 0.033 ni 4.4 zr 102 nb 0.33 b 0.036
end
=origens
0$$ a8 26 a11 71 e 18$ 1 1t
decay 0.5 1 2 5 10 15 20 25 30 years
3$$ 21 a3 1 a33 18 2t
4t
```

ENCLOSURE 2
Proposed Certificate of Compliance for Model GA-4 Cask

3.

a. General Atomics
3550 General Atomics Court
San Diego, CA 92121-1194

b. General Atomics application dated _____

c. Docket Number: 71-9226

4. This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: GA-4

(2) Description

A steel, depleted uranium and liquid shielded shipping cask for irradiated, non-failed PWR fuel assemblies. The cask body is square with rounded corners with right circular cylinder impact limiter support structures at the top and bottom of the cask with an impact limiter at each end. The neutron shield is located outside the cask body walls. The package has approximate dimensions as follows:

Fuel assembly cell dimensions	4 @ 8.78 inches square
Cavity length	167.26 inches
Cask body outer dimensions	27.3 inches sq. (flats) 33.81 inches sq. (corners)
Impact limiter support structure outer diameter	39.75 inches
Depleted uranium thickness	2.64 inches (flats) 2.05 inches (corners)
Impact limiter diameter	90 inches

Package length:

Without impact limiters	187.76 inches
With impact limiters	233.95 inches

The maximum weight of the contents is 6,648 pounds and the maximum gross weight of the package is 55,000 pounds.

The cask body is made of concentric Type XM-19 stainless steel shells. The inner shell is .375 inches thick and has an inside dimension of 18.16 inches square. The outer shell is 1.5 inches thick and is rounded at the corners. The outer dimension is 27.32 inches at the flats and 33.81 at the corners. The depleted uranium shield is located in the annulus between the two shells. The inner and outer shells are welded to a 9.5-inch thick Type XM-19 forged steel plate at the bottom and a forged Type XM-19 flange at the top. The bottom plate has a port for draining, leakage testing, or filling the cavity with water.

The cask is closed by a stainless steel lid that is bolted to the top end flange forging and has the same outer dimensions as the outer shell of the cask body. The lid is 11.0 inches thick and is made of forged Type XM-19 stainless steel. The lid is fastened by 12, 1-inch diameter bolts and are made of SB-637, Alloy N07718 material. The lid is sealed with two ethylene propylene O-rings that are recessed in dovetail grooves. The lid has a port for gas sampling, venting, pressurizing, vacuum drying, leakage testing, or inerting.

The cask body is surrounded by a neutron shield located between the impact limiter support structures located at the top and bottom of the cask. The package is equipped at each end with an impact limiter made of aluminum honeycomb.

A Type XM-19 stainless steel cruciform shaped fuel support structure is located inside the cask cavity and is welded to the inner shell of the cask body and can accommodate four PWR fuel assemblies. Holes in the four panels of the cruciform contain B_4C poison.

Two lifting and tie down trunnions are welded to the top end of the cask body at the two corners and two trunnions are located at a similar position at the bottom of the cask. The package is shipped in a horizontal orientation and is supported by the four trunnions. Two lifting sockets for redundant lifting are located at the top end of the cask on the cask body corners not containing lifting trunnions.

(3) Drawings

The package is constructed and assembled in accordance with the following General Atomics Drawing Nos.:

031348, sheets 1-19, Rev. D (Proprietary)
031348, sheets 1-19, Rev. E (Non-proprietary)

(b) Contents

(1) Type and form of material

Irradiated PWR fuel assemblies with solid UO_2 pellets. Each fuel assembly may have a maximum burnup of 35,000 MWD/MTU when cooled for at least 10 years, or 45,000 MWD/MTU when cooled for at least 15 years. The maximum heat load per assembly is 617 watts and 2468 watts per package. Prior to irradiation, the fuel assemblies must be within the following dimensions and specifications:

Assembly Type	14x14	15x15
Cladding Material	Zirc-4	Zirc-4
Maximum Initial Uranium Content (kg/assembly)	407	469
Maximum Initial Enrichment (wt % ^{235}U)	3.15	3.15
Number of Fuel Rods per Assembly	176 to 179	204 to 208
Minimum Cladding Thickness (in)	0.023	0.024
Pellet Diameter (in)	0.344 to 0.381	0.357 to 0.369
Maximum Active Fuel Length (in)	145.5	144

(2) Maximum quantity of material per package

Four (4) PWR fuel assemblies

(c) Transport Index for Criticality Control

Minimum transport index to be shown on label for nuclear criticality control: 100

6. The maximum heat load within the packaging at any time (transport, storage or testing) shall not exceed the decay heat limits in 5(b)(1).

7. Known or suspected failed fuel and fuel with cladding defects greater than pin holes and hairline cracks are not authorized.

8. Water and residual moisture shall be removed from the containment vessel in accordance with the procedures in Section 7.1 of the application.

9. Bolt Torque: The cask lid bolts must be torqued to 235 ±15 ft-lbs. The bolts used to secure the impact limiters must be torqued to 230 ± 15 ft-lbs.

10. Prior to each shipment, the package containment vessel seals must be shown to have no leakage when tested to a sensitivity of 1×10^{-3} std-cm^3/sec.

11. Containment vessel seals must be tested to a sensitivity of at least 5×10^{-8} std-cm^3/sec, and shown to have a leak rate no greater than 1×10^{-7} std-cm^3/sec:

    (a) Before first use of each packaging;

    (b) Within the 12-month period prior to each shipment; and

    (c) After seal replacement.

12. In addition to the requirements of Subpart G of 10 CFR Part 71:

    (a) Each package shall be prepared for shipment and operated in accordance with the Operating Procedures in Chapter 7 of the application; and
    (b) Each package must meet the acceptance tests and be maintained in accordance with the Acceptance Tests and Maintenance Program in Chapter 8 of the application.

13. The neutron shield material condition shall be verified before shipment as required in Chapter 7, Sections 7.1.1.4 and 7.1.2.4 of the application.

14. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR Part 71.12.

15. Expiration Date:

REFERENCES

General Atomics application dated

Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Date: _____

INSTRUCTIONS FOR INSERTING PAGES INTO 910469 REVISION F FOR REVISION H

REMOVE		INSERT	
PAGE NUMBER	REVISION	PAGE NUMBER	REVISION
i to vi	F	i to vi	H
1.1-1	A	1.1-1	G
1.3-3 to 1.3-21	F	1.3-3 to 1.3-21	H
2.3-2	D	2.3-2	H
5.2-7	A	5.2-7	G
6-i	E	6-i	G
6.1-3	E	6.1-3	G
6.1-5	E	6.1-5	G
6.2-2	E	6.2-2	G
6.3-1	F	6.3-1	H
6.3-2	E	6.3-2	G
6.3-19	E	6.3-19	G
6.4-8 to 6.4-12	E	6.4-8 to 6.4-12	G
6.6-1 to 6.6-188	E	6.6-1 to 6.6-176	G
7.1-4	E	7.1-4	G
7.1-9	F	7.1-9	H
8.1-9	E	8.1-9	G
8.2-1	E	8.2-1	G
8.2-3	F	8.2-3	H